ICT in SES

Points and lines

Lesson №9

Common properties

Coordinates

Coordinates in Suica

- Fixed Cartesian coordinate system
- Coordinates are represented as arrays
- Fixed ordering of coordinates in the array: [x, y, z]

Used for

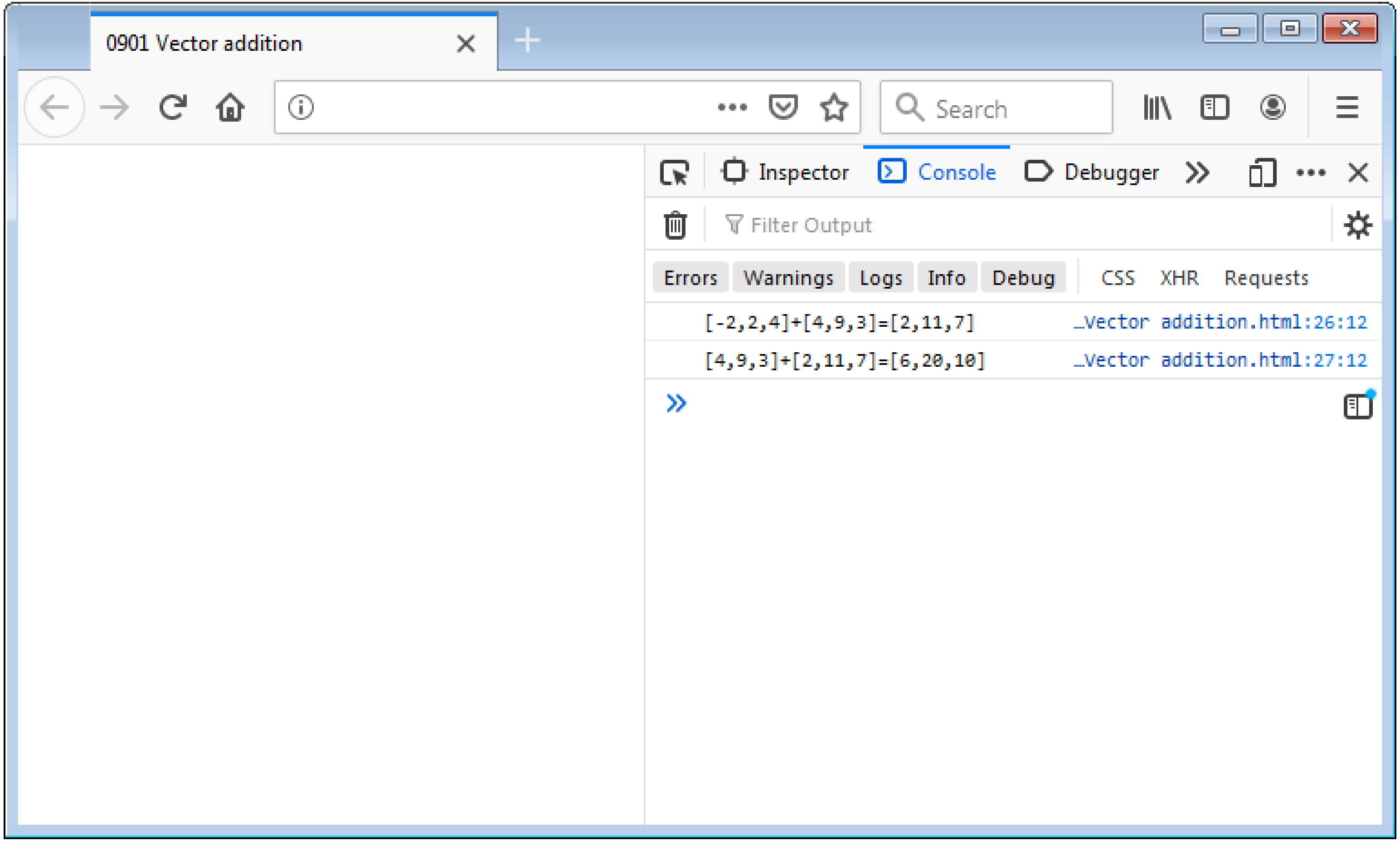
- Coordinates of points
- Coordinates of objects
- Vectors

Examples

Vector addition

- Component-wise processing

```
function vAdd(a,b)
{
   var x = a[0]+b[0];
   var y = a[1]+b[1];
   var z = a[2]+b[2];
   return [x,y,z];
}
```



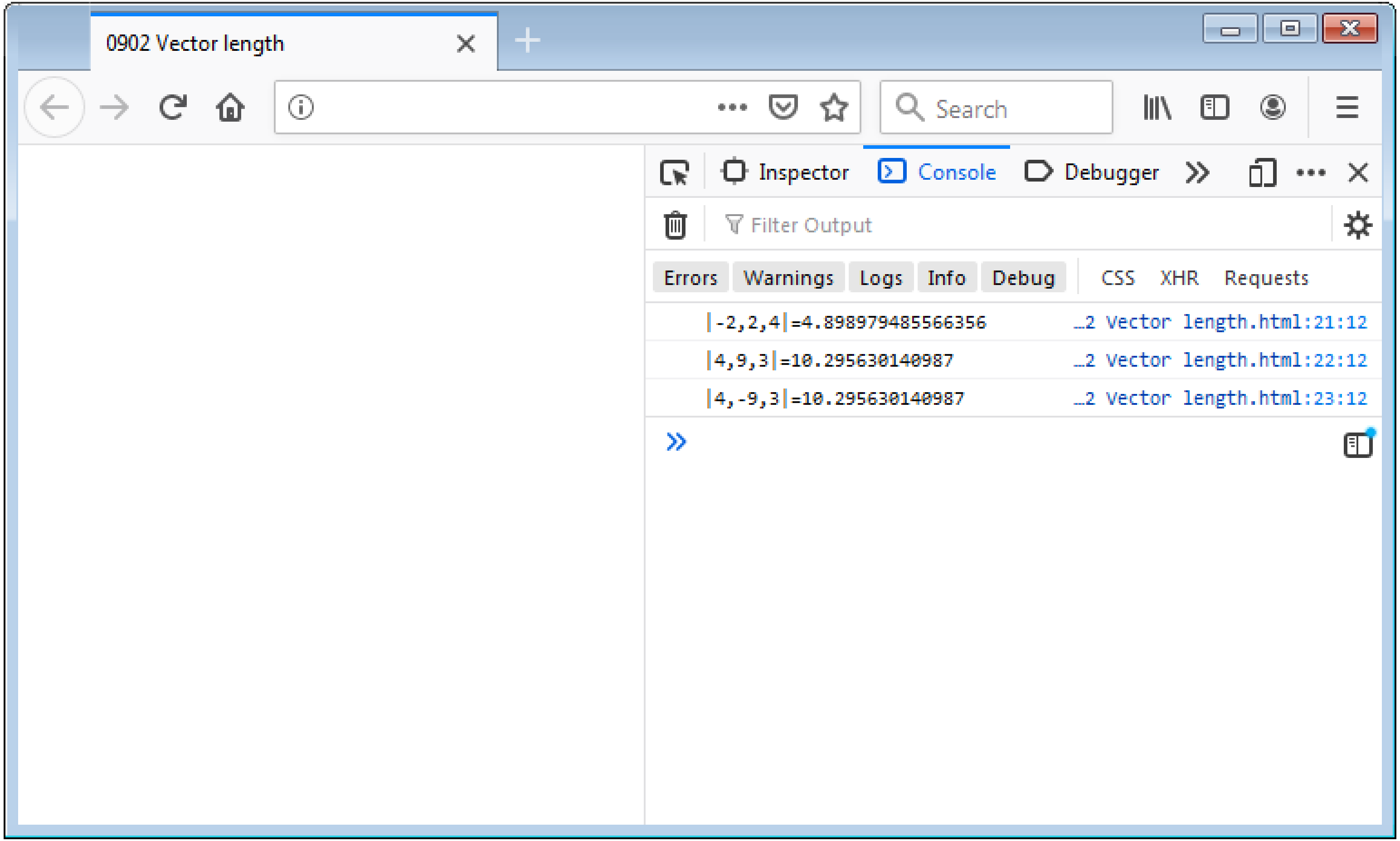
```
[-2,2,4]+[4,9,3]=[2,11,7]          …Vector addition.html:26:12
[4,9,3]+[2,11,7]=[6,20,10]         …Vector addition.html:27:12
```

