Module **LinearAlgebra**

Functions

`def` **`add_object_align_init`**`(context, operator)`

`def` **`createFaces`**`(vertIdx1, vertIdx2, closed=False, flipped=False)`

`def` **`create_mesh_object`**`(context, verts, edges, faces, name)`

```
def draw_parametric_surface(eq,
                            range_u_min,
                            range_u_max,
                            range_u_step,
                            range_v_min,
                            range_v_max,
                            range_v_step,
                            name,
                            wrap_u=False,
                            wrap_v=False,
                            close_v=False)
```

`def` **`object_data_add`**`(context, obdata, operator=None, name=None)`

Classes

`class` **`Color`** `(r, g, b, name)`

Class that defines a color in RGB format

`class` **`Colors`**

Class that defines a list of colors by name

Class variables

`var` **`colorsbyname`**

The type of the None singleton.

Static methods

`def` **`color`**`(name)`

Function that returns a color from his name

Parameters

name: name of the color

`def` **`colors`**`(names)`

Return a list of colors fron their names

Parameters

names: list of names

```
class EuclideanReference (o=Vector((0.0, 0.0, 0.0)),
                          u1=Vector((1.0, 0.0, 0.0)),
                          u2=Vector((0.0, 1.0, 0.0)))
```

Class used to work with Euclidean References

Initializes the elements of the reference from the origin and two independent vectors

Parameters

o: origin of u1, u2: vectors

Methods

`def base(self)`

Returns the columns of the matrix

`def coordinates(self, u=Vector((0.0, 0.0, 0.0)))`

Returns the coordinates of a point (expressed in the canonical reference) in the actual reference

Parameters

u: coordinates of a point in the canonical reference

`class LinearAlgebra`

Class used to define all the functions in this module to work with graphics in Blender

Initializes the values for scene, objects, meshes, collection, etc.

Methods

`def add_ligth(self, location=[0, 0, 100], energy=3, direction=[0, 0, -1])`

Adds a ligth to the scene

Parameters

location: location point of the light

energy: energy of the ligth

direction: direction of the light

`def add_ligths(self, energy=1)`

Adds diferent lights to the scene

Parameters

energy: energy of the lights

`def add_material(self, obj, material_name, r, g, b, opacity=1.0)`

Adds a material and color to an object

Parameters

obj: object

material_name: material's name

r, g, b: RGB color values

opacity: the opacity

```
def animate_revolution_surface(self,
                               fun=None,
                               tmin=0.0,
                               tmax=1.0,
                               steps=256,
                               curvethicknes=0.025,
                               thickness=0.025,
                               frames=3,
                               angle=3,
                               radians=False,
                               axis='Z',
                               symmetry=None,
                               name='Revolution surface',
                               color='AzureBlueDark',
                               point=None)
```

Draws and animates a revolution surface from a curve

Parameters

fun: parametric equacion of the curve

steps: number of steps to graw the curve

curvethicknes: thickness of the curve

frames: number of frames at each step of revolution

angle: step angle of the revolution

radians: if True, angle must be in radians

axis: axis of revolution. It must be 'X', 'Y' or 'Z'

symmetry: symmetry used to draw the curve

name: name of the surface

color: color of the surface

point: if not None draw three points and a cercle. Must be a float between tmax and tmin

```
def base_adaptada(self,
                  origin=Vector((0.0, 0.0, 0.0)),
                  axis=Vector((1.0, 1.0, 1.0)),
                  length=15,
                  scale=0.04,
                  name='Base adaptada')
```

Draws an ortonormal base from vector axis with origin in the point origin and sets the default origin and default base to them

Parameters

origin: origin of the vector and the base axis: first vector of the base

length: length of the axis

scale: scale of the base

name: name of the base

```
def base_canonica(self,
                  origin=Vector((0.0, 0.0, 0.0)),
                  length=15,
                  scale=0.04,
                  zaxis=True,
                  name='Base canònica')
```

Draws the canonical base

Parameters

origin: point where to represent the base

length: length of the axis

scale: scale of the cylinder

zaxis: if False the z axis is not drawn

name: name of the object

```
def base_canonica_white(self,
                        origin=Vector((0.0, 0.0, 0.0)),
                        length=20,
                        scale=0.04,
                        zaxis=True,
                        name='Base canònica')
```

Draws the canonical base in white

Parameters

origin: point where to represent the base

length: length of the axis

scale: scale of the cylinder

zaxis: if False the z axis is not drawn

name: name of the object

```
def base_cilinder(self)
```

Draws a base cilinder with radius 1 and depth 1

```
def base_cone(self)
```

Draws a base cone with radius1=1.5, radius2=0, depth=2

```
def base_disk(self)
```

Draws a base cone with radius1=1.5, radius2=0, depth=2

```
def base_is_canonica(self)
```

Returns True if self.base is the canonical basis

```
def base_no_canonica(self,
                     origin=Vector((0.0, 0.0, 0.0)),
```

```
                    u1=Vector((1.0, -1.0, 0.0)),
                    u2=Vector((0.5, -0.5, -0.5)),
                    u3=Vector((-1.0, 0.0, 1.0)),
                    length=12,
                    scale=0.04,
                    name="Base B'")
```

Draws the base {u1,u2,u3} with origin in the point origin and sets the default origin and default base to them

Parameters

origin: origin of the vector and the base

u1, u2, u3: vectors of the base

length: length of the axis

scale: scale of the base

name: name of the base

```
def canvi_base(self,
               vector=Vector((8.0, -6.0, 7.0)),
               u1=Vector((-0.3333333432674408, -0.6666666865348816, 0.6666666865348816)),
               u2=Vector((0.6666666865348816, 0.3333333432674408, 0.6666666865348816)),
               u3=Vector((-0.6666666865348816, 0.6666666865348816, 0.3333333432674408)),
               length=12)
```

Draw the components of a vectors in the canonical base and in the base {u1,u2,u3}. Sets the default origin and default base to them

Parameters

vector: vector to draw

u1, u2, u3: vectors of the base

length: length of the axis

```
def canvi_coordenades(self,
                      punt=Vector((8.0, -6.0, 7.0)),
                      origin=Vector((-2.0, 3.0, 3.0)),
                      u1=Vector((-0.3333333432674408, -0.6666666865348816, 0.6666666865348816)),
                      u2=Vector((0.6666666865348816, 0.3333333432674408, 0.6666666865348816)),
                      u3=Vector((-0.6666666865348816, 0.6666666865348816, 0.3333333432674408)),
                      length=12,
                      radius=0.1)
```

Draw the coordinates of a point in the canonical reference and in the reference {o;u1,u2,u3}. Sets the default origin and default base to them

Parameters

punt: point to draw

origin: origin of the reference

u1, u2, u3: vectors of the base

length: length of the axis

```
def cilindre(self,
             centre=Vector((0.0, 0.0, 0.0)),
             radi=1,
             height=5,
```

```
            eix='Z',
            color='AzureBlueDark',
            circlecolor='Blue')
```

Draws a bounded cylinder with direction eix Parameters:

centre: center of the cylinder

radi: radius

height: height

eix: X, Y, Z or a vector

color: color of the cylinder

circlecolor: color of the two circles of a bounded cylinder

```
def cilindre_elliptic(self,
                      o=[0, 0, 0],
                      u1=[1, 0, 0],
                      u2=[0, 1, 0],
                      a2=1,
                      b2=1,
                      principal=True,
                      canonica=True,
                      color='AzureBlueDark',
                      name='EllipticCylinder',
                      zmax=20,
                      cmax=20,
                      pmax=15,
                      thickness=0.02,
                      opacity=1.0,
                      preserve=True)
```

Draws an elliptic cylinder

Parameters

o: center of the elliptic cylinder

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2: squares of semi-axes of the elliptic cylinder. The equation is x'^2/a^2 + y'^2/b^2 = 1

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the elliptic cylinder

zmax: the elliptic cylinder is drawn between -zmax and zmax

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the elliptic cylinder

opacity: opacity of the elliptic cylinder

preserve: Keep self.origin and self.base as the principal reference

```
def cilindre_elliptic_simple(self, a=10, b=6, direccio='Z', pmax=20)
```

Draws an elliptic cylinder with direction X, Y or Z

Parameters

a, b: semiaxis of the ellipse

direction: direction of translation of the ellipse

pmax = height of the cylindrer

```
def cilindre_hiperbolic(self,
                        o=[0, 0, 0],
                        u1=[1, 0, 0],
                        u2=[0, 1, 0],
                        a2=1,
                        b2=1,
                        principal=True,
                        canonica=True,
                        color='AzureBlueDark',
                        name='Hyperbolic Cylinder',
                        xmax=None,
                        zmax=15,
                        cmax=15,
                        pmax=15,
                        thickness=0.02,
                        opacity=1.0,
                        preserve=True)
```

Draws an hyperbolic cylinder

Parameters

o: center of the hyperbolic cylinder

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2: squares of semi-axes of the hyperbolic cylinder. The equation is x'^2/a^2 - y'^2/b^2 = 1

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the hyperbolic cylinder

xmax: maximum value of the x coordinate

zmax: the hyperbolic cylinder is drawn between -zmax and zmax

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the hyperbolic cylinder

opacity: opacity of the hyperbolic cylinder

preserve: Keep self.origin and self.base as the principal reference

```
def cilindre_hiperbolic_simple(self, a=4, b=3, direccio='Z', pmax=15, hmax=20)
```

Draws an hyperbolic cylinder with direction X, Y or Z

Parameters

a, b: semiaxis of the hyperbole

direccio: direction of translation of the hyperbole

pmax = maximum value of the independent variable

hmax = height of the cylindrer

```
def cilindre_parabolic(self,
```

```
o=[0, 0, 0],
u1=[1, 0, 0],
u2=[0, 1, 0],
p=1,
principal=True,
canonica=True,
color='AzureBlueDark',
name='ParabolicCylinder',
xmax=12,
ymax=30,
cmax=20,
pmax=20,
thickness=0.02,
opacity=1.0,
preserve=True)
```

Draws an hyperbolic paraboloid

Parameters

o: vertex of the hyperbolic paraboloid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

p: Parameter of the cylinder z' = x'^2/(2*p)

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the elliptic paraboloid

xmax: maximum value of the coordinate x

ymax: maximum value of the coordinate y

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the hyperbolic paraboloid

opacity: opacity of the hyperbolic paraboloid

preserve: Keep self.origin and self.base as the principal reference

`def` **`cilindre_parabolic_simple`**`(self, a=3, direccio='Z', pmax=12, hmax=45)`

Draws a parabolic cylinder with direction X, Y or Z

Parameters

a: the initial parabola has equation of type z=\pm x^2/a^2

direccio: direction of translation of the parabola

pmax = maximum value of the independent variable

hmax = height of the cylindrer

`def` **`clear`**`(self)`

Clears and removes all the elements

`def` **`components_in_base`**`(self, vector=None, base=None)`

Returns the components of the vector 'vector' in the basis determined by self.rotation and the basis self.base

