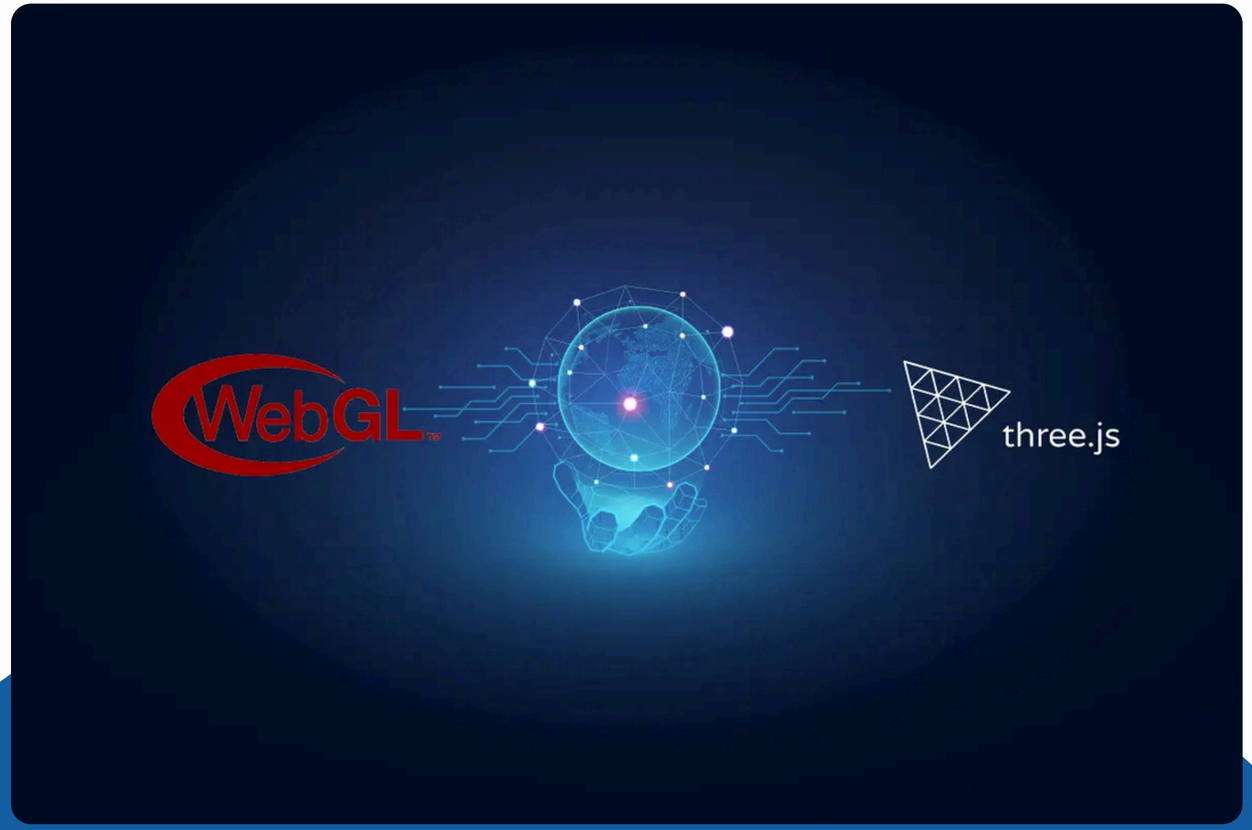
WebGL and Three.js



Team

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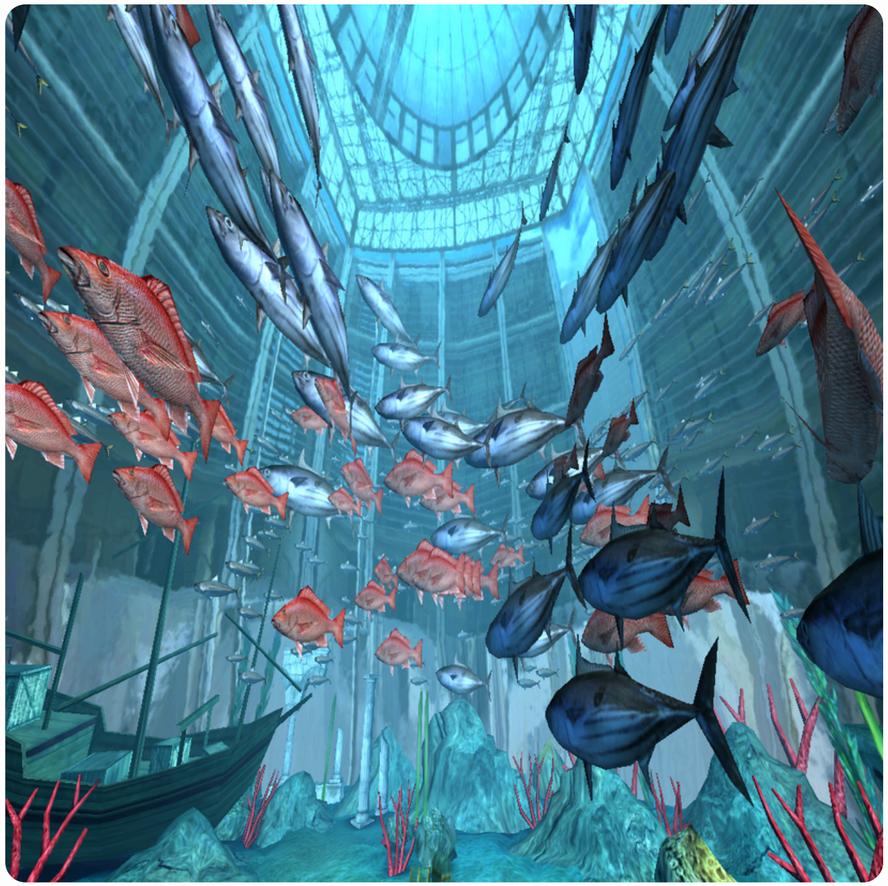
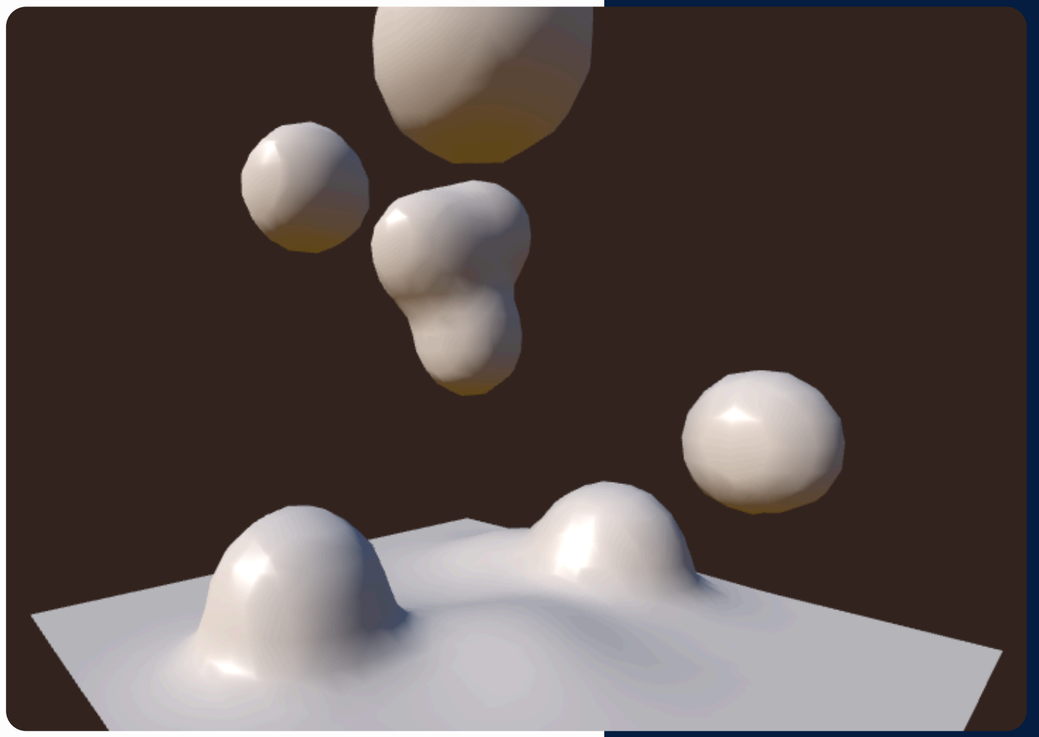
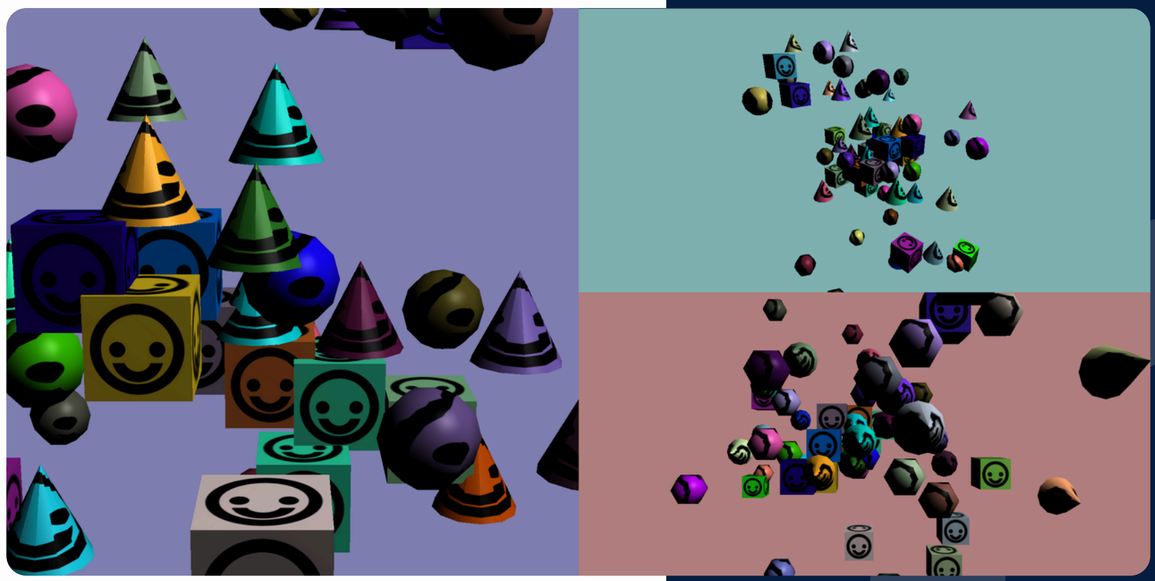
Overview:

WebGL Motivation