TRY IT

Vector length

- Coordinates are axial vector lengths

```
function vLen(a)
{
   return Math.sqrt(a[0]*a[0]+a[1]*a[1]+a[2]*a[2]);
}
```



```
|-2,2,4|=4.898979485566356        …2 Vector length.html:21:12
|4,9,3|=10.295630140987           …2 Vector length.html:22:12
|4,-9,3|=10.295630140987          …2 Vector length.html:23:12
```

TRY IT

Functions for vectors in Suica

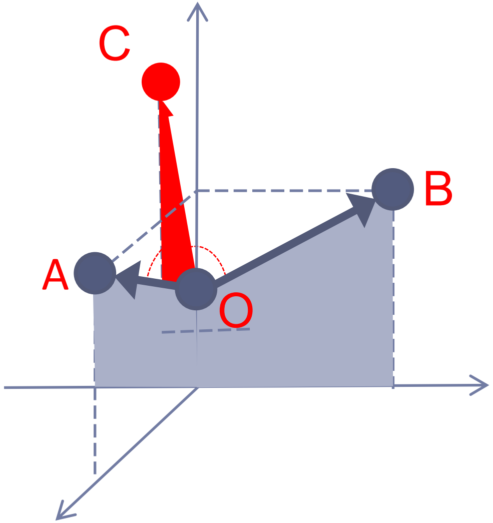
- Vector subtraction (vector between points) vectorPoints
- Unit vector unitVector
- Scalar multiplication scalarProduct
- Vector multiplication vectorProduct

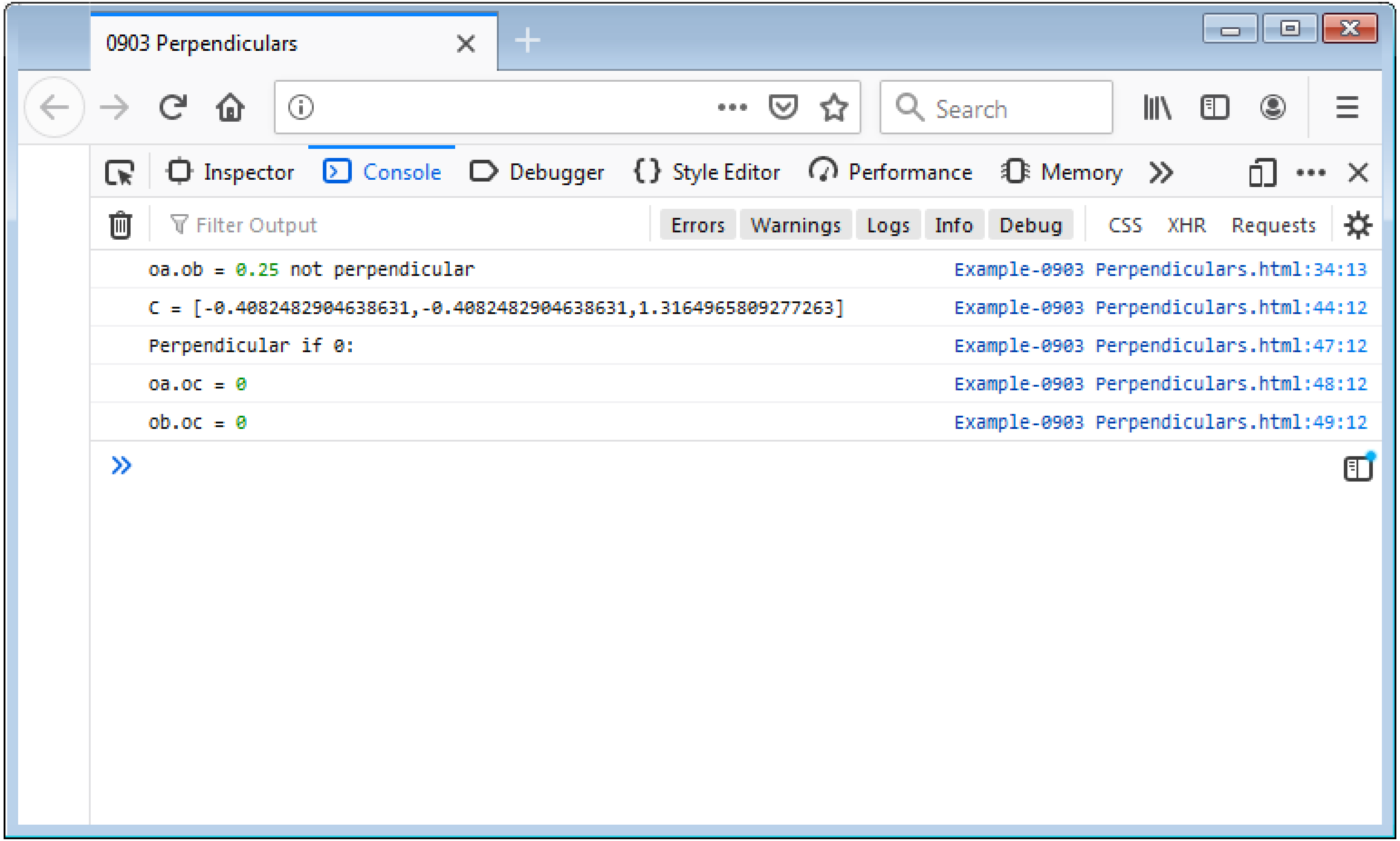
Problem

- Points A(1,0,1), B(0,1,1) and O(0,0,1/2)
- Are vector $\overrightarrow{OA}$ and $\overrightarrow{OB}$ perpendicular (orthogonal)
- Find point C such as $\overrightarrow{OC}$ is perpendicular to both $\overrightarrow{OA}$ and $\overrightarrow{OB}$, and is also with unit length

Solution

- $\overrightarrow{OA}$ and $\overrightarrow{OB}$ are perpendicular is their scalar product is 0
- Their vector product give a vector that is perpendicular to both of them





```
oa.ob = 0.25 not perpendicular                                   Example-0903 Perpendiculars.html:34:13
C = [-0.4082482904638631,-0.4082482904638631,1.3164965809277263] Example-0903 Perpendiculars.html:44:12
Perpendicular if 0:                                              Example-0903 Perpendiculars.html:47:12
oa.oc = 0                                                        Example-0903 Perpendiculars.html:48:12
ob.oc = 0                                                        Example-0903 Perpendiculars.html:49:12
»
```

