Making Fractal Pendant in ShapeJS

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Shapeways

G4G12
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BASIC code for Mandelbrot set fractal

2000 REM Initialize the color palette
2030 LET L = 100
2040 FOR I = 0 TO 100
2050 FOR J = 0 TO 100
2060 LET U = I / 50 - 1.5
2070 LET V = J / 50 - 1
2080 LET X = U
2090 LET Y = V
2100 LET N = 0
2120 LET R = X * X
2130 LET Q = Y * Y
2140 IF R + Q > 4 OR N >= L THEN GOTO 2190
2150 LET Y = 2 * X * Y + V
2160 LET X = R - Q + U
2170 LET N = N + 1
2180 GOTO 2120
2200 IF N < 10 THEN LET C = "black" ELSE LET C = P[ROUND(8 * (N-10) / (L-10))] 
2210 PLOT I, J, C
2220 NEXT J
2230 NEXT I
2240 END
Modern Times

ShapeJS web based IDE

```javascript
var x1 = Math.PI * 2 / 12;
var y2 = Math.PI / 2;

var splines = new Array();
var count = 0;
splines[count++] = new ReflectionSymmetry.getPlane(new Vector3d(0, -1, 0), 0.0);
splines[count++] = new ReflectionSymmetry.getPlane(new Vector3d(-1, 0, 0), 0.0);
splines[count++] = new ReflectionSymmetry.getPlane(new Vector3d(0, 1, 0), 0.0);
splines[count++] = new ReflectionSymmetry.getPlane(new Vector3d(0, 0, 1), 0.0);
splines[count++] = new ReflectionSymmetry.getPlane(new Vector3d(0, 0, -1), 0.0);
return splines;

function makePart(size, thickness)
{
  var union = new Union();
  var box = new Box([0, 0, 0], thickness, thickness, size);
  union.add(box);
  return union;
}

function main(args)
{
  var r = 25 * Math.PI;
  var voxelSize = 0.1 * Math.PI;
  var cz = Math.PI / 20;
  var cx = 0.04 * Math.PI;
  var cy = 0.04 * Math.PI;
  var part = makePart(20 * Math.PI, 5 * Math.PI);
  part.setRotation(new Rotation(new Vector3d(-1, 1, 0), 3 * Math.PI));
  return part;
}
```

Eval time: 6 Op count: 7 Op size: 80 Data size: 1
```javascript
function main(args) {
    w = 12*MM;
    Rout = 5*MM;
    Rin = 2*MM;
    bounds = new Bounds(-w,w,-w,w,-w,w);
    shape = new Torus(Rin, Rout);
    scene = new Scene(shape, bounds);
    return scene;
}
```

Simple shape

a torus
function main(args) {
    w = 12*MM;
    Rout = 8*MM;
    Rin = 2*MM;
    bounds = new Bounds(-w,w,-w,w,-w,w);
    shape = new Torus(Rin, Rout);
    scene = new Scene(shape, bounds);
    return scene;
}
function main(args) {
    w = 12*MM;
    Rout = 5*MM;
    Rin = 5*MM;
    bounds = new Bounds(-w, w, -w, w);
    shape = new Torus(Rin, Rout);
    scene = new Scene(shape, bounds);
    return scene;
}
function main(args) {
  w = 12*MM;
  Rout = 8*MM;
  Rin = 2*MM;
  axis = new Vector3d(-1,0,1);
  bounds = new Bounds(-w,w,-w,w,-w,w);
  shape = new Torus(Rin, Rout, axis);
  scene = new Scene(shape, bounds);
  return scene;
}
Simple shape
twisted torus

```javascript
function main(args) {
    w = 12*MM;
    Rout = 8*MM;
    Rin = 2*MM;
    axis = new Vector3d(-1,-1,1);
    bounds = new Bounds(-w,w,-w,w,-w,w);
    shape = new Torus(Rin, Rout, axis);
    scene = new Scene(shape, bounds);
    return scene;
}
```
Not much fun
Torus + Mirror
Torus + Mirror

Torus and its siamese twin
Moving original torus.
It's twin moves in opposite direction.
Torus + Mirror

Tilting original torus.

It’s twin tilts in opposite direction
Torus + 2 Mirrors

Going wild - 2 mirrors
Torus + 2 Mirrors

family of quadruplets
Torus + 2 Mirrors

Motion of original torus moves all siblings
Torus + 2 Mirrors

Changing mirror angle makes larger family
Torus + 2 Mirrors

Changing mirror angle makes larger family
Torus + 2 Mirrors

Changing mirror angle makes larger family
Moving one family member changes the look of the whole family.

Torus + 2 Mirrors
Torus + 2 Mirrors

Moving one family member changes the look of the whole family
Torus + 3 Mirrors

Going insane!

Using 3 mirrors
Torus + 3 Mirrors

Got infinite family.

But the family is rather orderly and boring.
Torus + 3 Mirrors

Got infinite family.

But the family is rather orderly and boring

Very predictable
Torus + 3 Mirrors

Twisting one sibling makes all family do the same
Another family made with 3 different mirrors
Torus + 3 Mirrors

Another family made with 3 different mirrors

There are only 3 such families

- \( \left( \frac{\pi}{3'}, \frac{\pi}{3'}, \frac{\pi}{3'} \right) \)
- \( \left( \frac{\pi}{2'}, \frac{\pi}{3'}, \frac{\pi}{6} \right) \)
- \( \left( \frac{\pi}{2'}, \frac{\pi}{4'}, \frac{\pi}{4} \right) \)
Torus + 4 Mirrors

Can we do better with 4 mirrors?
Torus + 4 Mirrors

4 mirrors

boring
Torus + 4 Mirrors

4 mirrors

boring

BORING
Torus + 4 Mirrors
Torus + 4 Mirrors

4 mirrors
boring
BORING
BORING
BORING
Spherical Mirrors

Magical spherical mirrors!
Spherical Mirrors

Magical spherical mirrors!
Spherical Mirrors

Magical spherical mirrors!
Spherical Mirrors

Reflection in 2 flat mirrors produce familiar result
Addition of 3rd spherical mirror gives something new
Addition of 3rd spherical mirror gives something new
Spherical Mirrors

All 4 mirrors make shape with fractal boundary
Spherical Mirrors

Deformation of mirrors arrangement makes non trivial change of shape
Deformation of mirrors arrangement makes non trivial change of shape
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Deformation of mirrors arrangement makes non trivial change of shape
The shape is three dimensional
The shape is three dimensional
The shape is three dimensional
The shape is three dimensional
Samples
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Final choice for pendant
Geometry of pendant

Fractal boundary is too thin to print
It needs to be "thickened"
Thickening of boundary

Fractal boundary is too thin to print
It needs to be "thickened"
Fractal boundary is too thin to print
It needs to be "thickened"
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Fractal boundary is too thin to print
It needs to be "thickened"
Conversion into Mesh

3D print needs 3D mesh file
Bundling 10 pendants in group reduces manufacturing cost
ShapeJS summary

- simple to code (javascript)
- volumetric modeling via signed distance function
- real time server side 3D rendering
- compatible with any device which can run web browser
- 3D print compatible models
- easy model sharing
- intellectual property protection

We are actively extending the system by adding new capabilities.

Suggestions are very welcome!