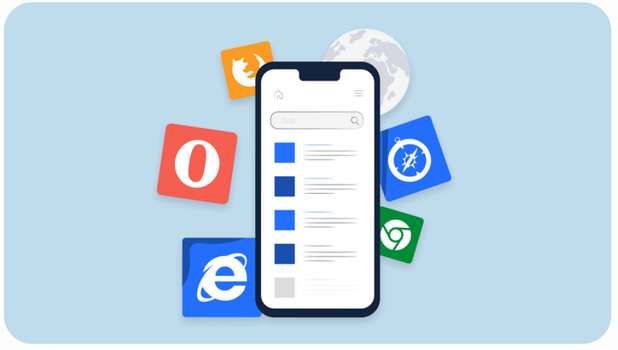
WebGL examples

1) WebGL Introduction

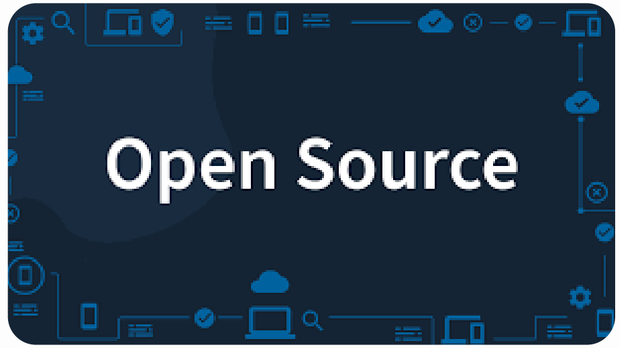
- Standard for web graphics.
- Interactive 2D and 3D rendering.
- JavaScript API compatible with HTML5.
- No plugins or add-ons required.