TRY IT

Point

Point in Suica

Point

- Graphical object with properties
- Used to draw a point

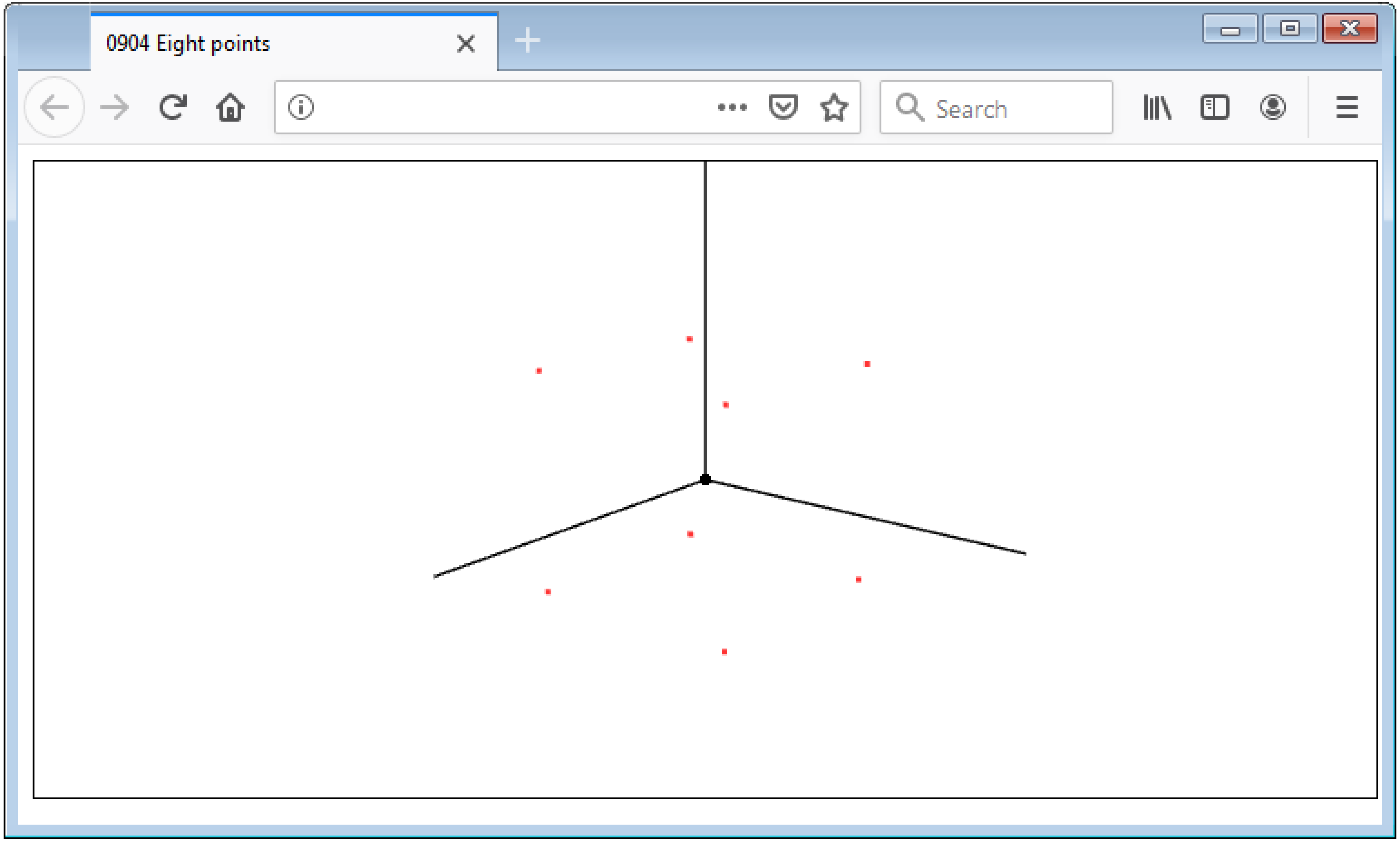
Creating a point

- With class new Suica.Point (*coordinates*)
- With function point (*координати*)
- Coordinates are vector, i.e. an array of 3 numbers

Example

- Create 8 point in the vertices of a cube
- If the cube size is 20, the coordinates are ±10
- 8 combinations of coordinates generate 8 vertices

```
point([+10,+10,+10]);
point([+10,+10,-10]);
point([+10,-10,+10]);
point([+10,-10,-10]);
point([-10,+10,+10]);
point([-10,+10,-10]);
point([-10,-10,+10]);
point([-10,-10,-10]);
```



TRY IT

Properties

Center

- Defined when a point is constructed
- Stored in property center

Size

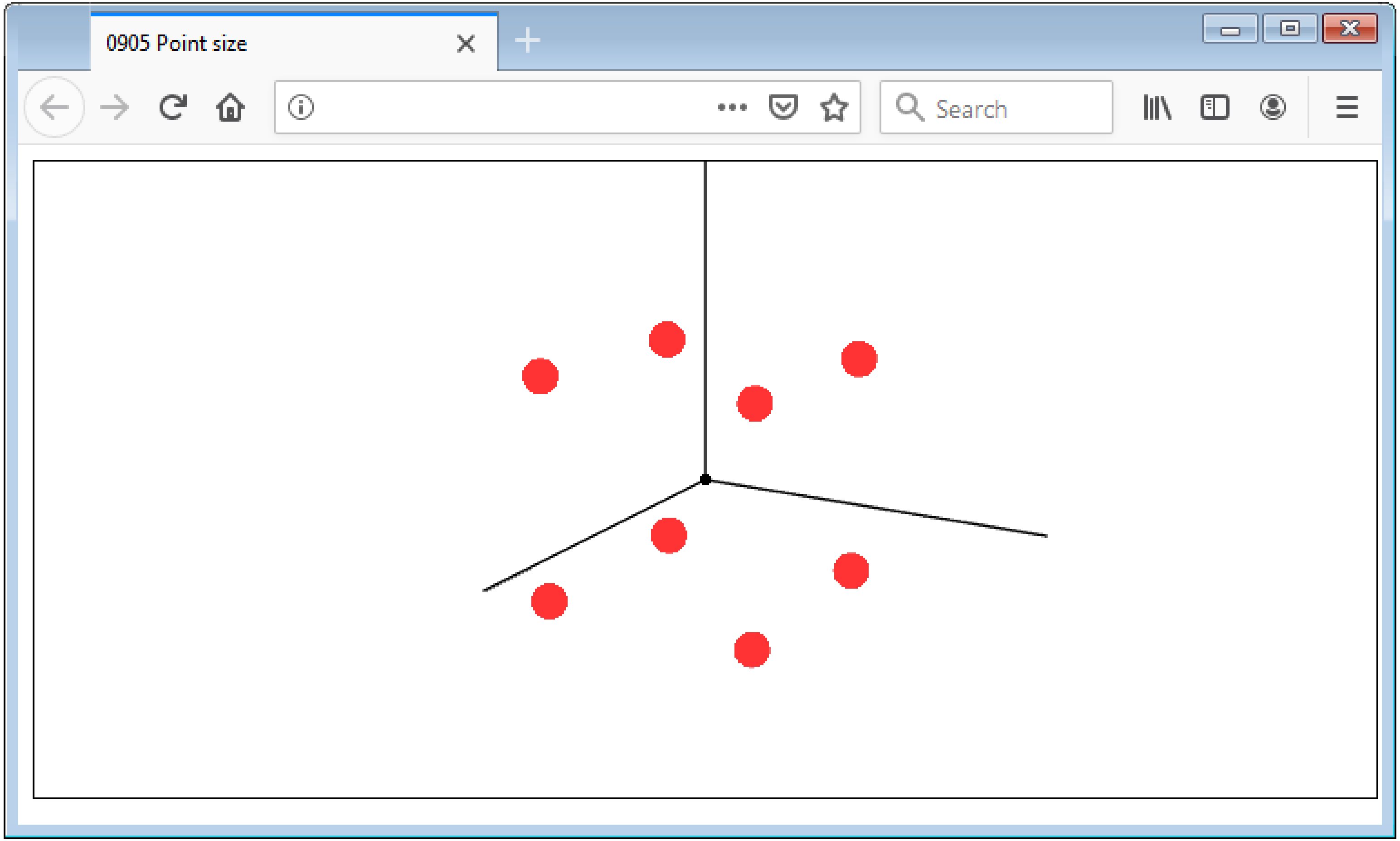
- Defines the visible size of a point
- Does not depend on distance
- By default the size is 3
- Stored in property pointSize

Example

- The points in cube vertices are big
- Created points a stored in a variable
- The variable is used to access the property

```
a = point([+10,+10,+10]);
a.pointSize = 20;

a = point([+10,+10,-10]);
a.pointSize = 20;
```