Parameters

vector: components of the vector in the canonical basis

base: A base of V3. If None, we use self.base

```
def con(self,
        o=[0, 0, 0],
        u1=[1, 0, 0],
        u2=[0, 1, 0],
        a2=1,
        b2=1,
        c2=1,
        half=False,
        principal=True,
        canonica=True,
        color='AzureBlueDark',
        name='Cone',
        xmax=None,
        cmax=15,
        pmax=15,
        thickness=0.02,
        opacity=1.0,
        preserve=True)
```

Draws a cone

Parameters

o: center of the cone

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2, c2: squares of semi-axes of the cone. The equation is x'^2/a^2 + y'^2/b^2 - z'^2/c^2 = 0

half: if True draws half cone

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the cone

xmax: maximum value of the x coordinate

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -pmax and pmax

thickness: thickness of the cone

opacity: opacity of the cone

preserve: Keep self.origin and self.base as the principal reference

```
def con_cilindre_elliptic(self, a2=1, b2=1, c2=1, x0=5, a=8, b=5, zmax=15)
```

Draws a cone with vertex at (0,0,0) and equation x^2/a2 + y^2/b2 - z^2/c2 == 0, an elliptic cylinder and their intersection

Parameters

a2, b2, c2: coefficients of the equation of the cone

x0: (x0,0,0) is the center of the ellipse in the plain XY

a, b: semiaxis of this ellipse

zmax: maximum value of the z coordinate

```
def con_revolucio(self, a=1.5, pmax=8, direccio='Z', punt=None)
```

Draws an animation showing a cone of revolution a: slope of the initial straight line

```
pmax: maximum value of the independent variable

direccio: 'X', the initial line is in the plane YX and rotates around the X axis
          'Y', the initial line is in the plane ZY and rotates around the Y axis
              'Z', the initial line is in the plane XZ and rotates around the Z axis

punt: if it's a value between -pmax and pmax, the animation shows a rotating point
```

```
def con_simple(self, a=4, b=3, c=2, direccio='Z', pmax=12)
```

Draws a con with direction X, Y or Z

Parameters

a, b, c: semiaxis of the cone

direccio: direction of the negative coefficient

pmax = maximum value of the independent variables

hmax = height of the cone

```
def cone(self,
        o=[0, 0, 0],
        u1=[1, 0, 0],
        u2=[0, 1, 0],
        a2=1,
        b2=1,
        c2=1,
        half=False,
        principal=True,
        canonica=True,
        color='AzureBlueDark',
        name='Cone',
        xmax=None,
        cmax=15,
        pmax=15,
        thickness=0.02,
        opacity=1.0,
        preserve=True)
```

Draws a cone

Parameters

o: center of the cone

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2, c2: squares of semi-axes of the cone. The equation is x'^2/a^2 + y'^2/b^2 - z'^2/c^2 = 0

half: if True draws half cone

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the cone

xmax: maximum value of the x coordinate

cmax: the canonical axis are drawn between -cmax and cmax pmax: the principal axis are drawn between -pmax and pmax

thickness: thickness of the cone

opacity: opacity of the cone

preserve: Keep self.origin and self.base as the principal reference

```
def coordinates_en_canonica(self, point=None)
```

Returns the coordinates of the point 'point' in the reference determined by self.origin, self.rotation and the basis self.base

Parameters

point: coordinates of the point in the reference {self.origin;self.base}

```
def coordinates_en_referencia(self, point=None)
```

Returns the coordinates of the point 'point' in the reference determined by self.origin, self.rotation and the basis self.base

Parameters

point: coordinates of the point in the canonical reference

```
def curve(self,
          fun=None,
          tmin=0.0,
          tmax=1.0,
          steps=25,
          thickness=0.01,
          name='Curve',
          color='White',
          axis=False,
          zaxis=True,
          o=Vector((0.0, 0.0, 0.0)),
          u1=Vector((1.0, 0.0, 0.0)),
          u2=Vector((0.0, 1.0, 0.0)),
          symmetry=None,
          change=False)
```

Draws a curve in a reference R' determined by the origin o and basis {v1, v2, v3} constructed from u1 and u2 and the symmetric curve or curves from the parameter 'symmetry'

Parameters

fun: the parametric function

tmin: minimum value of the parameter

tmax: maximum value of the parameter

steps: number of steps

thickness: thickness of the curve

name: name of the curve

color: color of the curve

axis: if True draws the axis of the reference R'

zaxis: if True draws the z' axis

o: origin of the reference R'

u1, u2: vectors to construct the basis {v1, v2, v3}

symmetry: list of values in ('XY','XZ','YZ','X','Y','Z','O'). For every value S, draw the symmetric curve respect to S change: if True, set the reference self.origin, self.base to {o; v1, v2, v3}

```
def delete_base_cilinder(self)
```

Removes the base cilinder

```
def delete_base_cone(self)
```

Removes the base cone

```
def delete_base_disk(self)
```

Removes the base disk

```
def distancia_rectes_encreuen(self,
                              p0=Vector((3.0, 4.0, -2.0)),
                              v0=Vector((1.0, 2.0, 3.0)),
                              c0='Black',
                              n0='Primera recta',
                              p1=Vector((-3.0, 4.0, 1.0)),
                              v1=Vector((1.0, -2.0, -1.0)),
                              c1='Blue',
                              n1='Segona recta',
                              canonica=True,
                              length=12,
                              size=15,
                              scale=0.03)
```

Draws the distance between two affine lines

Parameters

p0: point of the first line

v0: generator of the first line

c0: color of the first line

n0: name of the first line

p1: point of the second line

v1: generator of the second line

c1: color of the second line

n1: name of the second line

canonica: if True, draws the x, y and z axis

length: length of the axis x, y and z

size: lenght of the lines

```
def draw_base_axis(self, scale=0.05, head_height=0.15, axis=0, name='Axis', positive=True, zaxis=True)
```

Draws a reference axis given by self.origin, self.rotation and the basis self.base

Parameters

scale: scale of the cylinder

head_height: height of the head of the vector from self.base

axis: length of the coordinate axis. If the length is 0, only the basis vectors are drawn

name: name of the result object

positive: if True, draw the positive part of the axis zaxis: if True, draw the z axis

```
def draw_circle(self,
                center=[0, 0, 0],
                u1=Vector((1.0, 0.0, 0.0)),
                u2=Vector((0.0, 1.0, 0.0)),
                axis=False,
                zaxis=False,
                radius=1,
                steps=128,
                thickness=0.01,
                name='Circle',
                color='White',
                fillcolor=None,
                change=False)
```

Draws a circle of center 'center' and radius 'radius' in the plane determined by vectors u1 and u2

Parameters

center: center of the circle

u1, u2: vectors to construct the basis {v1, v2, v3}

axis: if True draws the axis of the reference R'

zaxis: if True draws the z' axis

radius: radius of the circle

steps: number of steps

thickness: thickness of the curve

name: name of the curve

color: color of the curve

change: if True, set the reference self.orifin, self.base to {o; v1, v2, v3}

```
def draw_components(self, vector=None, color='Cyan', name='Components', scale=0.0075)
```

Draws the components of the the vector 'vector' in the reference given by self.origin, self.rotation and the basis self.base

Parameters

vector: the vector

color: color of the lines of components

name: name of the object

scale: scale of the lines

```
def draw_cone(self,
              a=1.0,
              xmin=0.0,
              xmax=5.0,
              steps=50,
              scale=[1, 1, 1],
              half=False,
              color='AzureBlueDark',
              name='Cone',
              opacity=1.0,
              thickness=0.05)
```

Draws a cone from the line z = a*x in the XZ plane

Parameters

a: slope of the line

xmin: minimum value of x

xmax: maximum value of x

steps: numbers of steps to draw the parabola

scale: scaling factors in the X, Y and Z directions

half: if True, draws half cone

color: color of the surface

name: name of the surface

opacity: opacity of the surface

thickness: thickness of the surface

```
def draw_cube(self,
              origin=None,
              scale=[1, 1, 1],
              scalelines=0.05,
              vectors=False,
              color='Blue',
              linecolor='Red',
              vectorcolor='Black',
              name='Parallelepiped',
              opacity=1.0,
              thickness=0.0)
```

Draws a rectangular parallelepiped

Parameters

origin: center of the parallelepiped

scale: scale of the sides of the parallelepiped

scalelines: scale of the edges of the parallelepiped

vectors: if True, draws vectors from the origin to the vertices

color: color of the parallelepiped

linecolor: color of the edges

vectorcolor: color of the vectors

name: name of the parallelepiped

opacity: opacity of the parallelepiped

thickness: thickness of the parallelepiped

```
def draw_curve(self,
               fun=None,
               tmin=0.0,
               tmax=1.0,
               steps=25,
               thickness=0.01,
               name='Curve',
               color='White',
               axis=False,
               zaxis=True,
               o=Vector((0.0, 0.0, 0.0)),
               u1=Vector((1.0, 0.0, 0.0)),
               u2=Vector((0.0, 1.0, 0.0)))
```

Draws a curve in a reference R' determined by the origin o and basis {v1, v2, v3} constructed from u1 and u2

Parameters

fun: the parametric function

tmin: minimum value of the parameter

tmax: maximum value of the parameter

steps: number of steps

thickness: thickness of the curve

name: name of the curve

color: color of the curve

axis: if True draws the axis of the reference R'

zaxis: if True draws the z' axis

o: origin of the reference R'

u1, u2: vectors to construct the basis {v1, v2, v3}

```
def draw_disk(self,
              center=Vector((0.0, 0.0, 0.0)),
              radius=5,
              u1=Vector((1.0, 0.0, 0.0)),
              u2=Vector((0.0, 1.0, 0.0)),
              thickness=0.01,
              name='Disc',
              color='AzureBlueDark')
```

Draws a disc in a reference R' determined by self.origin and self.base

Parameters

radius: radius of the disc

thickness: thickness of the surface

name: name of the curve

color: color of the curve

```
def draw_ellipse(self,
                 center=[0, 0, 0],
                 u1=Vector((1.0, 0.0, 0.0)),
                 u2=Vector((0.0, 1.0, 0.0)),
                 a=1,
                 b=1,
                 axis=False,
                 zaxis=False,
                 steps=25,
                 thickness=0.01,
                 name='Ellipse',
                 color='White',
                 change=False)
```

Draws an ellipse of center 'center' and semi-axes a and b in the plane determined by vectors u1 and u2

Parameters

center: center of the ellipse

u1, u2: vectors to construct the basis {v1, v2, v3}

a, b: semi-axes of the ellipse

axis: if True draws the axis of the reference R'

zaxis: if True draws the z' axis

steps: number of steps

thickness: thickness of the curve

name: name of the curve

color: color of the curve

change: if True, set the reference self.orifin, self.base to {o; v1, v2, v3}

```
def draw_ellipsoid(self,
                   radius=5.0,
                   scale=[1.2, 1.8, 0.8],
                   color='AzureBlueDark',
                   name='Ellipsoid',
                   opacity=1.0,
                   thickness=0.05)
```