Advantages of WebGL

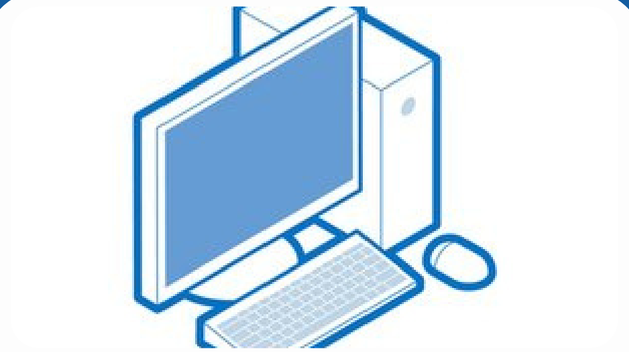
JavaScript programming



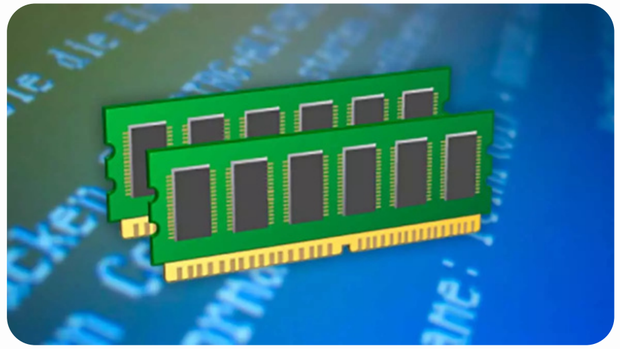
Better Mobile Browser Compatibility



Open Source



No Need for Compilation

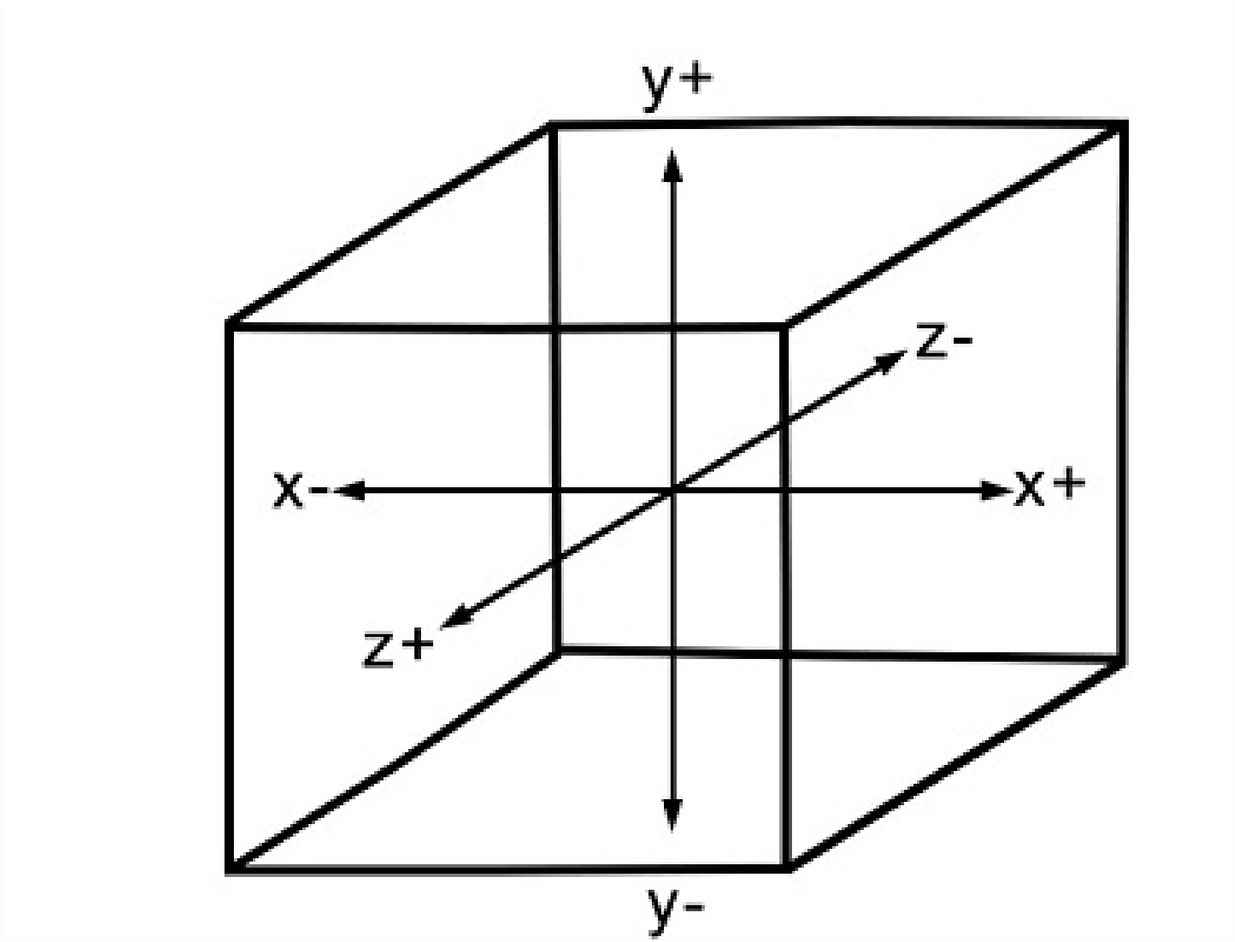