0905 Point size
Search

TRY IT

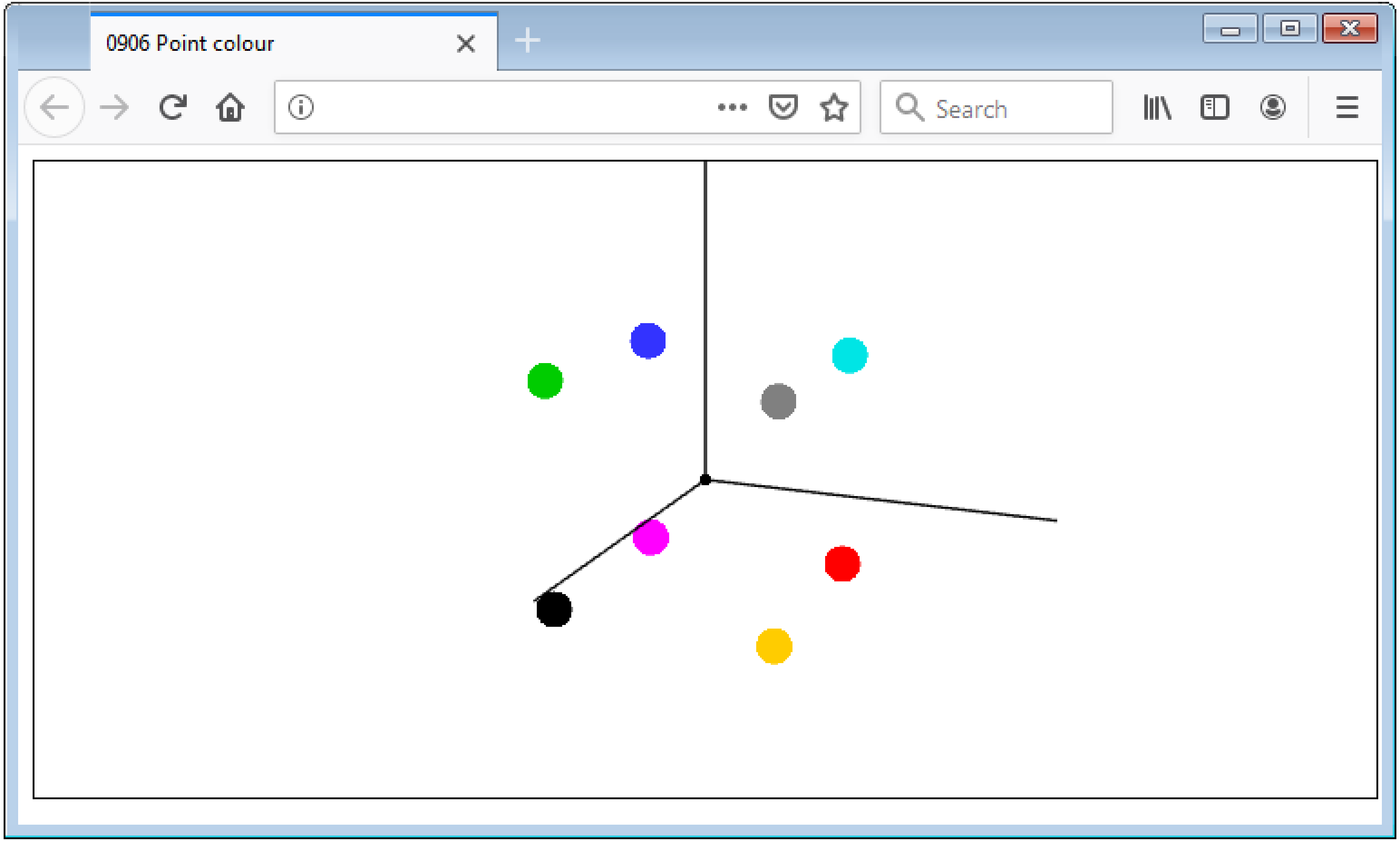
Colour

- Defines the point colour
- An array of three numbers from 0 to 1
- By default points are red
- Stored in property color

Example

- Big and colourfull points

```
a = point([+10,+10,+10]);
a.pointSize = 20;
a.color = [0.5,0.5,0.5];
```



TRY IT

Visibility

- Defines whether the point is drawn
- By default it is true
- Stored in property visible

Examples with points

Example №1

Random points on a line

- Two points in space
- Draw n random points between them

Idea

- Linear combination of the two points
- Coefficient is between 0 and 1
- Coefficient is random

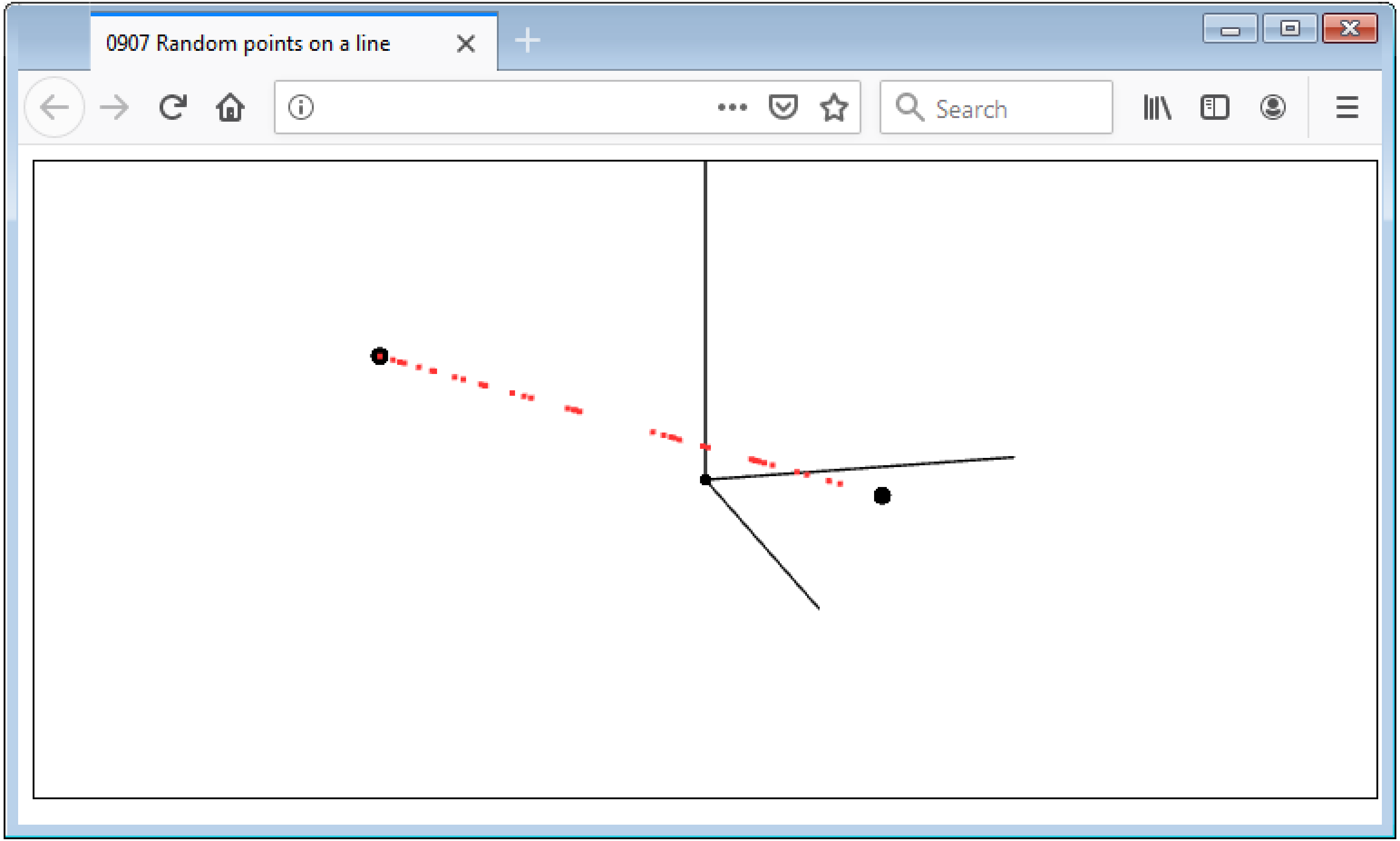
Solution

- Access to coordinates with center
- Random number with function random(*from*,*to*)

```
for (var i=0; i<n; i++)
{
   var k = random(0,1);

   var x = a.center[0]*(1-k)+k*b.center[0];
   var y = a.center[1]*(1-k)+k*b.center[1];
   var z = a.center[2]*(1-k)+k*b.center[2];

   point([x,y,z]);
}
```



TRY IT

Example №2

Random points on a circle

- Invisible circle with fixed radius
- Draw n random points on the circle

Idea

- Assume the circle center is (0,0,0)
- In polar coordinates the points have the same radius, but random angle