Draws en ellipsoid

Parameters

radius: radius of the sphere

scale: scaling factors in the X, Y and Z directions

color: color of the surface

name: name of the surface

opacity: opacity of the surface

thickness: thickness of the surface

```
def draw_elliptic_cylinder(self,
                           a=8.0,
                           b=5.0,
                           amin=0.0,
                           amax=6.283185307179586,
                           length=20,
                           steps=200,
                           scale=[1, 1, 1],
                           color='AzureBlueDark',
                           name='EllipticCylinder',
                           opacity=1.0,
                           thickness=0.05)
```

Draws an eliptic cylinder from the ellipse x = a*cos(t) y = b*sin(t) in the XY plane

Parameters

a, b: coefficients of the ellipsw

amin: minimum value of the angle t

amax: maximum value of the angle t

length: length in the Z direction

steps: numbers of steps to draw the parabola

scale: scaling factors in the X, Y and Z directions color: color of the surface

name: name of the surface

opacity: opacity of the surface

thickness: thickness of the surface

```
def draw_elliptic_paraboloid(self,
                             a=0.5,
                             xmin=0.0,
                             xmax=3.0,
                             steps=50,
                             scale=[1, 1, 1],
                             color='AzureBlueDark',
                             name='EllipticParaboloid',
                             opacity=1.0,
                             thickness=0.05)
```

Draws an elliptic paraboloid from the parabola z=a*t^2

Parameters

a: coefficient of the parabola

xmin: minimum value of x

xmax: maximum value of x

steps: numbers of steps to draw the parabola

scale: scaling factors in the X, Y and Z directions

color: color of the surface

name: name of the surface

opacity: opacity of the surface

thickness: thickness of the surface

```
def draw_frenet_curve(self,
                      fun=None,
                      var=None,
                      tmin=0.0,
                      tmax=1.0,
                      radius=0.1,
                      steps=25,
                      thickness=0.01,
                      name='Curve',
                      color='White',
                      point=True,
                      tangent=False,
                      acceleration=False,
                      normal=False,
                      osculator=False,
                      frenet=False,
                      units=False,
                      sizex=8,
                      sizey=8,
                      axis=10)
```

Draws a curve and diferents elements related to the curve

Parameters

fun: the parametric function

var = parameter variable of the function fun

tmin: minimum value of the parameter

tmax: maximum value of the parameter

radius: radius of the point

steps: number of steps

frames: increment of the frame set

thickness: thickness of the curve

name: name of the curve

color: color of the curve

point: if True draw a point along the curve

tangent: if True draw the tangent vector along the curve

acceleration: if True draw the acceleration vector along the curve

normal: if True draw the normal vector along the curve

osculator: if True draw the osculating plane along the curve

frenet: if True draw the Frenet trihedron along the curve

units: if True normalize the tangent and normal vectors

sizex, sizey: sizes of the osculating plane

axis: length of the coordinate axis

```
def draw_function(self,
                  f=None,
                  xmin=-3,
                  xmax=3,
                  xsteps=64,
                  ymin=-3,
                  ymax=3,
                  ysteps=64,
                  thickness=0.02,
                  opacity=1.0,
                  pmax=10,
                  name='Function',
                  color='AzureBlueDark',
                  axis=False,
                  o=Vector((0.0, 0.0, 0.0)),
                  u1=Vector((1.0, 0.0, 0.0)),
                  u2=Vector((0.0, 1.0, 0.0)))
```

Draws a function of two variables f(x,y) i the reference R' = {o, v1, v2, v3}

Parameters

f: the function of two variables f(x,y)

xmin: minimum value of x

xmax: maximum value of x

xsteps: steps in the x direction

ymin: minimum value of y

ymax: maximum value of y

ysteps: steps in the x direction

thickness: thickness of the surface

opacity: opacity of the surface

pmax: the axis are drawn between -pmax and pmax

name: name of the surface

color: color of the surface

axis: if True the axis of the reference R' are drawn

o: origin of the reference R'

u1, u2: vectors to construct the basis {v1, v2, v3}

```
def draw_hyperbole(self,
                   center=[0, 0, 0],
                   u1=Vector((1.0, 0.0, 0.0)),
                   u2=Vector((0.0, 1.0, 0.0)),
                   a=1,
                   b=1,
                   ymax=3.0,
                   axis=False,
                   zaxis=False,
                   steps=25,
                   thickness=0.01,
                   name='Hyperbole',
                   color='White',
                   change=False)
```

Draws an hyperbole of center 'center' and semi-axes a and b in the plane determined by vectors u1 and u2

Parameters

center: center of the hyperbole

u1, u2: vectors to construct the basis {v1, v2, v3}

a, b: semi-axes of the hyperbole

ymax: maximum value of the y'

axis: if True draws the axis of the reference R'

zaxis: if True draws the z' axis

steps: number of steps

thickness: thickness of the curve

name: name of the curve

color: color of the curve

change: if True, set the reference self.origin, self.base to {o; v1, v2, v3}

```
def draw_hyperbolic_cylinder(self,
                             a=1.0,
                             b=4.0,
                             xmin=2.0,
                             xmax=6.0,
                             length=20,
                             steps=50,
                             scale=[1, 1, 1],
                             color='AzureBlueDark',
                             name='HyperbolicCylinder',
                             opacity=1.0,
                             thickness=0.05)
```

Draws an hyperbolic cylinder from the hyperbole y = a * sqrt(x**2 - b) in the XY plane

Parameters

a, b: coefficients of the hyperbole

xmin: minimum value of x

xmax: maximum value of x

length: length in the Z direction

steps: numbers of steps to draw the parabola

scale: scaling factors in the X, Y and Z directions

color: color of the surface

name: name of the surface

opacity: opacity of the surface

thickness: thickness of the surface

```
def draw_hyperbolic_paraboloid(self,
                               a=0.2,
                               b=0.4,
                               xmax=10.0,
                               ymax=10.0,
                               steps=64,
                               scale=[1, 1, 1],
                               color='AzureBlueDark',
                               name='HyperbolicParaboloid',
                               opacity=1.0,
                               thickness=0.05)
```

Draws an hyperbolic paraboloid with equation z = a*x^2 - b*y^2

Parameters

a, b: coefficients of the parabolic hyperboloid

xmax: maximum value of x

ymax: maxim value y

steps: numbers of steps to draw the parabola

scale: scaling factors in the X, Y and Z directions

color: color of the surface

name: name of the surface

opacity: opacity of the surface

thickness: thickness of the surface

```
def draw_line(self,
              start=[1, 1, 1],
              end=[10, 10, 10],
              scale=0.05,
              name='Line',
              color='Black',
              segment=False)
```

Draws a line from the point start to the point end. The reference given by self.origin, self.rotation and the basis self.base is used

Parameters

start: starting point of the line

end: ending point of the line

scale: scale of the cylinder

name: name of the object

color: color of the vector

segment: if True, draw points start and end

```
def draw_mesh(self, mesh=None, name='Mesh', color='Blue', opacity=1)
```

Draws a mesh. This function is used by other functions

Parameters

mesh: the mesh to be drawn

name: name of the mesh

color: color of the mesh

opacity: opacity of the mesh

```
def draw_one_sheet_hyperboloid(self,
                               a=2.0,
                               b=2.0,
                               xmin=1.4142135623730951,
                               xmax=5.0,
                               steps=256,
                               scale=[1, 1, 1],
                               color='AzureBlueDark',
                               name='HyperboloidOneSheet',
                               opacity=1.0,
                               thickness=0.05)
```

Draws a one sheet hyperboloid from the hyperbole z = \pm a*sqrt(x^2-b) in the XZ plane

Parameters

a, b: coefficients of the hyperbole

xmin: minimum value of x

xmax: maximum value of x

steps: numbers of steps to draw the parabola

scale: scaling factors in the X, Y and Z directions

color: color of the surface

name: name of the surface

opacity: opacity of the surface

thickness: thickness of the surface

```
def draw_parabola(self,
                  vertex=[0, 0, 0],
                  u1=Vector((1.0, 0.0, 0.0)),
                  u2=Vector((0.0, 1.0, 0.0)),
                  a=1,
                  xmax=3.0,
                  axis=False,
                  zaxis=False,
```

```
                  steps=25,
                  thickness=0.01,
                  name='Parabola',
                  color='White',
                  change=False)
```

Draws a parabola of vertex 'vertex' of equation y'=ax'^2 in the reference {vertex; v1, v2, v3} determined by vectors u1 and u2

Parameters

vertex: vertex of the parabola

u1, u2: vectors to construct the basis {v1, v2, v3}

a: coefficient of the parabola

xmax: maximum value of x'

axis: if True draws the axis of the reference R'

zaxis: if True draws the z' axis

steps: number of steps

thickness: thickness of the curve

name: name of the curve

color: color of the curve

change: if True, set the reference self.orifin, self.base to {o; v1, v2, v3}

```
def draw_parabolic_cylinder(self,
                            p=0.25,
                            xmin=0.0,
                            xmax=6.0,
                            length=20,
                            steps=50,
                            scale=[1, 1, 1],
                            color='AzureBlueDark',
                            name='ParabolicCylinder',
                            opacity=1.0,
                            thickness=0.05)
```

Draws a parabolic cylinder from the parabola z=p*x^2 in the XZ plane

Parameters

p: coefficient of the parabola

xmin: minimum value of x

xmax: maximum value of x

length: length in the Y direction

steps: numbers of steps to draw the parabola

scale: scaling factors in the X, Y and Z directions

color: color of the surface

name: name of the surface

opacity: opacity of the surface

thickness: thickness of the surface

```
def draw_parallelepiped(self,
                        origin=[0, 0, 0],
```

```
                    u1=[1, 0, 0],
                    u2=[0, 1, 0],
                    u3=[0, 0, 1],
                    scalelines=0.025,
                    color='AzureBlueDark',
                    linecolor='OrangeObscureDull',
                    name='Parallelepiped',
                    opacity=1.0,
                    thickness=0.0)
```

Draws a parallelepiped

Parameters

origin: base vertex of the parallelepiped

u1, u2, u3: vectors that gives the edges

scalelines: scale of the edges of the parallelepiped

color: color of the parallelepiped

linecolor: color of the edges

name: name of the parallelepiped

opacity: opacity of the parallelepiped

thickness: thickness of the parallelepiped

```
def draw_parallelogram(self,
                       origin=[0, 0, 0],
                       u1=[1, 0, 0],
                       u2=[0, 1, 0],
                       scalelines=0.025,
                       color='AzureBlueDark',
                       linecolor='OrangeObscureDull',
                       name='Parallelogram',
                       opacity=1.0,
                       thickness=0.0)
```

Draws a parallelogram

Parameters

origin: base vertex of the parallelogram

u1, u2: vectors that gives the edges

scalelines: scale of the edges of the parallelogram

color: color of the parallelogram

linecolor: color of the edges

name: name of the parallelogram

opacity: opacity of the parallelogram

thickness: thickness of the parallelogram

```
def draw_plane(self,
               normal=None,
               base=None,
               sizex=10,
               sizey=10,
               color='AzureBlueDark',
               name='Plane',
```

```
              opacity=1.0,
              thickness=0.01)
```