Automatic Memory Management

Easy to Set Up

2) WebGL Basics

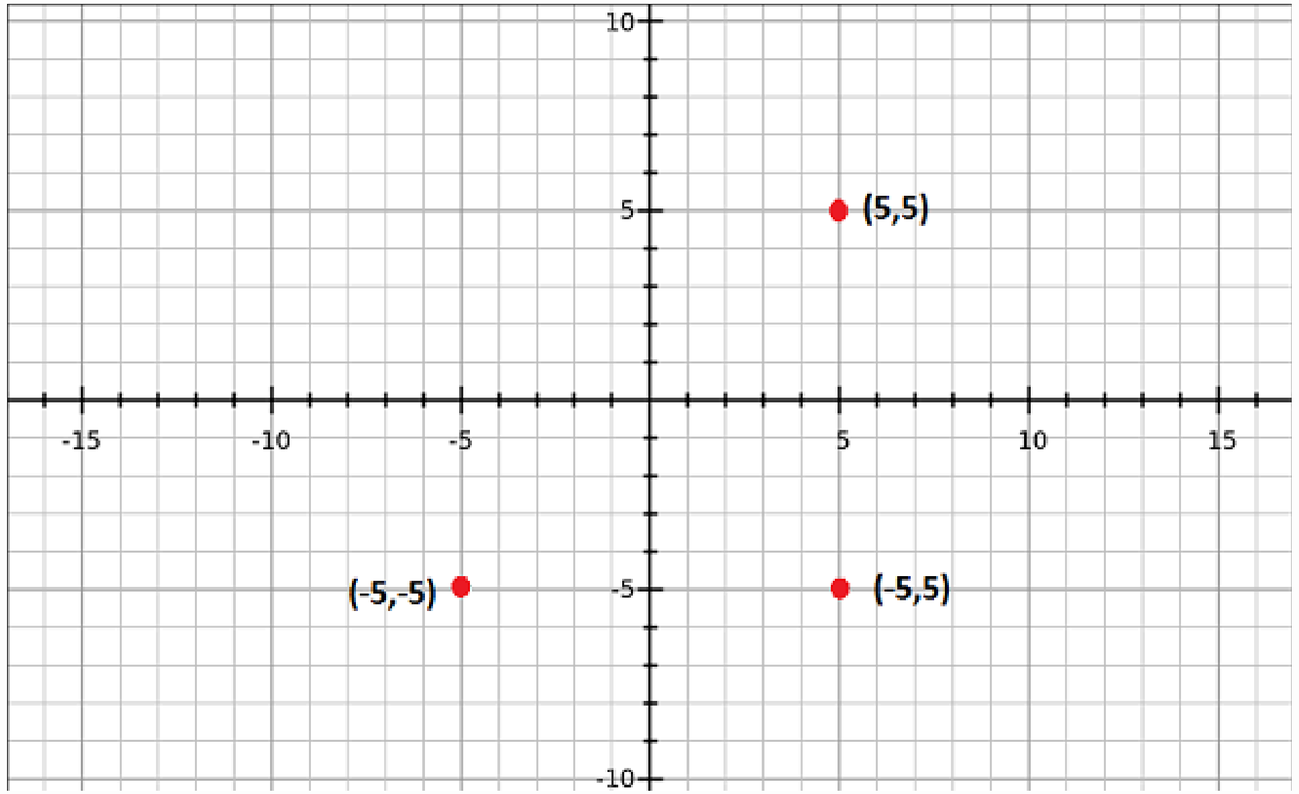
- Coordinates:



2) WebGL Basics

- Graphics:
  - Vertex or Index.
  - **Buffer object**.

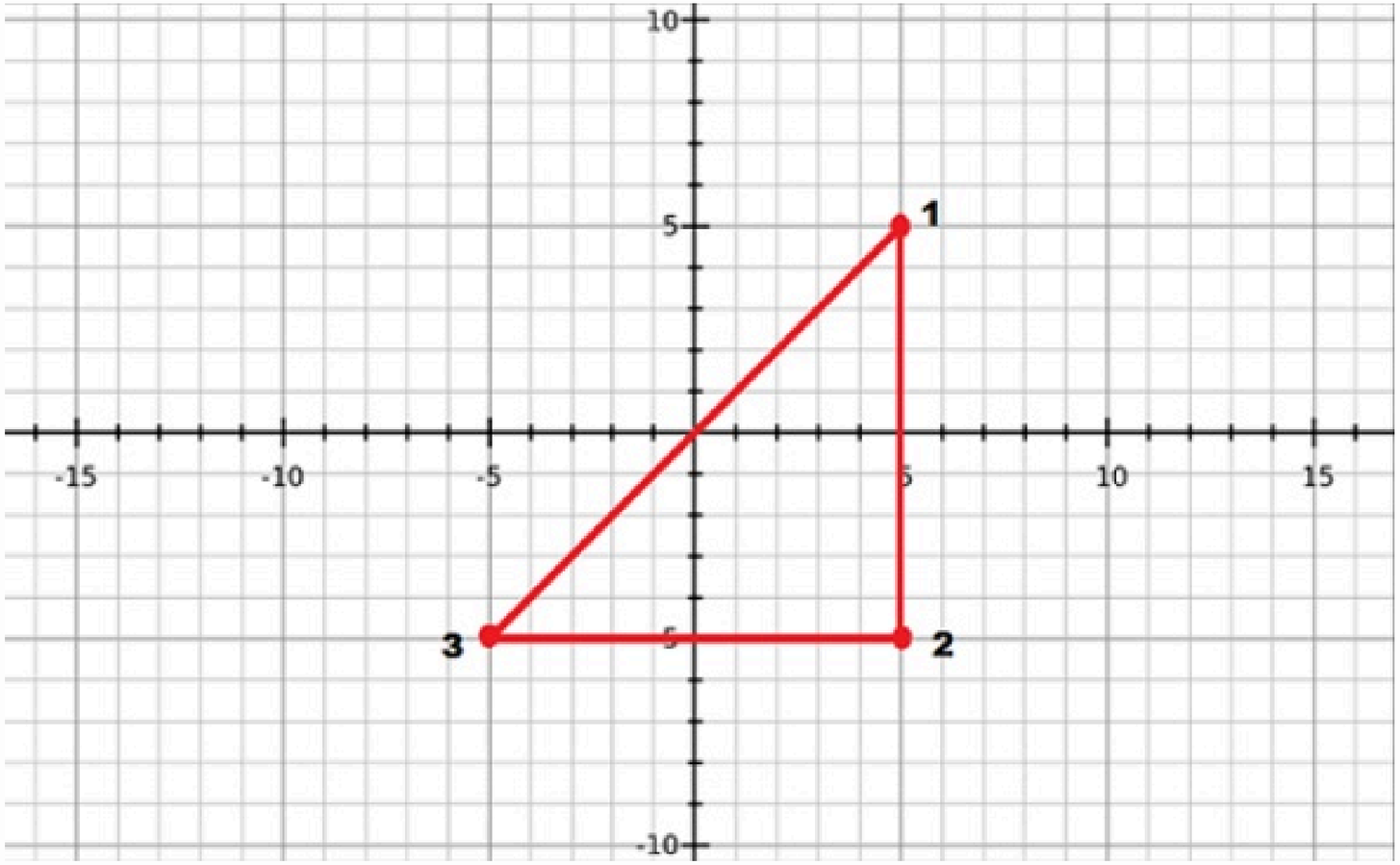
(0.5, 0.5), (-0.5, 0.5), (-0.5, -0.5)