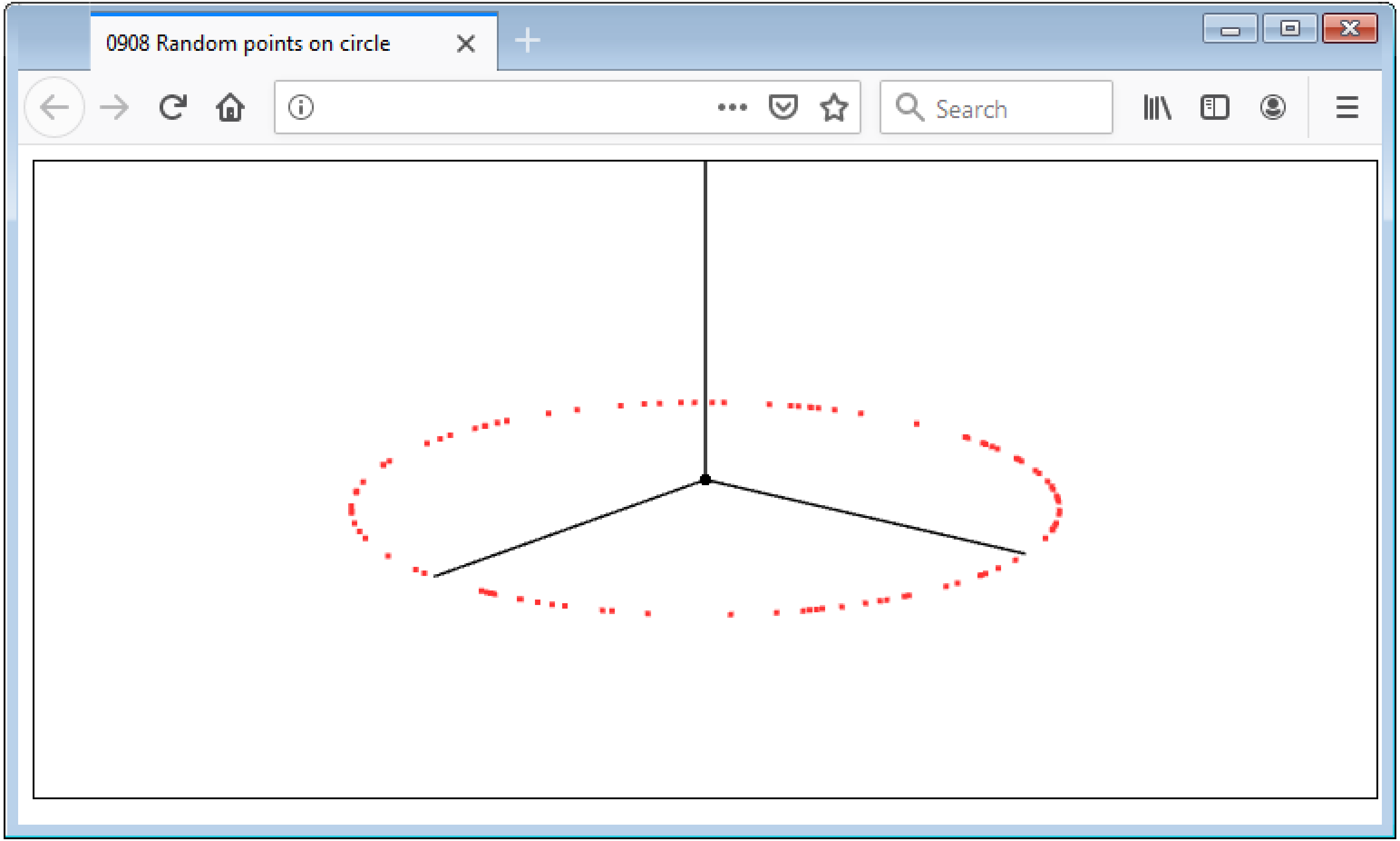
Solution

- Using radians(*angle*) to convert degrees to radians
- Cartesian coordinates are calculated from polar coordinates

```
for (var i=0; i<n; i++)
{
   var alpha = random(0,radians(360));

   var x = r*Math.cos(alpha);
   var y = r*Math.sin(alpha);

   point([x,y,0]);
}
```



TRY IT

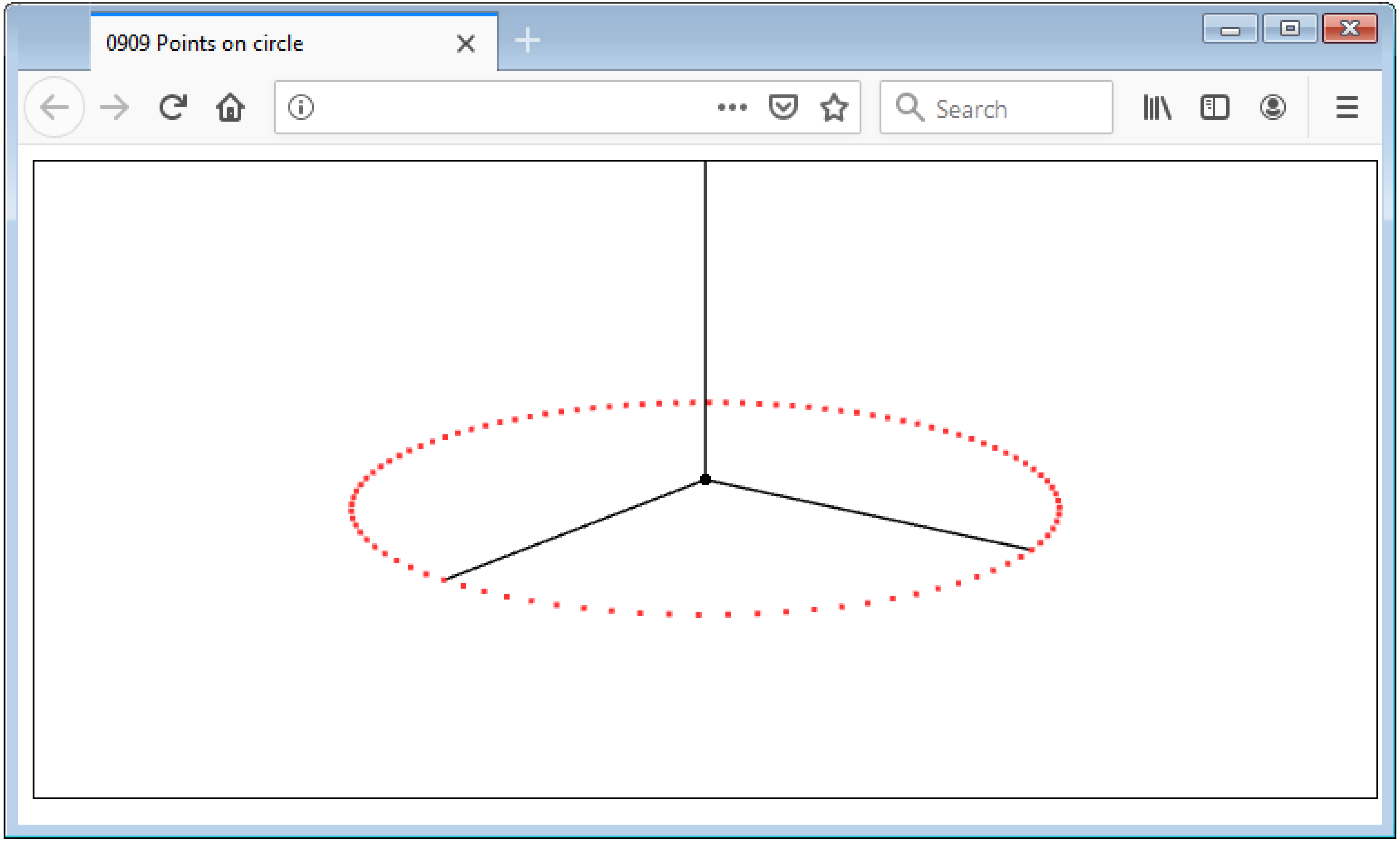
Modification

- The points are uniformly distributed
- Point Nºi is at angle 360.i/n

```
for (var i=0; i<n; i++)
{
   var alpha = radians(360*i/n);

   var x = r*Math.cos(alpha);
   var y = r*Math.sin(alpha);

   point([x,y,0]);
}
```