Draws a plane with normal vector or base vectors. It passes through the point self.origin. Only normal or base can be not None

Parameters

normal: normal vector to the plane

base: list of two independent vectors

sizex: x-size of the plane

sizey: y-size of the plane

color: color of the plane

name: name of the plane

opacity: opacity of the plane

thickness: thickness of the plane

```
def draw_plane_surface(self,
                       origin=None,
                       normal=None,
                       base=None,
                       sizex=10,
                       sizey=10,
                       vectors=False,
                       scalelines=0.05,
                       scalevector=0.03,
                       color='AzureBlueDark',
                       linecolor='BlueDarkDull',
                       vectorcolor='Black',
                       name='Plane',
                       opacity=1.0,
                       thickness=0.0)
```

Draws a plane with normal vector or base vectors. It passes through the point origin. Only normal or base can be not None

Parameters

origin: a point in the plane

normal: normal vector to the plane

base: list of two independent vectors

sizex: x-size of the plane

sizey: y-size of the plane

vectors: if True, draw the generators of the plane

scalelines: scale of the lines limiting the plane

scalevector: scale of the generators

color: color of the plane

linecolor: color of the lines limiting the plane

vectorcolor: color of the generators

name: name of the plane

opacity: opacity of the plane

thickness: thickness of the plane

```
def draw_point(self, radius=0.1, location=(0, 0, 0), name='Point', color='Black', opacity=1.0)
```

Draws a point (in the reference self.origin, self.base)

Parameters

radius: radius of the point

location: location of the point

name: name of the point

color: color of the point

opacity: opacity of the point

```
def draw_points(self, points=[], name='Points', color='Blue', opacity=1)
```

Draws a list of points

Parameters

points: list of points

name: name of the list of points

color: color of the points

opacity: opacity of the points

```
def draw_polygon(self,
                 origin=[0, 0, 0],
                 u1=[1, 0, 0],
                 u2=[0, 1, 0],
                 points=[[0, 0], [1, 0], [0, 1]],
                 scalelines=0.075,
                 color='AzureBlueDark',
                 linecolor='OrangeObscureDull',
                 name='Polygon',
                 opacity=1.0,
                 thickness=0.0,
                 vectors=None,
                 scalevectors=0.01)
```

Draws a polygon

Parameters

origin: base vertex of the polygon

u1, u2: base vectors for the polygon

points: list of coordinates of points. The coordinates are taken in the reference {origin; u1, u2}

scalelines: scale of the edges of the polygon

color: color of the polygon

linecolor: color of the edges

name: name of the polygon

opacity: opacity of the polygon

thickness: thickness of the polygon

```
def draw_pyramid(self,
                 origin=[0, 0, 0],
                 u1=[1, 0, 0],
```

```
                  u2=[0, 1, 0],
                  u3=[0.5, 0.5, 1],
                  scalelines=0.025,
                  color='AzureBlueDark',
                  linecolor='OrangeObscureDull',
                  name='Pyramid',
                  opacity=1.0,
                  thickness=0.0)
```

Draws a pyramid

Parameters

origin: base vertex of the pyramid

u1, u2, u3: vectors that gives the edges

scalelines: scale of the edges of the pyramid

color: color of the pyramid

linecolor: color of the edges

name: name of the pyramid

opacity: opacity of the pyramid

thickness: thickness of the pyramid

```
def draw_regular_polygon(self,
                         origin=[0, 0, 0],
                         u1=[1, 0, 0],
                         u2=[0, 1, 0],
                         vertexs=5,
                         radius=1,
                         scalelines=0.075,
                         color='AzureBlueDark',
                         linecolor='OrangeObscureDull',
                         name='RegularPolygon',
                         opacity=1.0,
                         thickness=0.0,
                         vectors=None)
```

Draws a regular polygon

Parameters

origin: base vertex of the polygon

u1, u2: base vectors for the polygon

vertexs: number of vertices of the polygon

radius: radius of the polygon

scalelines: scale of the edges of the polygon

color: color of the polygon

linecolor: color of the edges

name: name of the polygon

opacity: opacity of the polygon

thickness: thickness of the polygon

```
def draw_simple_curve(self, fun=None, tmin=0.0, tmax=1.0, steps=25, thickness=0.02, color='White',
                      name='Curve')
```

Draws a parametric curve

Parameters

fun: the parametric function

tmin: minimum value of the parameter

tmax: maximum value of the parameter

steps: number of steps

thickness: thickness of the curve

color: color of the curve

name: name of the curve

```
def draw_surface(self,
                 eq=None,
                 umin=-1,
                 umax=1,
                 usteps=64,
                 vmin=-1,
                 vmax=1,
                 vsteps=64,
                 thickness=0.02,
                 opacity=1.0,
                 pmax=10,
                 name='Surface',
                 color='AzureBlueDark',
                 axis=False,
                 o=Vector((0.0, 0.0, 0.0)),
                 u1=Vector((1.0, 0.0, 0.0)),
                 u2=Vector((0.0, 1.0, 0.0)),
                 wrap_u=False,
                 wrap_v=False,
                 close_v=False)
```

Draws a parametric surface in the reference R'

Parameters

eq: parametric equacion f(u,v)

umin: minimum value of u

umax: maximum value of u

usteps: steps in the u direction

vmin: minimum value of v

vmax: maximum value of v

vsteps: steps in the v direction

thickness: thickness of the surface

opacity: opacity of the surface

color: color of the surface

pmax: the principal axis are drawn between -cmax and cmax

name: name of the surface

color: color of the surface

axis: if True draw the axis of the reference {o, v1, v2, v3} o: origin of the reference R'

u1, u2: vectors to construct the basis {v1, v2, v3}

scale: scale coefficients

wrap_u: wrap the u coordinate

wrap_v: wrap the u coordinate

close_v: close the v coordinate

```
def draw_tetrahedron(self,
                     origin=[0, 0, 0],
                     u1=[2, 0, 0],
                     u2=[1.0000000000000002, 1.7320508075688772, 0],
                     u3=[1.0, 0.5773502691896257, 2],
                     scalelines=0.025,
                     color='AzureBlueDark',
                     linecolor='OrangeObscureDull',
                     name='Tetrahedron',
                     opacity=1.0,
                     thickness=0.0)
```

Draws a tetrahedron

Parameters

origin: base vertex of the tetrahedron

u1, u2, u3: vectors that gives the edges

scalelines: scale of the edges of the tetrahedron

color: color of the tetrahedron

linecolor: color of the edges

name: name of the tetrahedron

opacity: opacity of the tetrahedron

thickness: thickness of the tetrahedron

```
def draw_triangle(self,
                  origin=[0, 0, 0],
                  u1=[1, 0, 0],
                  u2=[0, 1, 0],
                  points=[[0, 0], [1, 0], [0, 1]],
                  scalelines=0.075,
                  color='AzureBlueDark',
                  linecolor='OrangeObscureDull',
                  name='Triangle',
                  opacity=1.0,
                  thickness=0.0)
```

Draws a triangle. It's a polygon with three vertices

Parameters

origin: base vertex of the triangle

u1, u2: base vectors for the triangle

points: list of coordinates of points. The coordinates are taken in the reference {origin; u1, u2}

scalelines: scale of the edges of the triangle

color: color of the triangle

linecolor: color of the edges

name: name of the triangle

opacity: opacity of the triangle

thickness: thickness of the triangle

```
def draw_two_sheets_hyperboloid(self,
                                a=2.0,
                                b=1.0,
                                xmin=0.0,
                                xmax=5.0,
                                steps=50,
                                scale=[1, 1, 1],
                                color='AzureBlueDark',
                                name='HyperboloidTwoSheets',
                                opacity=1.0,
                                thickness=0.05)
```

Draws a two sheet hyperboloid from the hyperbole z = \pm a * math.sqrt(x**2+b) in the XZ plane

Parameters

a, b: coefficients of the hyperbole

xmin: minimum value of x

xmax: maximum value of x

steps: numbers of steps to draw the parabola

scale: scaling factors in the X, Y and Z directions

color: color of the surface

name: name of the surface

opacity: opacity of the surface

thickness: thickness of the surface

```
def draw_vector(self,
                vector=None,
                canonica=False,
                color='Black',
                scale=0.05,
                arrow=True,
                head_height=None,
                axis=0,
                name='Vector',
                positive=True)
```

Draw the vector with components 'vector'

Parameters

vector: components of the vector

canonica: if True, the components are in the canonical basis, else they are in the basis self.base. Finally, self.rotation is applied

color: color of the vector

scale: scale of the cylinder

arrow: if True draws the vector itself

head_height: height of the head of the vector head_scale: scale of the head of the vector

axis: if not zero, draw also the line generated by the vector

positive: if axis is not zero and positive is True, draw only the positive part of the line generated by the vector

```
def draw_vector_field(self,
                      f=None,
                      xmin=-3,
                      xmax=3,
                      xsteps=8,
                      ymin=-3,
                      ymax=3,
                      ysteps=8,
                      zmin=-3,
                      zmax=3,
                      zsteps=8,
                      name='Vector Field',
                      color='Red',
                      scale=0.02,
                      head_height=0.05)
```

Draws a vector field

Parameters

f: the vector field

xmin: minimum value of x

xmax: maximum value of x

xsteps: steps in the x direction

ymin: minimum value of y

ymax: maximum value of y

ysteps: steps in the y direction

zmin: minimum value of z

zmax: maximum value of z

zsteps: steps in the z direction

name: name of the vector field

color: color of the vector field

scale: scale of the vectors

head_height: head height of the vectors

```
def draw_vectors(self,
                 vectors=[],
                 canonica=False,
                 color='Black',
                 scale=0.05,
                 head_height=0.2,
                 name='Vectors',
                 axis=0)
```

Draws a list of vectors.