2) WebGL Basics

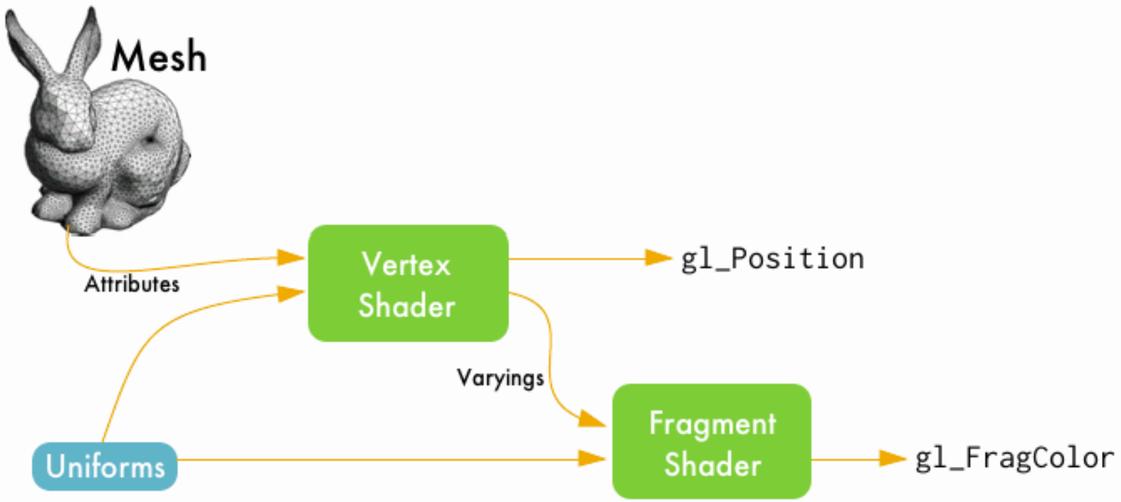
- Graphics:

(0.5, 0.5), (-0.5, 0.5), (-0.5, -0.5)

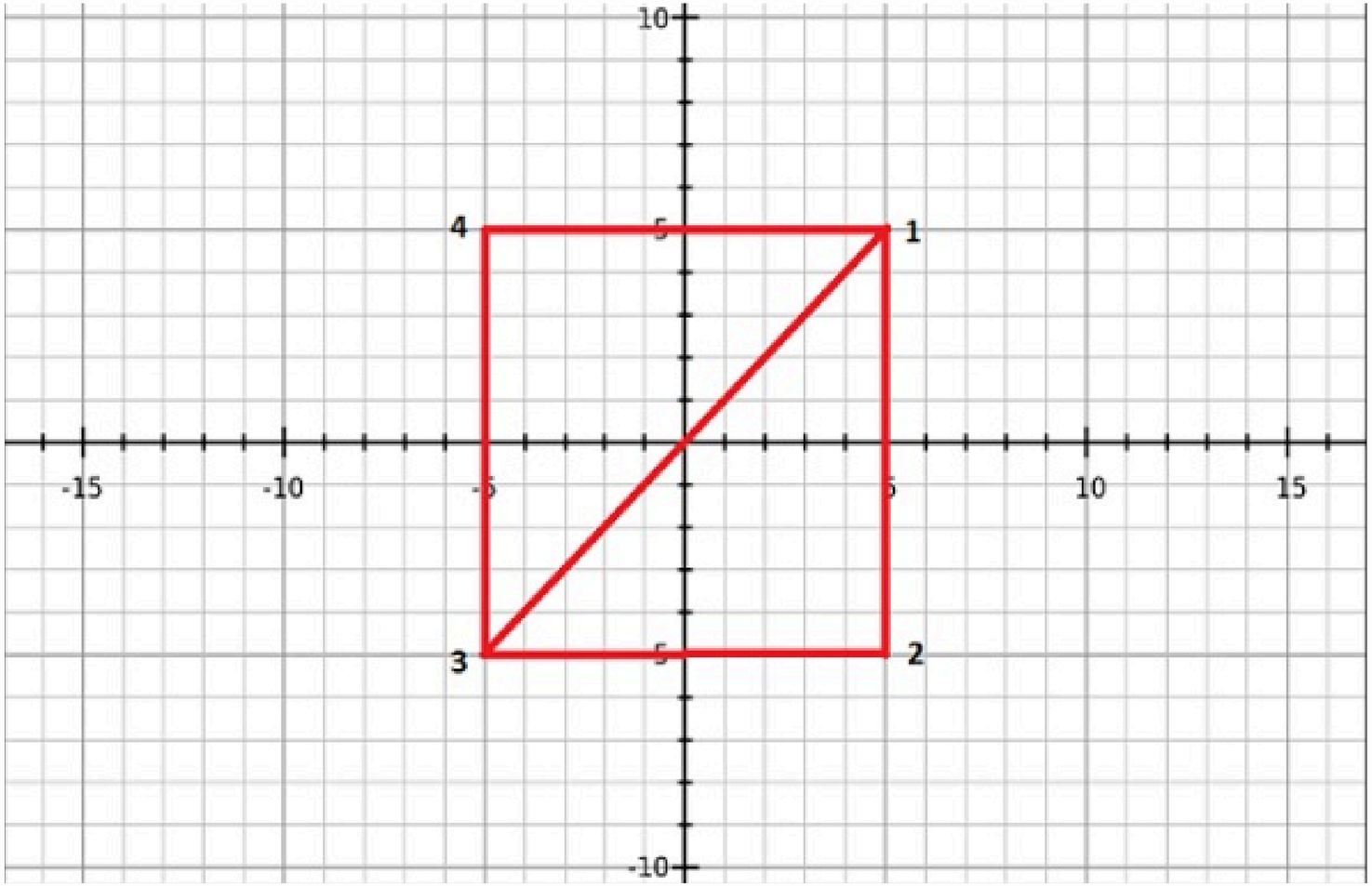


2) WebGL Basics

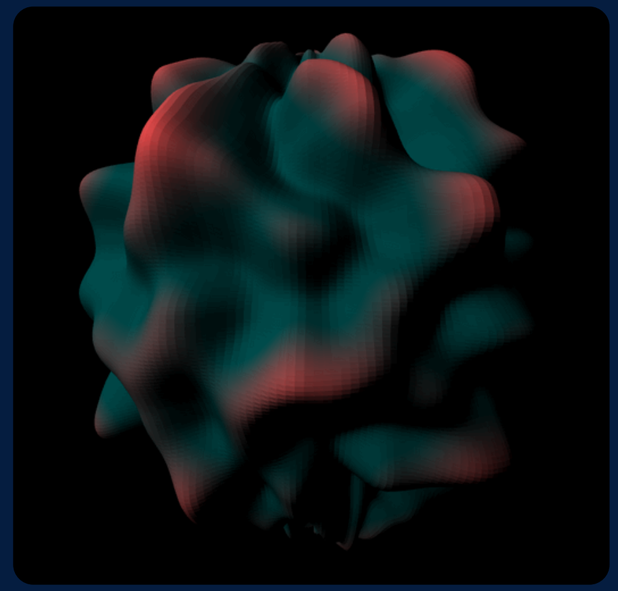
- Buffers:
  - WebGL data storage areas.
- Meshes:
  - **drawArray()** and **drawElement().**
  - **Mode.**