TRY IT

Example №3

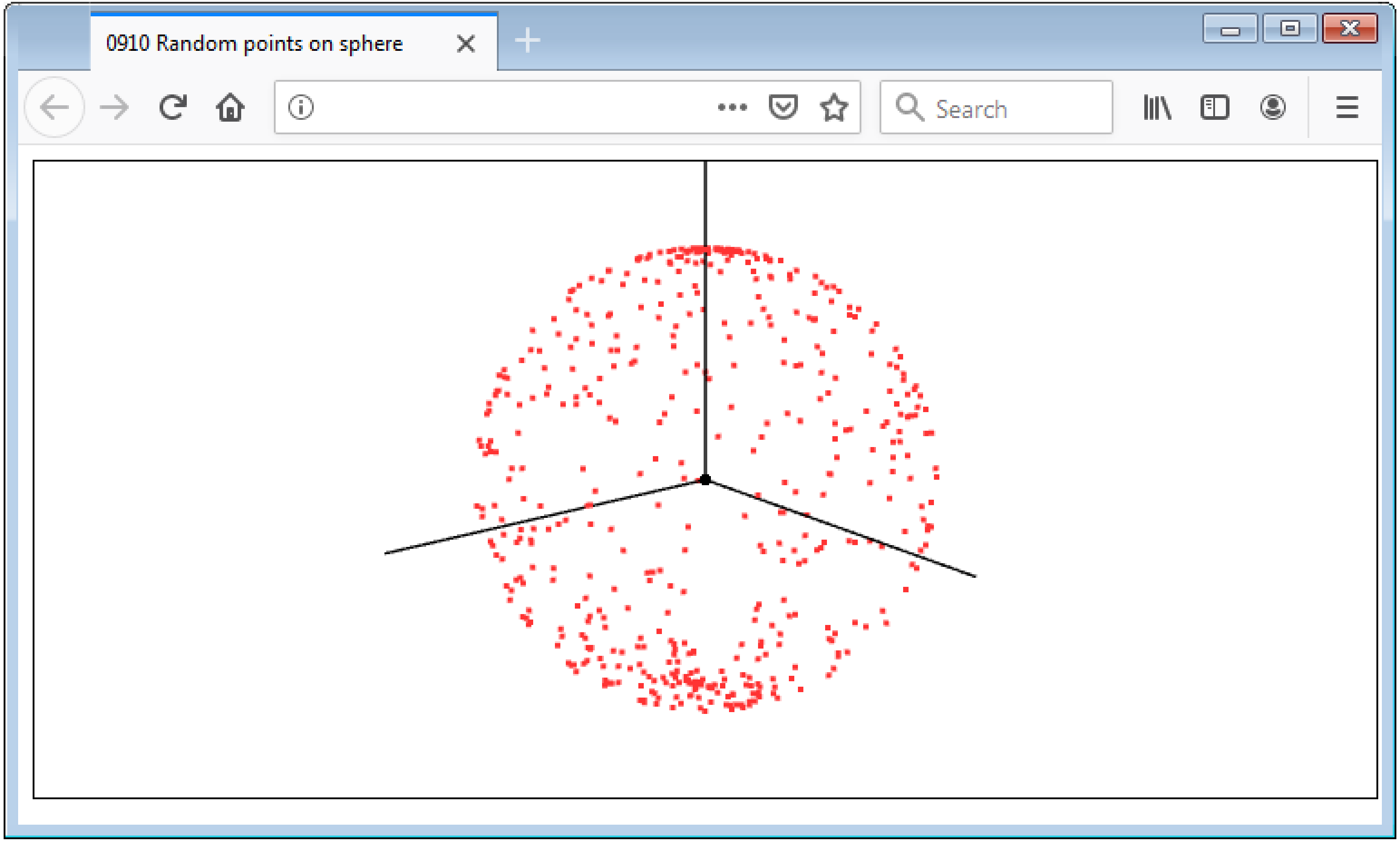
Random points on a sphere

- Solution similar to the example with the circle
- Converting spherical coordinates to Cartesian

```
var alpha = radians(random(0,360));
var beta = radians(random(-90,90));

var x = r*Math.cos(alpha)*Math.cos(beta);
var y = r*Math.sin(alpha)*Math.cos(beta);
var z = r*Math.sin(beta);

point([x,y,z]);
```

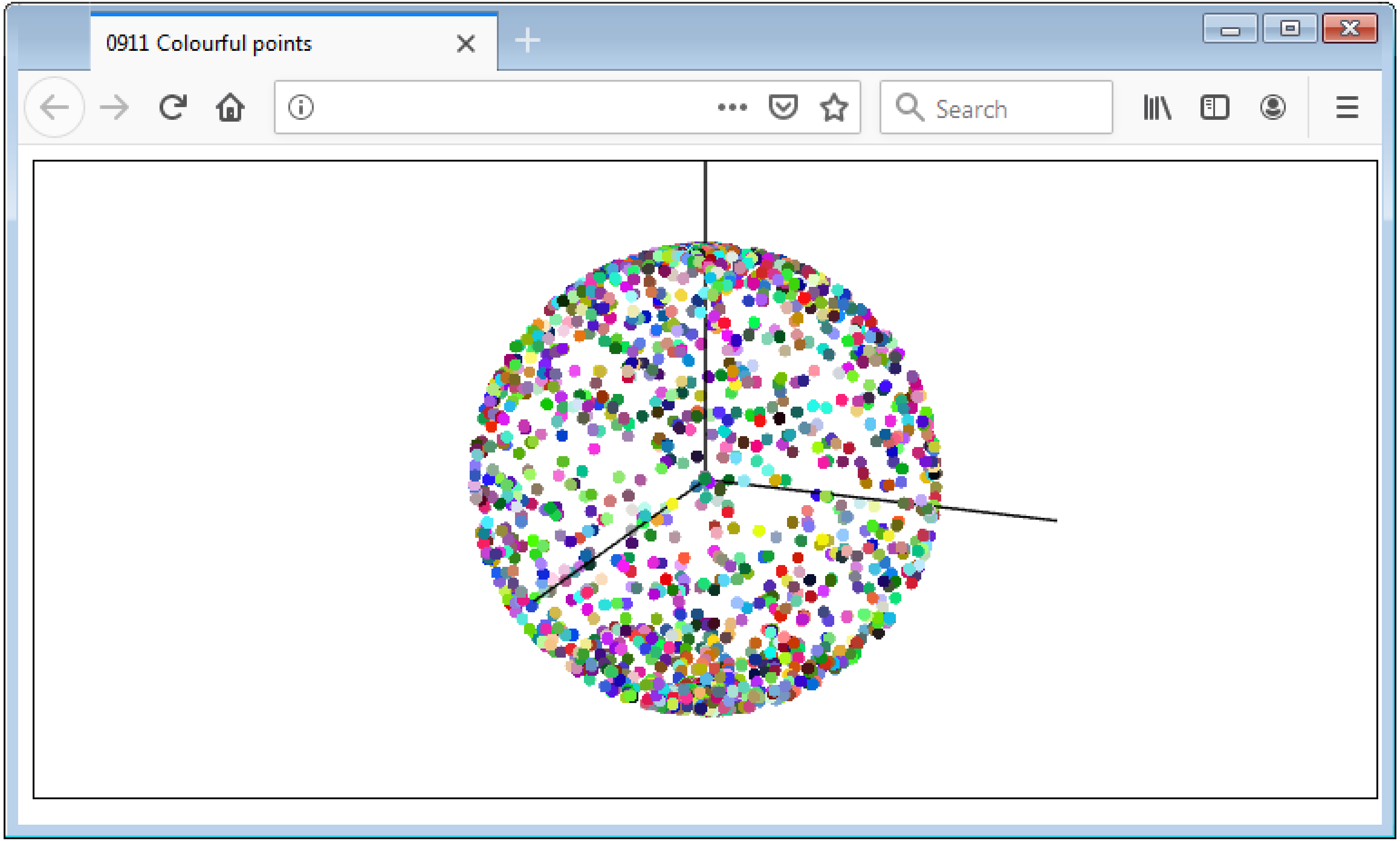


TRY IT

Modification

- Fat colourful points
- Random colours

```
var a = point([x,y,z]);
a.color = [random(0,1),random(0,1),random(0,1)];
a.pointSize = 7;
```



TRY IT

Line, ray, segment

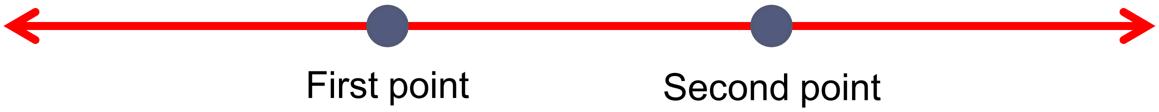
Line in Suica

Line

- Graphical object with properties
- Used to draw a line through two points

Creating a line

- With class new Suica.Line (*point, point*)
- With function line (*point, point*)