Parameters

vectors: list of vectors

anonica: if True, the the vectors are expressed in the canonical basis.

color: color of the vectors

scale: scale of the cylinder

head_height: height of the head of the vector

axis: if not zero, draw also the line generated by every vector

```
def ellipse(self, center=Vector((0.0, 0.0, 0.0)), a=8, b=5, canonica=True)
```

Draws the ellipse of equation (x-x0)^2/a^2 + (y-y0)^2/b^2 == 1

Parameters

centre: center of the ellipse

a, b: semiaxis of the ellipse

canonica: if True, draws the x and y axis

```
def ellipsoid(self,
              o=[0, 0, 0],
              u1=[1, 0, 0],
              u2=[0, 1, 0],
              a2=1,
              b2=1,
              c2=1,
              principal=True,
              canonica=True,
              color='AzureBlueDark',
              name='Ellipsoid',
              cmax=15,
              pmax=15,
              thickness=0.02,
              opacity=1.0,
              preserve=True)
```

Draws an ellipsoid

Parameters

o: center of the ellipsoid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors in the following way v1 = u1 v2 = u2 - u2.project(v1) v1.normalize() v2.normalize() v3 = v1.cross(v2)

a2, b2, c2: squares of semi-axes of the ellipsoid. The equation is x'^2/a^2 + y'^2/b^2 + z'^2/c^2 = 1

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the ellipsoid

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -pmax and pmax

thickness: thickness of the ellipsoid

opacity: opaccity of the ellipsoid

preserve: Keep self.origin and self.base as the principal reference

```
def ellipsoide(self,
               o=[0, 0, 0],
```

```
              u1=[1, 0, 0],
              u2=[0, 1, 0],
              a2=1,
              b2=1,
              c2=1,
              principal=True,
              canonica=True,
              color='AzureBlueDark',
              name='Ellipsoid',
              cmax=15,
              pmax=15,
              thickness=0.02,
              opacity=1.0,
              preserve=True)
```

Draws an ellipsoid

Parameters

o: center of the ellipsoid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors in the following way v1 = u1 v2 = u2 - u2.project(v1) v1.normalize() v2.normalize() v3 = v1.cross(v2)

a2, b2, c2: squares of semi-axes of the ellipsoid. The equation is x'^2/a^2 + y'^2/b^2 + z'^2/c^2 = 1

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the ellipsoid

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -pmax and pmax

thickness: thickness of the ellipsoid

opacity: opaccity of the ellipsoid

preserve: Keep self.origin and self.base as the principal reference

```
def ellipsoide_revolucio(self, a=12, b=8, direccio='Z', punt=None)
```

Draws an animation showing an ellipsoid of revolution a, b: semiaxis of the initial ellipse

```
direccio: 'X', the initial ellipse is in the plane XZ and rotates around the X axis
                  'Y', the initial ellipse is in the plane YZ and rotates around the Y axis
                  'Z', the initial ellipse is in the plane ZX and rotates around the Z axis

punt: if it's a value between 0 and pi, the animation shows a rotating point
```

```
def elliptic_cylinder(self,
                      o=[0, 0, 0],
                      u1=[1, 0, 0],
                      u2=[0, 1, 0],
                      a2=1,
                      b2=1,
                      principal=True,
                      canonica=True,
                      color='AzureBlueDark',
                      name='EllipticCylinder',
                      zmax=20,
                      cmax=20,
                      pmax=15,
```

```
                    thickness=0.02,
                    opacity=1.0,
                    preserve=True)
```

Draws an elliptic cylinder

Parameters

o: center of the elliptic cylinder

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2: squares of semi-axes of the elliptic cylinder. The equation is x'^2/a^2 + y'^2/b^2 = 1

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the elliptic cylinder

zmax: the elliptic cylinder is drawn between -zmax and zmax

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the elliptic cylinder

opacity: opacity of the elliptic cylinder

preserve: Keep self.origin and self.base as the principal reference

```
def elliptic_paraboloid(self,
                        o=[0, 0, 0],
                        u1=[1, 0, 0],
                        u2=[0, 1, 0],
                        a2=1,
                        b2=1,
                        principal=True,
                        canonica=True,
                        color='AzureBlueDark',
                        name='EllipticParaboloid',
                        xmax=None,
                        cmax=15,
                        pmax=15,
                        thickness=0.02,
                        opacity=1.0,
                        preserve=True)
```

Draws an elliptic paraboloid

Parameters

o: vertex of the elliptic paraboloid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2: squares of semi-axes of the elliptic paraboloid. The equation is z = x'^2/a^2 + y'^2/b^2

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the elliptic paraboloid

xmax: maximum value of the coordinate x

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the elliptic paraboloid

opacity: opacity of the elliptic paraboloid

preserve: Keep self.origin and self.base as the principal reference

```
def esfera(self,
           o=[0, 0, 0],
           r2=1,
           principal=True,
           canonica=True,
           color='AzureBlueDark',
           name='Sphere',
           cmax=15,
           pmax=15,
           thickness=0.02,
           opacity=1.0,
           preserve=True)
```

Draws a sphere of center 'o' and radius squared equal to 'r2'

Parameters

o: center of the sphere

r2: radius of the sphere squared

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the sphere

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the sphere

opacity: opacity of the sphere

preserve: Keep self.origin and self.base as the principal reference

```
def esfera_cilindre_elliptic(self, radi=10, x0=5, a=5, b=5)
```

Draws an sphere centered at (0,0,0), an elliptic cylinder and their intersection

Parameters

radi: radius of the sphere

x0: (x0,0,0) is the center of the ellipse in the plain XY

a, b: semiaxis of this ellipse

```
def gir_poligon(self,
                centre=Vector((0.0, 0.0, 0.0)),
                costats=6,
                origen=Vector((0.0, 0.0, 0.0)),
                radi=8)
```

Draws an animation of the rotation around a point of a polygon in the plane XY

Parameters

centre: center of the polygon

costats: sides of the polygon

origen: center of the rotation

radi: radius of the polygon

```
def hiperbola(self, center=Vector((0.0, 0.0, 0.0)), a=8, b=5, negatiu=False, canonica=True)
```

Draws the hyperbole of equation (x-x0)^2/a^2 - (y-y0)^2/b^2 == 1 (or -1)

Parameters

centre: center of the hyperbole

a, b: semiaxis of the hyperbole

canonica: if True, draws the x and y axis

negatiu: if True, draws the hyperbole (x-x0)^2/a^2 - (y-y0)^2/b^2 == -1

```
def hiperboloide_dues_fulles(self,
                             o=[0, 0, 0],
                             u1=[1, 0, 0],
                             u2=[0, 1, 0],
                             a2=1,
                             b2=1,
                             c2=1,
                             principal=True,
                             canonica=True,
                             color='AzureBlueDark',
                             name='TwoSheetParaboloid',
                             xmax=None,
                             cmax=15,
                             pmax=15,
                             thickness=0.02,
                             opacity=1.0,
                             preserve=True)
```

Draws a two sheets hyperboloid

Parameters

o: center of the hyperboloid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2, c2: squares of semi-axes of the hyperboloid. The equation is x'^2/a^2 + y'^2/b^2 - z'^2/c^2 = -1

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the hyperboloid

xmax: maximum value of the x coordinate

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the hyperboloid

opacity: opacity of the hyperboloid

preserve: Keep self.origin and self.base as the principal reference

```
def hiperboloide_dues_fulles_revolucio(self, a=3, b=2, pmax=8, direccio='Z', punt=None)
```

Draws an animation showing a two sheet hyperboloid of revolution a, b: semiaxis of the initial hyperbole

```
    pmax: maximum value of the independent variable

    direccio: 'X', the initial hyperbole is in the plane YX and rotates around the X axis
              'Y', the initial hyperbole is in the plane ZY and rotates around the Y axis
                  'Z', the initial hyperbole is in the plane XZ and rotates around the Z axis

    punt: if it's a value between 0 and pi, the animation shows a rotating point
```

```
def hiperboloide_una_fulla(self,
                           o=[0, 0, 0],
                           u1=[1, 0, 0],
                           u2=[0, 1, 0],
                           a2=1,
                           b2=1,
                           c2=1,
                           principal=True,
                           canonica=True,
                           color='AzureBlueDark',
                           name='OneSheetHyperboloid',
                           xmax=None,
                           cmax=15,
                           pmax=15,
                           thickness=0.02,
                           opacity=1.0,
                           preserve=True)
```

Draws an one sheet hyperboloid

Parameters

o: center of the hyperboloid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2, c2: squares of semi-axes of the hyperboloid. The equation is x'^2/a^2 + y'^2/b^2 - z'^2/c^2 = 1

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the hyperboloid

xmax: maximum value of the x coordinate

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the hyperboloid

opacity: opacity of the hyperboloid

preserve: Keep self.origin and self.base as the principal reference

```
def hiperboloide_una_fulla_revolucio(self, a=3, b=2, pmax=8, direccio='Z', punt=None)
```

Draws an animation showing an one sheet hyperboloid of revolution a, b: semiaxis of the initial hyperbole

```
pmax: maximum value of the independent variable

direccio: 'X', the initial hyperbole is in the plane XZ and rotates around the X axis
          'Y', the initial hyperbole is in the plane YX and rotates around the Y axis
              'Z', the initial hyperbole is in the plane ZX and rotates around the Z axis

punt: if it's a value between 0 and pi, the animation shows a rotating point
```

```
def hyperbolic_cylinder(self,
                        o=[0, 0, 0],
                        u1=[1, 0, 0],
                        u2=[0, 1, 0],
                        a2=1,
                        b2=1,
                        principal=True,
                        canonica=True,
                        color='AzureBlueDark',
                        name='Hyperbolic Cylinder',
                        xmax=None,
                        zmax=15,
                        cmax=15,
                        pmax=15,
                        thickness=0.02,
                        opacity=1.0,
                        preserve=True)
```

Draws an hyperbolic cylinder

Parameters

o: center of the hyperbolic cylinder

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2: squares of semi-axes of the hyperbolic cylinder. The equation is x'^2/a^2 - y'^2/b^2 = 1

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the hyperbolic cylinder

xmax: maximum value of the x coordinate

zmax: the hyperbolic cylinder is drawn between -zmax and zmax

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the hyperbolic cylinder

opacity: opacity of the hyperbolic cylinder

preserve: Keep self.origin and self.base as the principal reference

```
def hyperbolic_paraboloid(self,
                          o=[0, 0, 0],
                          u1=[1, 0, 0],
                          u2=[0, 1, 0],
                          a2=1,
                          b2=1,
                          principal=True,
                          canonica=True,
                          color='AzureBlueDark',
                          name='HyperbolicParaboloid',
```

```
xmax=None,
ymax=None,
cmax=15,
pmax=15,
thickness=0.02,
opacity=1.0,
preserve=True)
```

Draws an hyperbolic paraboloid

Parameters

o: vertex of the hyperbolic paraboloid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2: squares of semi-axes of the hyperbolic paraboloid. The equation is z = x'^2/a^2 - y'^2/b^2

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the elliptic paraboloid

xmax: maximum value of the coordinate x

ymax: maximum value of the coordinate y

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the hyperbolic paraboloid

opacity: opacity of the hyperbolic paraboloid

preserve: Keep self.origin and self.base as the principal reference

```
def join(self, llista)
```

Joins a list of objects

Parameters

llista: list of objects

```
def moviment_helicoidal_cilindre(self,
                                 centre=Vector((0.0, 0.0, 0.0)),
                                 radi=3,
                                 altura=12,
                                 opacity=1,
                                 origen=Vector((4.0, 3.0, 0.0)),
                                 eix='Z',
                                 rounds=1,
                                 translacio=0.0,
                                 aligned=False,
                                 reverse=False)
```

Draws an animation of the helical motion of an orthohedron around an affine line

Parameters

centre: center of the cylinder

radi: radius of the cylinder

altura: height of the cylinder

origen: point of the affine line

eix: axis of rotation

opacity: opacity of the orthohedron

translation: translation of the helical motion (distance by round) if translation = 0.0, it's a rotation motion

aligned: if True, aligns the orthohedron with the axis of rotation

```
def moviment_helicoidal_ortoedre(self,
                                 centre=Vector((0.0, 0.0, 0.0)),
                                 costats=Vector((3.0, 5.0, 2.0)),
                                 opacity=1,
                                 origen=Vector((4.0, 3.0, 0.0)),
                                 eix='Z',
                                 rounds=1,
                                 translacio=0.0,
                                 aligned=False)
```