2) WebGL Basics



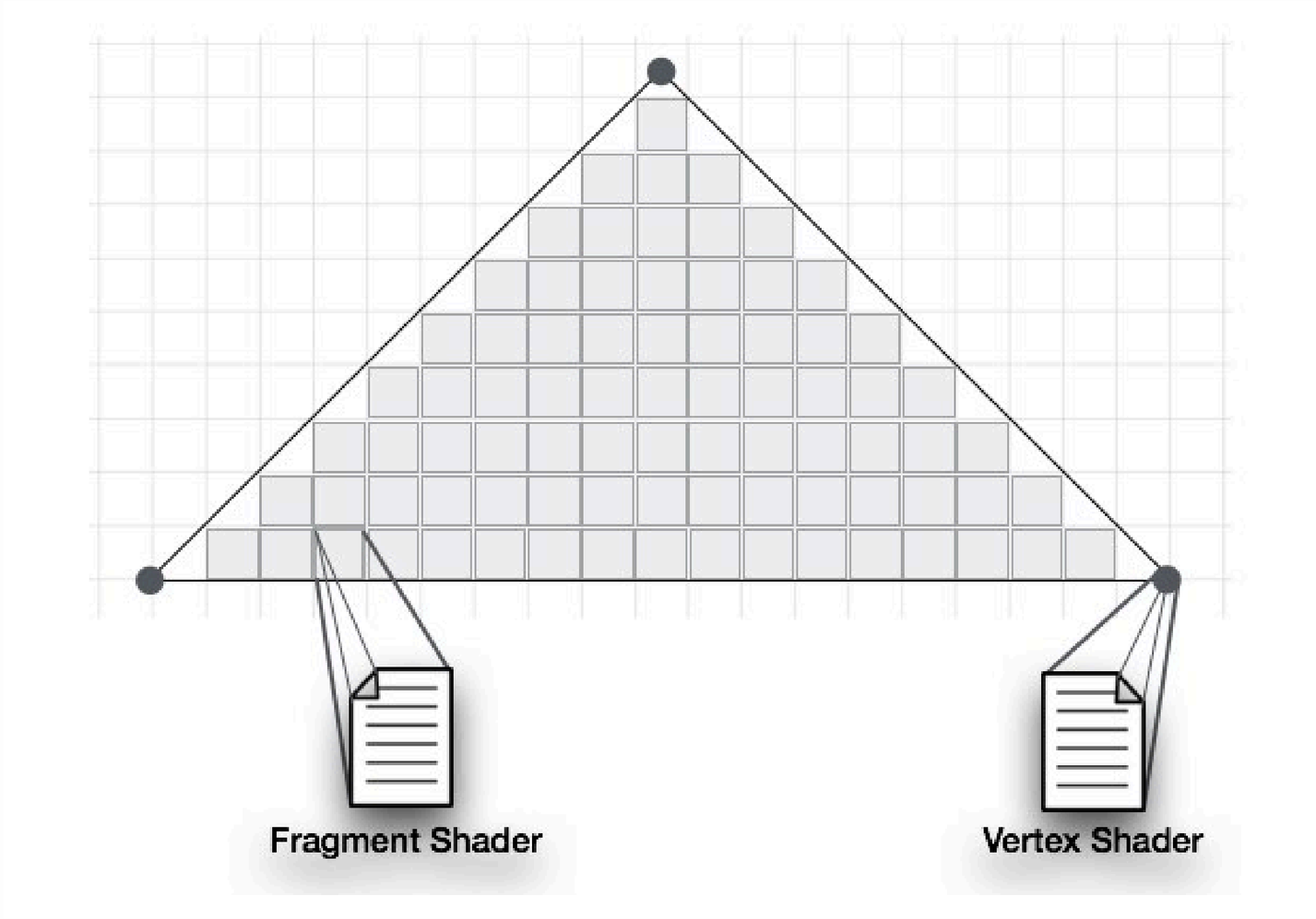
2) WebGL Basics



- Shaders:
  - GPU acceleration.
  - GLSL.
  - Interaction of components.
  - **Vertex Shader** and **Fragment Shader.**

Shader examples

2) WebGL Basics



3) WebGL 2D and 3D

- Prepare the canvas and get WebGL rendering context.

```
this.canvas = document.getElementById(canvasID) as HTMLCanvasElement;
this.context = this.canvas.getContext('webgl')!;
```

3) WebGL 2D and 3D

- Define the geometry and store it in buffer objects.

```
const vertices = [-0.5, 0.5, -0.5, -0.5, 0.0, -0.5];
const vertexBuffer = this.context.createBuffer();
this.context.bindBuffer(this.context.ARRAY_BUFFER, vertexBuffer);
this.context.bufferData(this.context.ARRAY_BUFFER, new Float32Array(vertices), this.context.STATIC_DRAW);
this.context.bindBuffer(this.context.ARRAY_BUFFER, null);
```

3) WebGL 2D and 3D

- Create and compile Shader programs.

```
const vertCode = `
  attribute vec2 coordinates;
  void main(void) {
    gl_Position = vec4(coordinates, 0.0, 1.0);
  }`;
const vertShader = this.context.createShader(this.context.VERTEX_SHADER)!;
this.context.shaderSource(vertShader, vertCode);
this.context.compileShader(vertShader);
const fragCode = `
  void main(void) {
    gl_FragColor = vec4(0.0, 0.0, 0.0, 0.1);
  }`;
const fragShader = this.context.createShader(this.context.FRAGMENT_SHADER)!;
this.context.shaderSource(fragShader, fragCode);
this.context.compileShader(fragShader);
```