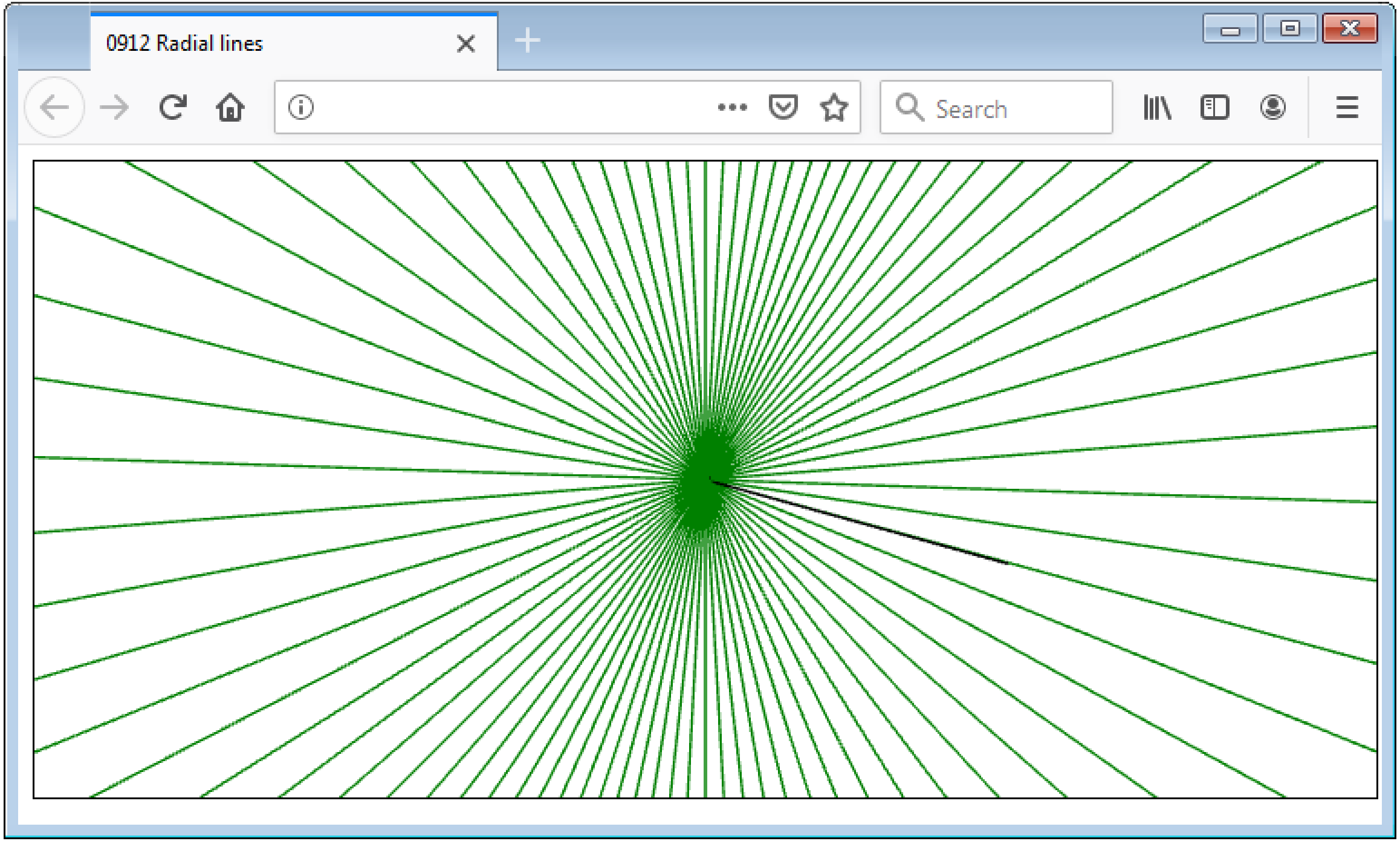
Example

- Create radial and uniformly distributed lines
- One of the points is fixed, the other orbits around

```
for (var i=0; i<n; i++)
{
   var alpha = radians(180*i/n);

   var x = Math.cos(alpha);
   var z = Math.sin(alpha);

   line([0,0,0],[x,0,z]);
}
```



TRY IT

Properties

Line properties

- Coordinates of points defining the line are stored in properties to and from
- Colour is stored in color, by default it is green
- Visibility is stored in visible

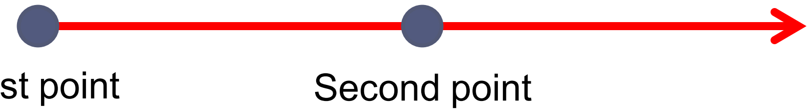
Ray in Suica

Ray

- Used to draw ray from one point through another one
- Same properties as the line

Creating a ray

- With class new Suica.Ray (*point, point*)
- With function ray (*point, point*)



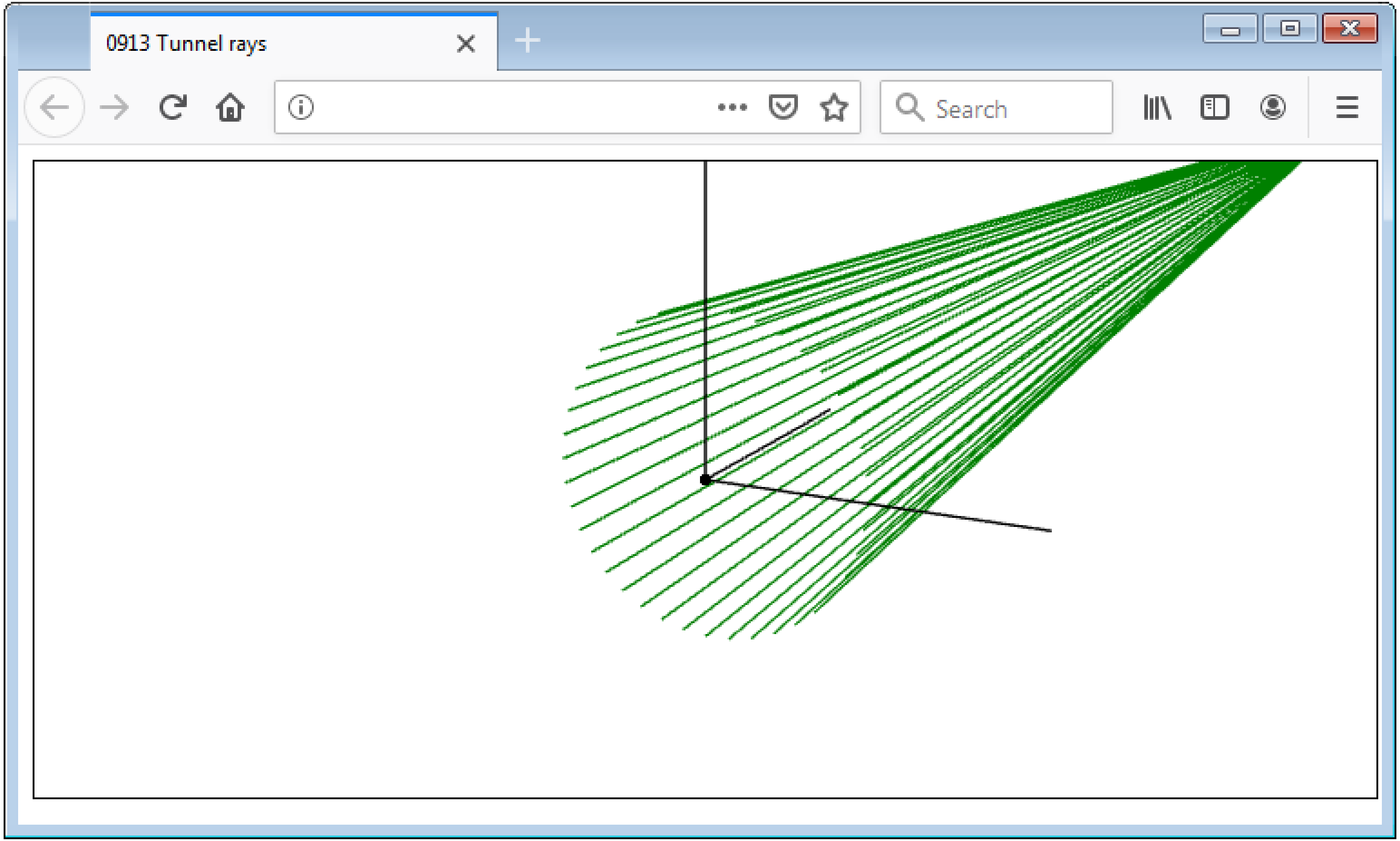
Example

- Create a tunnel from parallel rays
- The first point of each ray is on a circle, the second point is at perpendicular distance of 1 unit

```
for (var i=0; i<n; i++)
{
   var alpha = radians(360*i/n);

   var x = 15*Math.cos(alpha);
   var z = 15*Math.sin(alpha);

   ray([x,0,z],[x,1,z]);
}
```