Draws an animation of the helical motion of an orthohedron around an affine line

Parameters

centre: center of the orthohedron

costats: half sides of the orthohedron

origen: point of the affine line

eix: axis of rotation

opacity: opacity of the orthohedron

translation: translation of the helical motion (distance by round) if translation = 0.0, it's a rotation motion

aligned: if True, aligns the orthohedron with the axis of rotation

```
def moviment_helicoidal_punt(self,
                             punt=Vector((0.0, 0.0, 0.0)),
                             origen=Vector((-3.0, -3.0, -4.0)),
                             eix='Z',
                             rounds=5,
                             translacio=2,
                             vectors=True,
                             reverse=False)
```

Draws an animation of the helical motion of an orthohedron around an affine line

Parameters

punt: posició inicial del punt

origen: point of the affine line

eix: axis of rotation

rounds: rounds of the point aroud the axis

translation: translation of the helical motion (distance by frame) if translation = 0.0, it's a rotation motion

```
def one_sheet_hyperboloid(self,
                          o=[0, 0, 0],
                          u1=[1, 0, 0],
                          u2=[0, 1, 0],
                          a2=1,
                          b2=1,
                          c2=1,
```

```
                                  principal=True,
                                  canonica=True,
                                  color='AzureBlueDark',
                                  name='OneSheetHyperboloid',
                                  xmax=None,
                                  cmax=15,
                                  pmax=15,
                                  thickness=0.02,
                                  opacity=1.0,
                                  preserve=True)
```

Draws an one sheet hyperboloid

Parameters

o: center of the hyperboloid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2, c2: squares of semi-axes of the hyperboloid. The equation is x'^2/a^2 + y'^2/b^2 - z'^2/c^2 = 1

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the hyperboloid

xmax: maximum value of the x coordinate

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the hyperboloid

opacity: opacity of the hyperboloid

preserve: Keep self.origin and self.base as the principal reference

```
def ortoedre(self,
             centre=Vector((0.0, 0.0, 0.0)),
             costats=[6, 10, 8],
             scalelines=0.05,
             vectors=False,
             color='Blue',
             linecolor='Red',
             vectorcolor='Black',
             name='Ortoedre',
             opacity=1.0,
             thickness=0.0)
```

```
def parabola(self, vertex=Vector((0.0, 0.0, 0.0)), p=5, xmax=15, eixos='XY', canonica=True)
```

Draws the parabola of equation y - y0 = (x-x0)^2/(2*p) or x - x0 = (y-y0)^2/(2*p)

Parameters

vertex: vertex of the parabola

p: parameter of the parabola

pmax: maximum value of the independent variable

eixos: 'XY', draws y - y0 = (x-x0)^2/(2*p) 'YX', draws x - x0 = (y-y0)^2/(2*p)

canonica: if True, draws the x and y axis

```
def parabolic_cylinder(self,
```

```
def paraboloic_cylinder(self,
                        o=[0, 0, 0],
                        u1=[1, 0, 0],
                        u2=[0, 1, 0],
                        p=1,
                        principal=True,
                        canonica=True,
                        color='AzureBlueDark',
                        name='ParabolicCylinder',
                        xmax=12,
                        ymax=30,
                        cmax=20,
                        pmax=20,
                        thickness=0.02,
                        opacity=1.0,
                        preserve=True)
```

Draws an hyperbolic paraboloid

Parameters

o: vertex of the hyperbolic paraboloid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

p: Parameter of the cylinder z' = x'^2/(2*p)

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the elliptic paraboloid

xmax: maximum value of the coordinate x

ymax: maximum value of the coordinate y

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the hyperbolic paraboloid

opacity: opacity of the hyperbolic paraboloid

preserve: Keep self.origin and self.base as the principal reference

```
def paraboloide_elliptic(self,
                         o=[0, 0, 0],
                         u1=[1, 0, 0],
                         u2=[0, 1, 0],
                         a2=1,
                         b2=1,
                         principal=True,
                         canonica=True,
                         color='AzureBlueDark',
                         name='EllipticParaboloid',
                         xmax=None,
                         cmax=15,
                         pmax=15,
                         thickness=0.02,
                         opacity=1.0,
                         preserve=True)
```

Draws an elliptic paraboloid

Parameters

o: vertex of the elliptic paraboloid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2: squares of semi-axes of the elliptic paraboloid. The equation is z = x'^2/a^2 + y'^2/b^2

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the elliptic paraboloid

xmax: maximum value of the coordinate x

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the elliptic paraboloid

opacity: opacity of the elliptic paraboloid

preserve: Keep self.origin and self.base as the principal reference

`def` **`paraboloide_elliptic_revolucio`**`(self, a=0.5, pmax=5, direccio='Z', punt=None)`

Draws an animation showing an elliptic paraboloid of revolution a: The constant of the initial parabola

```
pmax: maximum value of the independent variable

direccio: 'X', the initial parabola is in the plane YX and rotates around the X axis
          'Y', the initial parabola is in the plane ZY and rotates around the Y axis
              'Z', the initial parabola is in the plane XZ and rotates around the Z axis

punt: if it's a value between -pmax and pmax, the animation shows a rotating point
```

`def` **`paraboloide_elliptic_simple`**`(self, a=3, b=4, direccio='Z', xmax=12)`

Draws the hyperbolic paraboloid of equation z = x^2/a^2 - y^2/b^2

Parameters

a, b: constants the defines he hyperbolic paraboloid

xmax, ymax: maximun values of the x and y coordinates

```
def paraboloide_hiperbolic(self,
                           o=[0, 0, 0],
                           u1=[1, 0, 0],
                           u2=[0, 1, 0],
                           a2=1,
                           b2=1,
                           principal=True,
                           canonica=True,
                           color='AzureBlueDark',
                           name='HyperbolicParaboloid',
                           xmax=None,
                           ymax=None,
                           cmax=15,
                           pmax=15,
                           thickness=0.02,
                           opacity=1.0,
                           preserve=True)
```

Draws an hyperbolic paraboloid

Parameters

o: vertex of the hyperbolic paraboloid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2: squares of semi-axes of the hyperbolic paraboloid. The equation is z = x'^2/a^2 - y'^2/b^2

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the elliptic paraboloid

xmax: maximum value of the coordinate x

ymax: maximum value of the coordinate y

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the hyperbolic paraboloid

opacity: opacity of the hyperbolic paraboloid

preserve: Keep self.origin and self.base as the principal reference

```
def paraboloide_hiperbolic_simple(self, a=3, b=4, xmax=12, ymax=12)
```

Draws the hyperbolic paraboloid of equation z = x^2/a^2 - y^2/b^2

Parameters

a, b: constants the defines he hyperbolic paraboloid

xmax, ymax: maximun values of the x and y coordinates

```
def pla_afi(self,
            punt=Vector((0.0, 0.0, 0.0)),
            normal=None,
            v1=Vector((3.0, 2.0, 1.0)),
            v2=Vector((1.0, -2.0, 0.5)),
            canonica=False,
            name='Pla afí',
            length=15,
            color='Cyan',
            sizex=25,
            sizey=20,
            opacity=0.9,
            elements=True)
```

Draws the affine plane generated by two vectors passing through a point

Parameters

punt: point of the plane

normal: normal vector of the plane

v1, v2: generators of the plane

canonica: if True, draws the x, y and z axis

name: name of the affine plane

length: length of the axis x, y and z

color: color of the plane

sizex, sizey: size of the plane

opacicity: opacity of the plane

```
def pla_vectorial(self,
                  v1=Vector((3.0, 2.0, 1.0)),
                  v2=Vector((1.0, -2.0, 0.5)),
                  canonica=False,
                  length=15,
                  color='Cyan',
                  sizex=25,
                  sizey=20,
                  opacity=0.8)
```

Draws the plane generated by two vectors

Parameters

v1, v2: generators of the plane

canonica: if True, draws the x, y and z axis

length: length of the axis x, y and z

color: color of the plane

sizex, sizey: size of the plane

opacicity: opacity of the plane

```
def posicio_relativa_tres_plans(self,
                                punts=None,
                                normals=None,
                                colors=None,
                                canonica=True,
                                length=25,
                                sizex=45,
                                sizey=40,
                                opacity=1.0,
                                elements=False)
```

Draws threee planes

Parametres

punts: three points, one for each plane

normals: three normal vectors, one for each plane

colors: three colors, one for each plane

canonica: if True, draws the x, y and z axis

length: length of the axis x, y and z

sizex, sizey: size of the planes

opacicity: opacity of the planes

elements: if True, draws the point and the normal vector for each plane

```
def product_components(self, u, v)
```

Computes the vectorial product u x v

Parameters

u, v: two Vectors

```
def projeccio_ortogonal_simetric_pla_afi(self,
```

```
                                                punt=Vector((6.0, -5.0, 8.0)),
                                                p0=Vector((3.0, -2.0, -3.0)),
                                                v1=Vector((3.0, -1.0, 1.0)),
                                                v2=Vector((1.0, 0.5, 0.5)),
                                                radi=0.15,
                                                sizex=35,
                                                sizey=30,
                                                canonica=True)
```

Draws the orthogonal projection and the symmetric of a point with respect an affine plane

Parameters

punt: the initial point

p0: point of the affine plane

v1, v2: generators of the plane

radi: radius of the points

sizex, sizey: sizes of the affine plane

canonica: if True, draws the x, y and z axis

```
def projeccio_ortogonal_simetric_pla_vectorial(self,
                                               vector=Vector((7.0, -1.0, 12.0)),
                                               v1=Vector((3.0, -1.0, 1.0)),
                                               v2=Vector((1.0, 0.5, 0.5)),
                                               canonica=True)
```

Draws the otoghonal projection and the symmetric of a vector with respecte a plane

Parameters

vector: the initial vector

v1, v2: generators of the plane

canonica: if True, draws the x, y and z axis

```
def projeccio_ortogonal_simetric_recta_afi(self,
                                           punt=Vector((6.0, -5.0, 8.0)),
                                           p0=Vector((3.0, -2.0, -3.0)),
                                           v1=Vector((3.0, -1.0, 1.0)),
                                           scale=0.1,
                                           radi=0.15,
                                           canonica=True)
```

Draws the orthogonal projection and the symmetric of a point with respect an affine line

Parameters

punt: the initial point

p0: point of the affine line

v1: generator of the line

radi: radius of the points

canonica: if True, draws the x, y and z axis

```
def projeccio_ortogonal_simetric_recta_vectorial(self,
                                                 vector=Vector((7.0, -1.0, 12.0)),
                                                 v1=Vector((3.0, -1.0, 1.0)),
```

```
                                                canonica=True)
```

Draws the otoghonal projection and the symmetric of a vector with respecte a line