3) WebGL 2D and 3D

- Create and compile Shader programs.

```
const shaderProgram = this.context.createProgram()!;
this.context.attachShader(shaderProgram, vertShader);
this.context.attachShader(shaderProgram, fragShader);
this.context.linkProgram(shaderProgram);

this.context.useProgram(shaderProgram);
```

3) WebGL 2D and 3D

- Associate the shader programs with buffer objects.

```
this.context.bindBuffer(this.context.ARRAY_BUFFER, vertexBuffer);
const coord = this.context.getAttribLocation(shaderProgram, "coordinates");
this.context.vertexAttribPointer(coord, 2, this.context.FLOAT, false, 0, 0);
this.context.enableVertexAttribArray(coord);
```

3) WebGL 2D and 3D

- Drawing the required object.

```
this.context.clearColor(0.5, 0.5, 0.5, 0.9);
this.context.enable(this.context.DEPTH_TEST);
this.context.clear(this.context.COLOR_BUFFER_BIT);
this.context.viewport(0, 0, this.canvas.width, this.canvas.height);
this.context.drawArrays(this.context.TRIANGLES, 0, 3);
```

3) WebGL 2D and 3D

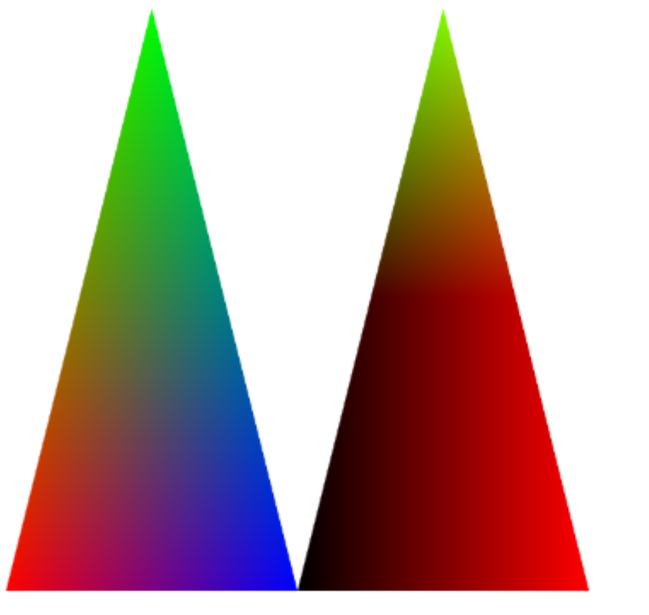
- Result:

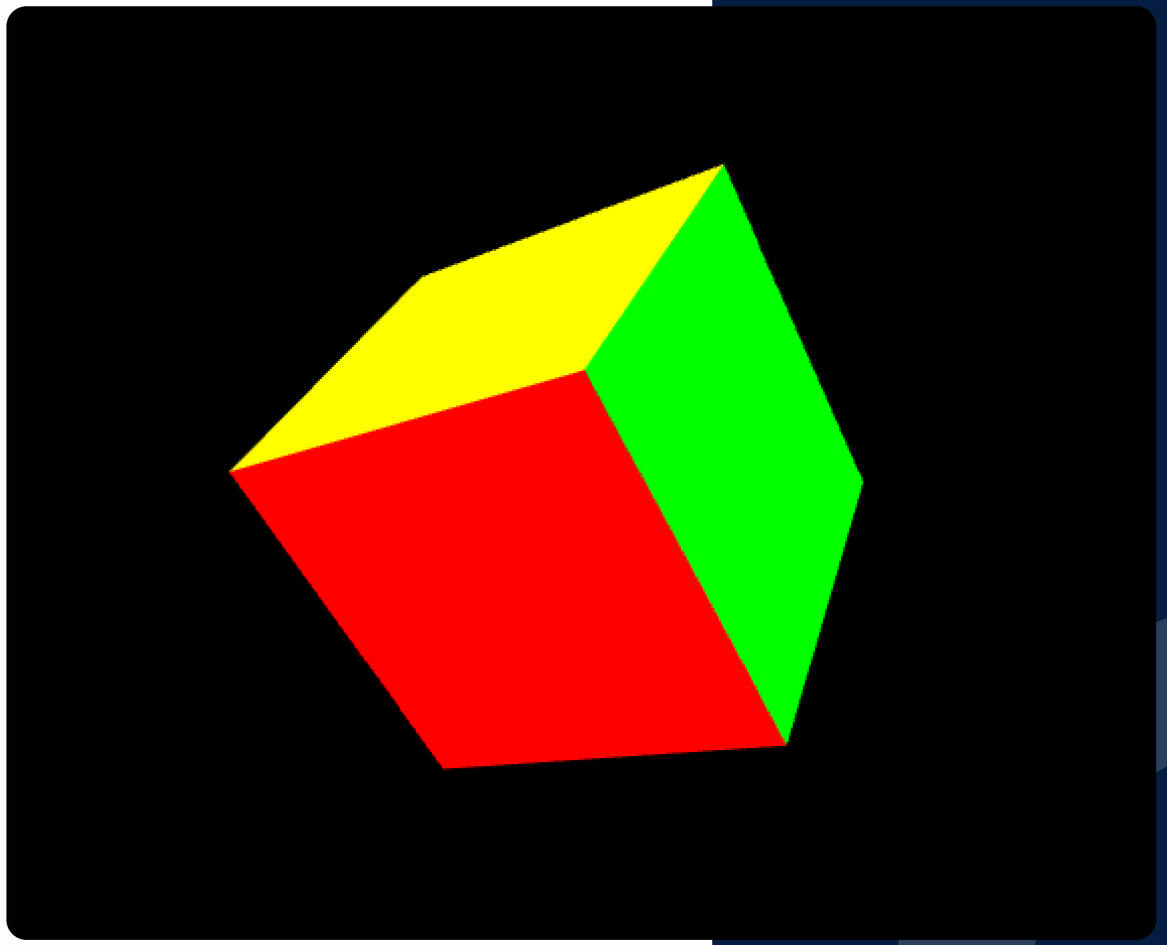
3) WebGL 2D and 3D


```
const positions = [
  // Front face
  -1.0, -1.0, 1.0, 1.0, -1.0, 1.0, 1.0, 1.0, 1.0, -1.0, 1.0, 1.0,

  // Back face
  -1.0, -1.0, -1.0, -1.0, 1.0, -1.0, 1.0, 1.0, -1.0, 1.0, -1.0, -1.0,

  // Top face
  -1.0, 1.0, -1.0, -1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, -1.0,

  // Bottom face
  -1.0, -1.0, -1.0, 1.0, -1.0, -1.0, 1.0, -1.0, 1.0, -1.0, -1.0, 1.0,

  // Right face
  1.0, -1.0, -1.0, 1.0, 1.0, -1.0, 1.0, 1.0, 1.0, 1.0, -1.0, 1.0,

  // Left face
  -1.0, -1.0, -1.0, -1.0, -1.0, 1.0, -1.0, 1.0, 1.0, -1.0, 1.0, -1.0,
];
```