TRY IT

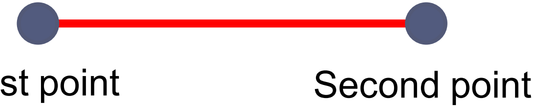
Segment in Suica

Segment

- Used to draw a segment between two points
- Same properties as the line

Creating a segment

- With class new Suica.Segment (*point, point*)
- With function segment (*point, point*)

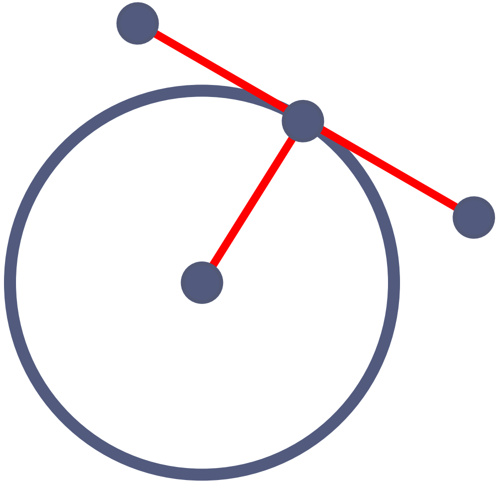


Example

- Create segments tangent to a circle

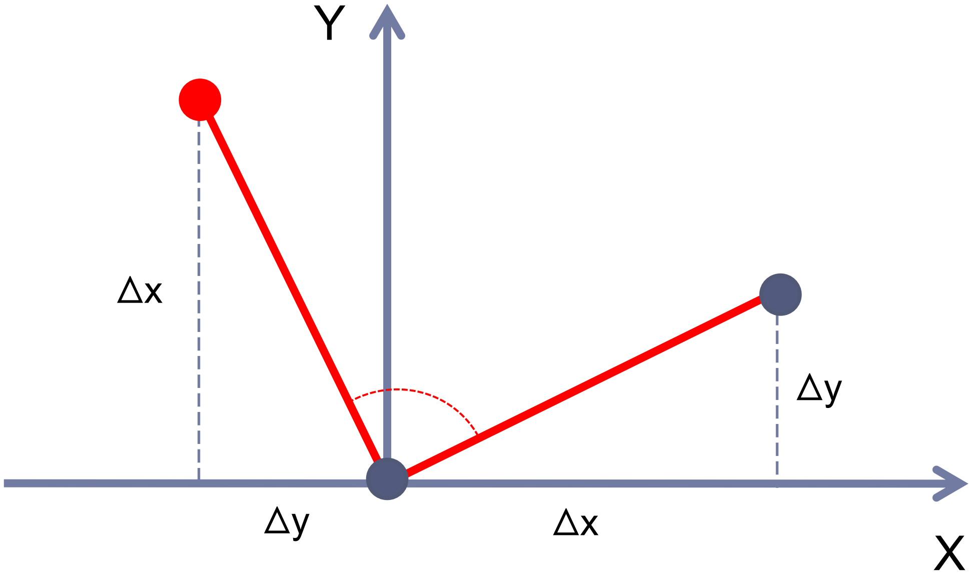
Idea

- There is a tangent point
- The vector from circle's center to this point is perpendicular to the vectors from this point to the ends of the segment



Rotation 90°

- Using same triangles
- If a vector is (Δx,Δy), the perpendicular vectors are (–Δy,Δx) and (Δy,–Δx)



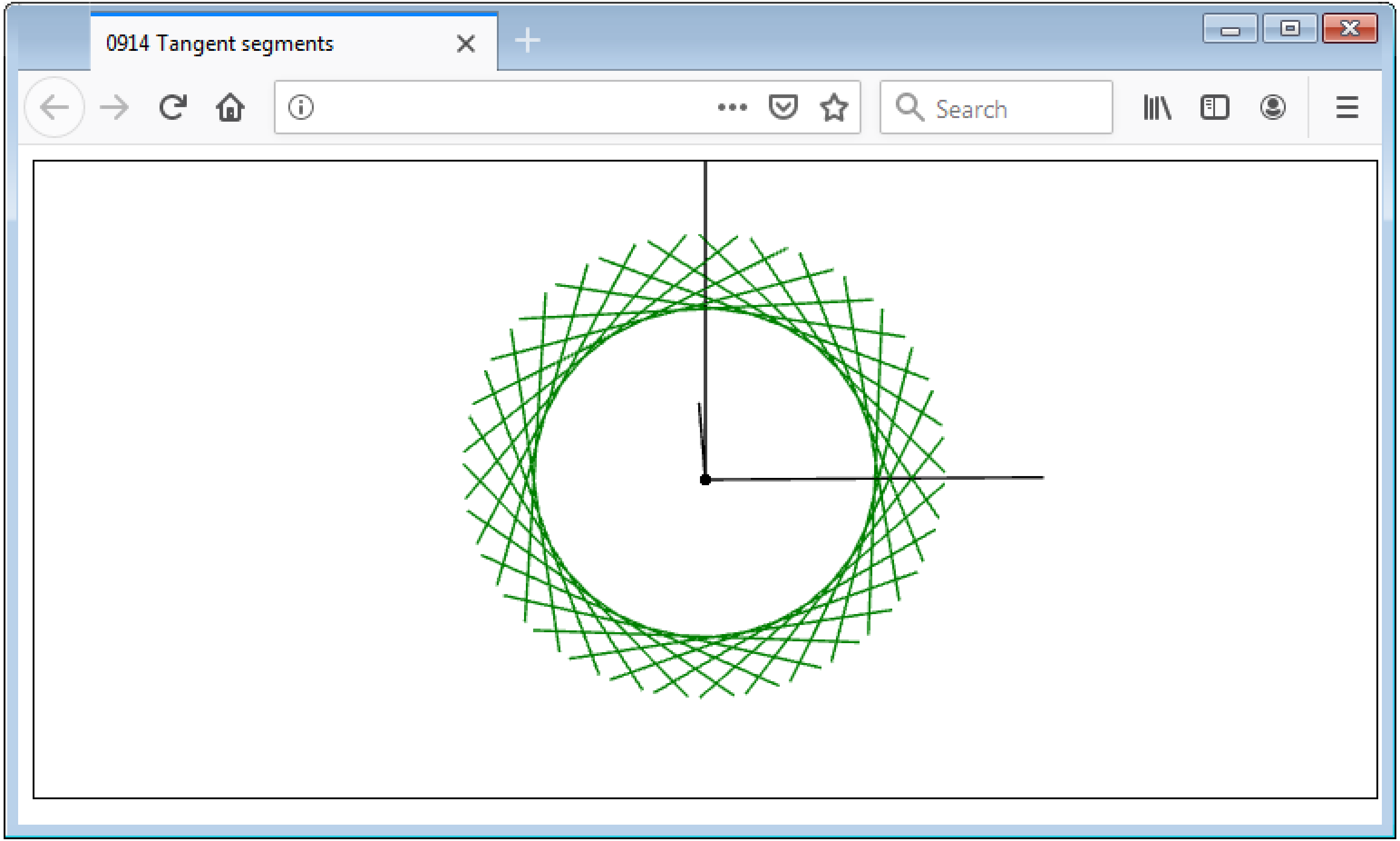
Solution

- Coordinate of a point on the circle are the coordinates of the vector to this point
- The vector is used to find the end points of the segment

```
for (var i=0; i<n; i++)
{
   var alpha = radians(360*i/n);

   var dX = 15*Math.cos(alpha);
   var dZ = 15*Math.sin(alpha);

   segment([dX-dZ,0,dZ+dX],[dX+dZ,0,dZ-dX]);
}
```



TRY IT

Summary

Graphical properties

Values

- Coordinates and vectors are arrays of three numbers
- Colours are arrays of three numbers from 0 to 1

Help functions

- random – a random number in an interval
- radians – converts from degrees to radians

Common properties

- center – coordinates of an object
- color – colour of an object
- visible – visibility of an object
- pointSize – size of a point (or all objects drawn by points)

Graphical objects

Point

- Created with new Suica.Point or point
- Supports common properties center, color, visible и pointSize

Line

- Created with new Suica.Line or line
- Contains points from and to
- Supports common properties color and visible

Ray

- Created with new Suica.Ray or ray
- Same properties as the line

Segment

- Created with new Suica.Segment or segment
- Same properties as the line

ICT in SES

The end

Comments, questions