Parameters

vector: the initial vector

v1: generator of the line

canonica: if True, draws the x, y and z axis

```
def punt_referencia_canonica(self,
                             punt=Vector((-4.0, 7.0, 6.0)),
                             radius=0.1,
                             length=12,
                             name='Punt p',
                             coordenades=True,
                             vector=True)
```

Draws a point expressed in the canonical reference

Parameters

punt: the point to draw

length: length of the axis

name: name of the point

coordenades: if True draws lines representing the coordinates

vector: if True, it draws the position vector

```
def punt_referencia_no_canonica(self,
                                punt=Vector((5.0, 6.0, -5.0)),
                                origin=Vector((-2.0, 3.0, 3.0)),
                                u1=Vector((-0.3333333432674408, -0.6666666865348816,
                                0.6666666865348816)),
                                u2=Vector((0.6666666865348816, 0.3333333432674408, 0.6666666865348816)),
                                u3=Vector((-0.6666666865348816, 0.6666666865348816,
                                0.3333333432674408)),
                                length=12,
                                scale=0.04,
                                radius=0.1,
                                name='Punt p',
                                vector=True)
```

Draws a point expressed in the reference {o,u1,u2,u3} with origin in the point origin and sets the default origin and default base to them

Parameters

punt: point to draw

origin: origin of the reference

u1, u2, u3: vectors of the base

length: length of the axis

scale: scale of the axis

name: name of the reference

vector: if True, it draws the position vector

```
def recta_afi(self,
```

```
def recta_afi(self,
              punt=Vector((3.0, 4.0, -2.0)),
              v=Vector((1.0, 2.0, 1.0)),
              color='Black',
              size=15,
              name='Recta afí',
              canonica=True,
              length=12,
              scale=0.03,
              elements=True)
```

Draws the affine line generated by a vector passing through a point

Parameters

punt: point of the plane

v: generators of the line

canonica: if True, draws the x, y and z axis

name: name of the affine plane

length: length of the axis x, y and z

color: color of the plane

size: lenght of the line

scale: scale of the line

```
def referencia_canonica(self,
                        origin=Vector((0.0, 0.0, 0.0)),
                        length=15,
                        scale=0.04,
                        zaxis=True,
                        name='Referència canònica')
```

Draws the canonical reference

Parameters

origin: point where to represent the base

length: length of the axis

scale: scale of the cylinder

zaxis: if False the z axis is not drawn

name: name of the object

```
def referencia_no_canonica(self,
                           origin=Vector((0.0, 0.0, 0.0)),
                           u1=Vector((1.0, -1.0, 0.0)),
                           u2=Vector((-0.5, 1.0, 0.5)),
                           u3=Vector((-1.0, 0.0, 1.0)),
                           length=12,
                           scale=0.04,
                           name="Referència R'")
```

Draws the reference {o;u1,u2,u3} with origin in the point origin and sets the default origin and default base to them

Parameters

origin: origin of the reference

u1, u2, u3: vectors of the base

length: length of the axis

scale: scale of the axis

name: name of the reference

```
def reset(self)
```

Resets origin, base, rotation, frames and colors

```
def reset_base(self)
```

Sets self.base to the canonical basis

```
def reset_colors(self)
```

Set self.colors to default colors

```
def reset_frames(self)
```

Set self.frame to 0

Parameters

name: name of a color

```
def reset_origin(self)
```

Sets the origin to the point (0,0,0)

```
def reset_rotation(self)
```

Sets the rotation to identity, i.e., rotation of 0 degrees around the vector (1,0,0)

```
def revolution_surface(self,
                       fun=None,
                       tmin=0.0,
                       tmax=1.0,
                       o=Vector((0.0, 0.0, 0.0)),
                       u1=Vector((1.0, 0.0, 0.0)),
                       u2=Vector((0.0, 1.0, 0.0)),
                       pmax=0,
                       steps=256,
                       thickness=0.025,
                       axis='Z',
                       name='Revolution surface',
                       color='AzureBlueDark')
```

Draws a revolution surface from a curve in the reference R'

Parameters

fun: parametric equacion of the curve

steps: number of steps

axis: axis of revolution. It must be 'X', 'Y' or 'Z'

o: origin of the reference R'

u1, u2: vectors to construct the basis {v1, v2, v3}

pmax: the principal axis are drawn between -pmax and pmax

color: color of the surface

```
def rotacio_ortoedre(self,
```

```
                    centre=Vector((0.0, 0.0, 0.0)),
                    costats=Vector((8.0, 5.0, 4.0)),
                    eix='Z',
                    opacity=1)
```

Draws an animation of an orthohedron rotating around a vectorial line

Parameters

centre: center of the orthohedron

costats: half sides of the orthohedron

eix: axis of rotation

opacity: opacity of the orthohedron

```
def rotacio_ortoedre_angles_euler(self,
                                  centre=Vector((0.0, 0.0, 0.0)),
                                  costats=Vector((8.0, 5.0, 4.0)),
                                  psi=90,
                                  theta=60,
                                  phi=45,
                                  radians=False,
                                  opacity=1,
                                  eixos='zxz')
```

Draws an animation of an orthohedron rotating given the Euler's angles

Parameters

centre: center of the orthohedron

costats: half sides of the orthohedron

psi, theta, phi: Euler's angles

radians: if True the Euler's angles must in radians. If False in degrees

opacity: opacity of the orthohedron

eixos: axis of the three rotations

```
def rotacio_ortoedre_voltant_vector(self,
                                    centre=Vector((0.0, 0.0, 0.0)),
                                    costats=Vector((8.0, 5.0, 4.0)),
                                    angle=80,
                                    radians=False,
                                    vector=Vector((1.0, -2.0, 1.0)),
                                    opacity=0.7,
                                    euler=None,
                                    reverse=False)
```

Draws an animation of a vector rotating around a vectorial line

Parameters

centre: center of the orthohedron

costats: half sides of the orthohedron

angle: angle of rotation

radians: if True the Euler's angles must in radians. If False in degrees

vector: generator of the vectorial line

opacity: opacity of the orthohedron

euler: None or the value of the three Euler's axis

reverse: if True, shows the rotation with Euler's angles in reverse order

```
def rotacio_punt(self,
                 punt=Vector((6.0, 8.0, 5.0)),
                 origen=Vector((4.0, 3.0, 0.0)),
                 eix=Vector((1.0, 1.0, 1.0)),
                 vectors=True)
```

Draws an animation of a point rotating around an afine line

Parameters

punt: point to rotate

origen: point of the affine line

eix: axis of rotation, given by a vector or by X, Y or Z

```
def rotacio_vector(self, vector=Vector((6.0, 8.0, 5.0)), eix=Vector((1.0, 1.0, 1.0)), adaptada=False)
```

Draws an animation of a vector rotating around a vectorial line

Parameters

vector: vector to rotate

eix: axis of rotation, given by a vector or by X, Y or Z

adaptada: if True, draws a base adapted to the rotation

```
def rotate_euler(self,
                 obj=None,
                 psi=0.0,
                 theta=0.0,
                 phi=0.0,
                 frames=3,
                 axis='ZXZ',
                 amax=15,
                 scaleaxis=0.075,
                 reverse=False,
                 local=False,
                 radians=False,
                 canonica=True,
                 positive=False)
```

Rotates an object by the Euler angles psi, theta and phi

Parameters

object: the object

psi, theta, phi: the Euler angles expressed in degrees

axis: it must be 'XYZ', 'XZY', 'YXZ', 'YZX', 'ZXY', 'ZYX', 'XYX', 'XZX', 'YXY', 'YZY', 'ZXZ' or 'ZYZ'

amax: axis valur for draw_base_axis

scaleaxis: scale value for draw_base_axis

local: if True the center of rotation is the location of the object

radians: if True, psi, theta and phi must be in radians

positive: if False and psi, theta or phi are greather than 180 degrees, they rae converted to negative angles

```
def rotate_object(self,
```

```
                   obj=None,
                   axis='Z',
                   frames=1,
                   origin=Vector((0.0, 0.0, 0.0)),
                   localaxis=None,
                   localangle=None,
                   translation=0.0,
                   rounds=1,
                   length=25,
                   draw=True)
```

Rotates an object around the axis

Parameters

obj: the object

axis: it must be 'X', 'Y', 'Z' or a Vector

frames: increment of the frame set

traslation: tranlation by round

local: if True the center of rotation is the location of the object

```
def rotate_object_by_axis_angle(self,
                                obj=None,
                                axis=Vector((1.0, 0.0, 0.0)),
                                angle=90,
                                amax=15,
                                frames=1,
                                scaleaxis=0.075,
                                local=False)
```

Rotates an object around an angle 'angle' around the axis

Parameters

obj: the object

axis: any non nul Vector

angle: the angle of rotation in degrees

frames: increment of the frame set

scaleaxis: scale value for draw_base_axis

local: if True the center of rotation is the location of the object

```
def rotate_objects(self,
                   objs=[],
                   axis='Z',
                   angle=None,
                   frames=1,
                   origin=Vector((0.0, 0.0, 0.0)),
                   translation=0,
                   rounds=1,
                   length=25,
                   draw=False)
```

Rotates an object around the axis

Parameters

objs: the list of objects

axis: it must be 'X', 'Y', 'Z' or a Vector

```
def rotate_point(self, punt=None, origen=Vector((0.0, 0.0, 0.0)), axis='Z', length=25, vectors=True)
```

Rotates a point around an affine line

Parameters

point: the point

origen: a point of the affine line

axis: it must be 'X', 'Y', 'Z' or a vector

length: length of the

```
def rotate_vector(self, vector=None, axis='Z', length=25)
```

Rotates a vector around the axis

Parameters

vector: the vector

axis: it must be 'X', 'Y', 'Z' or a vector

```
def segment_esferic(self,
                    r=10,
                    p1=1.5707963267948966,
                    s1=0,
                    p2=1.5707963267948966,
                    s2=1.5707963267948966,
                    name='Segment')
```

Draws an spheric segment in a sphere centered at origin with radius r from the point whith spherical coordinates (radi,p1,s1) to the point (radi,p2,s2).

Parameters

r: radius of the sphere p1: polar angle of the first point s1: azimuthal angle of the first point p2: polar angle of the second point s2: azimuthal angle of the second point

```
def set_base(self, base=[[1, 0, 0], [0, 1, 0], [0, 0, 1]], orthonormal=False)
```

Sets the self.base, i.e., the basis of the reference coordinates used to display objects

Parameters

base: list of three vectors

orthonormal: if True, the Gram-Schmidt method is applied and the vectors are normalized.

```
def set_colors(self, names=None)
```

Set self.colors to the list of colors with names 'names'

Parameters

names: list of name colors

```
def set_cursor(self, origin=[0, 0, 0], direction=[1, 0, 0], axis='x')
```

Sets the cursor position and direction

Parameters

origin: position of the cursor

direction: vector that indicates the direction of the axis 'axis'

axis: 'x', 'y' or 'z'

```
def set_cursor_rotation(self,
                        origin=[0, 0, 0],
                        rotation=Matrix(((1.0, 0.0, 0.0), (0.0, 1.0, 0.0), (0.0, 0.0, 1.0))))
```

Sets the rotation of the cursor

Parameters

origin: position of the cursor

rotation: matrix of a rotation

```
def set_default_color(self, name)
```

Set self.defaultcolor to the color with name 'name'

Parameters

name: name of a color

```
def set_origin(self, vector=[0, 0, 0])
```

Sets the origin of the reference coordinates used to display objects.

