Module **`LinearAlgebra`**

Functions

`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)`

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`

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 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_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_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_is_canonica(self)

Returns True if sel.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_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=15, pmax=15, thickness=0.02, opacity=1.0, change=False)

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

`def cilindre_elliptic_simple(self, a=10, b=6, direccio='Z', pmax=26)`

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='HyperbolicCylinder', xmax=None, zmax=20, cmax=15, pmax=15, thickness=0.02, opacity=1.0)`

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

`def cilindre_hiperbolic_simple(self, a=4, b=3, direccio='Z', pmax=12, hmax=26)`

Draws an hyperbolic cylinder with direction X, Y or Z

Parameters

a, b: semiaxis of the hyperbole

direction: 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], a=1, principal=True, canonica=True,
                       color='AzureBlueDark', name='ParabolicCylinder', xmax=None, ymax=30, cmax=20,
                       pmax=20, thickness=0.02, opacity=1.0)
```

Draws an hyperbolic paraboloid

Parameters

o: vertex of the hyperbolic paraboloid

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

a: coefficient of the intial parabola

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

```
def cilindre_parabolic_simple(self, a=3, direccio='Z', pmax=10, hmax=26)
```

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

direction: direction of translation of the hyperbole

pmax = maximum value of the independent variable

hmax = height of the cylindrer

```
def clear(self)
```

Clears and removes all the elements

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

Computes the vectorial product u x v

Parameters

u, v: two Vectors

```
def components_in_base(self, vector=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

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)

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

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 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)

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

`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.orifin, 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 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=25, thickness=0.01, name='Circle',
                color='White', 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_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')
```

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

```
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: coefficients 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=0.01, 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=0.15, 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)
```

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

```
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)
```

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

```
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=15,
                      pmax=15, thickness=0.02, opacity=1.0, change=False)
```

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

```
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)
```

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

```
def esfera(self, centre=Vector((0.0, 0.0, 0.0)), radi=10, cmax=20)
```

Draws a sphere

Parametre

centre: center of the sphere

radi: radius of the sphere

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

```
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)

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

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)

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

`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='HyperbolicCylinder', xmax=None, zmax=20, cmax=15, pmax=15, thickness=0.02, opacity=1.0)`

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

`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)`

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

```
def join(self, list)
```

Joins a list of objects

Parameters

list: list of objects

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

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 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)
```

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

```
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, o=[0, 0, 0], u1=[1, 0, 0], u2=[0, 1, 0], a=1, principal=True, canonica=True,
                       color='AzureBlueDark', name='ParabolicCylinder', xmax=None, ymax=30, cmax=20,
                       pmax=20, thickness=0.02, opacity=1.0)
```

Draws an hyperbolic paraboloid

Parameters

o: vertex of the hyperbolic paraboloid

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

a: coefficient of the intial parabola

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

```
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)
```

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

`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_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)`

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

`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)), 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=0.8, elements=True)`

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

Parameters

punt: point 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

opacity: 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

opacity: opacity of the plane

```
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)
```

Draws a point expressed in the canonical reference

Parameters

punt: the point to draw

length: length of the axis

name: name of the point

components: if True draws lines representing the coordinates

```
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')
```

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

```
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_vector(self, vector=Vector((6.0, 8.0, 5.0)), eix=Vector((1.0, 1.0, 1.0)))

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

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, helicoidal=0.0, rounds=1, draw=True)
```

Rotates an object around the axis

Parameters

obj: the object

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

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 Vectors

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_vector(self, vector=None, axis='Z')
```

Rotates a vector around the axis

Parameters

vector: the vector

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

```
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)
```

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)
```

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

Parameters

o: center of the spherecmax=15

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

```
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*x^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, 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 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)
```

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

```
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

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