Parameters

vector: origin's position

```
def set_rotation(self, angle=None, vector=None, quaternion=None)
```

Sets self.rotation to the rotation defined by an angle and an axis or by a quaternion.

Parameters

angle: angle of rotation in degrees

vector: axis of rotation

quaternion: quaternion that defines a rotation

The angle and vector takes precedence over the quaternion

```
def simple_curve(self,
                 f=None,
                 tmin=0.0,
                 tmax=1.0,
                 steps=25,
                 name='Simple curve',
                 symmetry=None,
                 draw=False)
```

Return a curve defined by the parametrization f

Parameters

f: Parametrization of the curve

tmin: minimum value of the parameter

tmax: maximum value of the parameter

steps: number of steps

name: name of the curve

symmetry: None or a value in the list ('XY','XZ','YZ','X','Y','Z','O'). Symmetry of the curve

draw: if True, the curve is drawn

```
def sphere(self,
           o=[0, 0, 0],
           r2=1,
           principal=True,
           canonica=True,
           color='AzureBlueDark',
           name='Sphere',
           cmax=15,
           pmax=15,
           thickness=0.02,
           opacity=1.0,
           preserve=True)
```

Draws a sphere of center 'o' and radius squared equal to 'r2'

Parameters

o: center of the sphere

r2: radius of the sphere squared

principal: if True, the principal axis are drawn

canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the sphere

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the sphere

opacity: opacity of the sphere

preserve: Keep self.origin and self.base as the principal reference

```
def superficie_revolucio_parabola(self, a=0.2, vertex=Vector((0.0, 0.0, 0.0)), pmax=8, pla='XZ',
                                  punt=None)
```

Draws an animation of a revolution surface from a paràbola

Parameters

a: the paràbola is of the form y = a*x^2

vertex: vertex of the parabola

pmax: maximum value of the independent variable

pla: a value from the list ('XY','YX','XZ','ZX','YZ','ZY') representing the variables for the equation 'XY' y = a*x^2 and rotaqtion around the X axis 'YX' x = a*y^2 and rotaqtion around the Y axis 'XZ' z = a*x^2 and rotaqtion around the X axis 'ZX' x = a*z^2 and rotaqtion around the Z axis 'YZ' z = a*y^2 and rotaqtion around the Y axis 'ZY' y = a*z^2 and rotaqtion around the Z axis

punt: punt: if it's a float value, draws a moving poing

```
def tor(self, centre=Vector((8.0, 0.0, 3.0)), radi=3, cmax=15, punt=None)
```

Draws a torus of revolution from a circumference

Parameters

centre: center of the circumference

radi: radius of the circumference

cmax: maximum values of the x, y and z coordinates

punt: if it's a float value, draws a moving poing

```
def triangle_esferic(self,
                     r=10,
                     p1=1.5707963267948966,
                     s1=0,
                     p2=1.5707963267948966,
                     s2=1.5707963267948966,
                     p3=0,
                     s3=0)
```

Draws an spheric triangle in a sphere centered at origin with radius r with vetices whith spherical coordinates (radi,p1,s1), (radi,p2,s2) and (radi,p2,s2).

Parameters

r: radius of the sphere p1: polar angle of the first point s1: azimuthal angle of the first point p2: polar angle of the second point s2: azimuthal angle of the second point p3: polar angle of the third point s3: azimuthal angle of the third point

```
def triangle_esferic_aleatori(self, r=10)
```

Draws a random spheric triangle in a sphere centered at origin with radius r

Parameters

r: radius of the sphere

```
def two_sheets_hyperboloid(self,
                           o=[0, 0, 0],
                           u1=[1, 0, 0],
                           u2=[0, 1, 0],
                           a2=1,
                           b2=1,
                           c2=1,
                           principal=True,
                           canonica=True,
                           color='AzureBlueDark',
                           name='TwoSheetParaboloid',
                           xmax=None,
                           cmax=15,
                           pmax=15,
                           thickness=0.02,
                           opacity=1.0,
                           preserve=True)
```

Draws a two sheets hyperboloid

Parameters

o: center of the hyperboloid

u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors

a2, b2, c2: squares of semi-axes of the hyperboloid. The equation is x'^2/a^2 + y'^2/b^2 - z'^2/c^2 = -1

principal: if True, the principal axis are drawn canonica: if True, the canonical axis are drawn

color: color of the surface

name: name of the hyperboloid

xmax: maximum value of the x coordinate

cmax: the canonical axis are drawn between -cmax and cmax

pmax: the principal axis are drawn between -cmax and cmax

thickness: thickness of the hyperboloid

opacity: opacity of the hyperboloid

preserve: Keep self.origin and self.base as the principal reference

```
def vector_base_canonica(self, vector=Vector((-4.0, 7.0, 6.0)), length=12, name='Vector',
                         components=True)
```

Draws a vector expressed in the canonical base

Parameters

vector: the vector to draw

length: length of the axis

name: name of the vector

components: if True draws lines representing the components

```
def vector_base_no_canonica(self,
                            vector=Vector((5.0, 6.0, -5.0)),
                            origin=Vector((0.0, 0.0, 0.0)),
                            u1=Vector((-0.3333333432674408, -0.6666666865348816, 0.6666666865348816)),
                            u2=Vector((0.6666666865348816, 0.3333333432674408, 0.6666666865348816)),
                            u3=Vector((-0.6666666865348816, 0.6666666865348816, 0.3333333432674408)),
                            length=12,
                            scale=0.04,
                            name="Base B'")
```

Draws a vector expressed in the base {u1,u2,u3} with origin in the point origin and sets the default origin and default base to them

Parameters

vector: vector to draw

origin: origin of the vector and the base

u1, u2, u3: vectors of the base

length: length of the axis

scale: scale of the base

name: name of the base

```
def vectors_to_quaternion(self, u1=Vector((1.0, 0.0, 0.0)), u2=Vector((0.0, 1.0, 0.0)))
```

Returns the quaternion correspondint to the base {v1,v2,v3} u1, u2: the principal basis {v1, v2, v3} is constructed from this vectors in the following way v1 = u1 v2 = u2 - u2.project(v1) v1.normalize() v2.normalize() v3 = v1.cross(v2)

```
class Rotation (angle=None, vector=None, axis=None, quaternion=None, radians=False)
```

Class used for work with rotations. The stored value in the class is a quaternion

Initializes the value for a rotation

Parameters

angle: angle of rotation

vector: axis of rotation

quaternion: The quaternion itself

radians: must be True if the angle is entered in radians and False if the is entered in degrees.

Static methods

```
def from_euler_angles(psi, theta, phi, axis='ZXZ', radians=False)
```

Initializes a rotation from its Euler angles in the order ZXZ

Parameters

phi, theta, psi: Euler angles

axis: it must be 'XYZ', 'XZY', 'YXZ', 'YZX', 'ZXY', 'ZYX', 'XYX', 'XZX', 'YXY', 'YZY', 'ZXZ' or 'ZYZ'

radians: if radians, psi, theta and must be in radians

Methods

```
def apply(self, v)
```

Applies the rotation to an object v Parameters: v: any object that can be transformed by a rotation

```
def to_axis_angle(self, radians=False)
```

Returns the axis and angle of the rotation

Parameters

radians: if True, the angle returned is in radians, if not, is returned in degrees

```
def to_euler_angles(self, axis='ZXZ', randomize=False, radians=False)
```

Returns the Euler angles according to axis 'axis'

Parameters

axis: it must be 'XYZ', 'XZY', 'YXZ', 'YZX', 'ZXY', 'ZYX', 'XYX', 'XZX', 'YXY', 'YZY', 'ZXZ' or 'ZYZ'

radians: if True, the angle returned is in radians, if not, is returned in degrees

Functions

- `add_object_align_init`
- `createFaces`
- `create_mesh_object`
- `draw_parametric_surface`
- `object_data_add`

Classes

- **Color**

- **Colors**
  - color
  - colors
  - colorsbyname

- **EuclideanReference**
  - base
  - coordinates

- **LinearAlgebra**
  - add_ligth
  - add_ligths
  - add_material
  - animate_revolution_surface
  - base_adaptada
  - base_canonica
  - base_canonica_white
  - base_cilinder
  - base_cone
  - base_disk
  - base_is_canonica
  - base_no_canonica
  - canvi_base
  - canvi_coordenades
  - cilindre
  - cilindre_elliptic
  - cilindre_elliptic_simple
  - cilindre_hiperbolic
  - cilindre_hiperbolic_simple
  - cilindre_parabolic
  - cilindre_parabolic_simple
  - clear
  - components_in_base
  - con
  - con_cilindre_elliptic
  - con_revolucio
  - con_simple
  - cone
  - coordinates_en_canonica
  - coordinates_en_referencia
  - curve
  - delete_base_cilinder
  - delete_base_cone
  - delete_base_disk
  - distancia_rectes_encreuen
  - draw_base_axis
  - draw_circle
  - draw_components
  - draw_cone
  - draw_cube
  - draw_curve
  - draw_disk
  - draw_ellipse
  - draw_ellipsoid
  - draw_elliptic_cylinder
  - draw_elliptic_paraboloid
  - draw_frenet_curve

- draw_function
- draw_hyperbole
- draw_hyperbolic_cylinder
- draw_hyperbolic_paraboloid
- draw_line
- draw_mesh
- draw_one_sheet_hyperboloid
- draw_parabola
- draw_parabolic_cylinder
- draw_parallelepiped
- draw_parallelogram
- draw_plane
- draw_plane_surface
- draw_point
- draw_points
- draw_polygon
- draw_pyramid
- draw_regular_polygon
- draw_simple_curve
- draw_surface
- draw_tetrahedron
- draw_triangle
- draw_two_sheets_hyperboloid
- draw_vector
- draw_vector_field
- draw_vectors
- ellipse
- ellipsoid
- ellipsoide
- ellipsoide_revolucio
- elliptic_cylinder
- elliptic_paraboloid
- esfera
- esfera_cilindre_elliptic
- gir_poligon
- hiperbola
- hiperboloide_dues_fulles
- hiperboloide_dues_fulles_revolucio
- hiperboloide_una_fulla
- hiperboloide_una_fulla_revolucio
- hyperbolic_cylinder
- hyperbolic_paraboloid
- join
- moviment_helicoidal_cilindre
- moviment_helicoidal_ortoedre
- moviment_helicoidal_punt
- one_sheet_hyperboloid
- ortoedre
- parabola
- parabolic_cylinder
- paraboloide_elliptic
- paraboloide_elliptic_revolucio
- paraboloide_elliptic_simple
- paraboloide_hiperbolic
- paraboloide_hiperbolic_simple
- pla_afi
- pla_vectorial
- posicio_relativa_tres_plans
- product_components