3) WebGL 2D and 3D

```
const colors = new Float32Array([
  1.0, 0.0, 0.0, // Red
  0.0, 1.0, 0.0, // Green
  0.0, 0.0, 1.0, // Blue
])
```

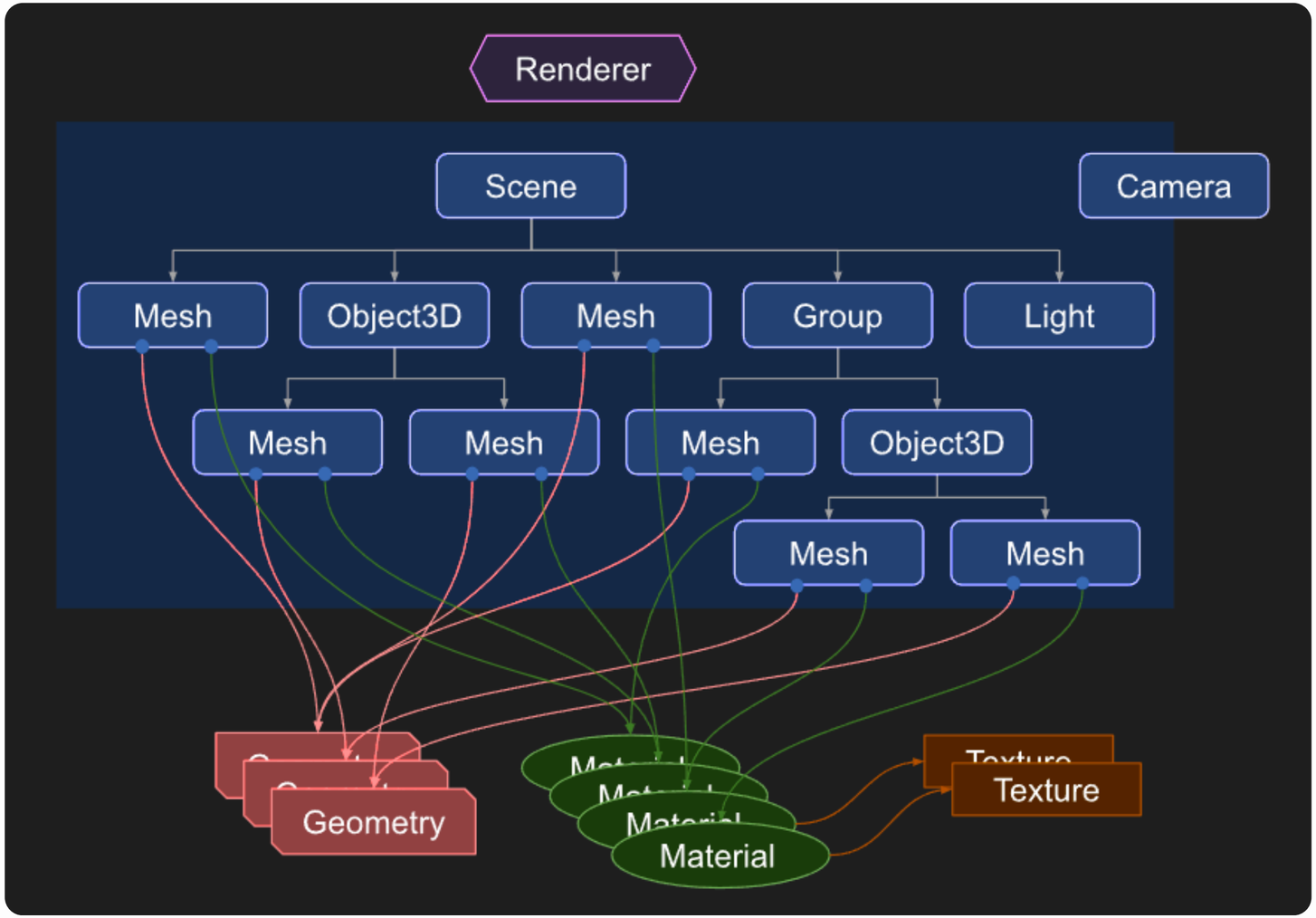




4) Three.js introduction

What is Three.js?

6) Three.js structure



7) First scene

1)
- import * as THREE from "three";
- const scene = new THREE.Scene();

2)
- const camera = new THREE.PerspectiveCamera(75, window.innerWidth / window.innerHeight, 0.1, 1000);

3)
- const renderer = new THREE.WebGLRenderer();
- renderer.setSize(window.innerWidth, window.innerHeight);
- document.body.appendChild(renderer.domElement);
- renderer.render(scene, camera);

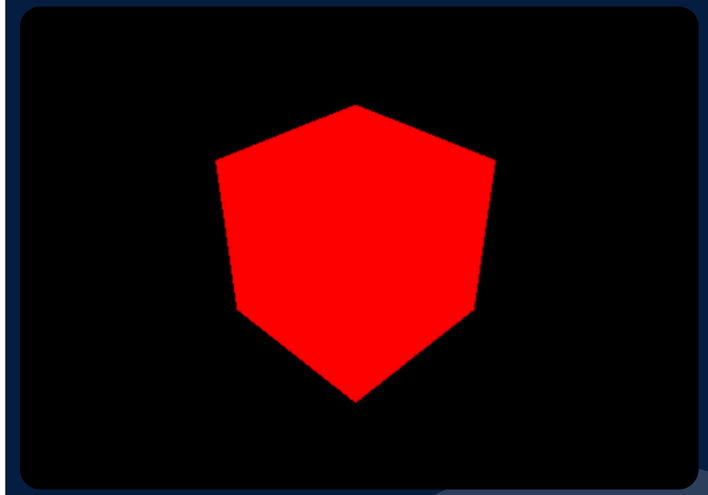
7) First scene

4)
- const geometry = new THREE.BoxGeometry(1, 1, 1);

5)
- const material = new THREE.MeshBasicMaterial({ color: "red"});

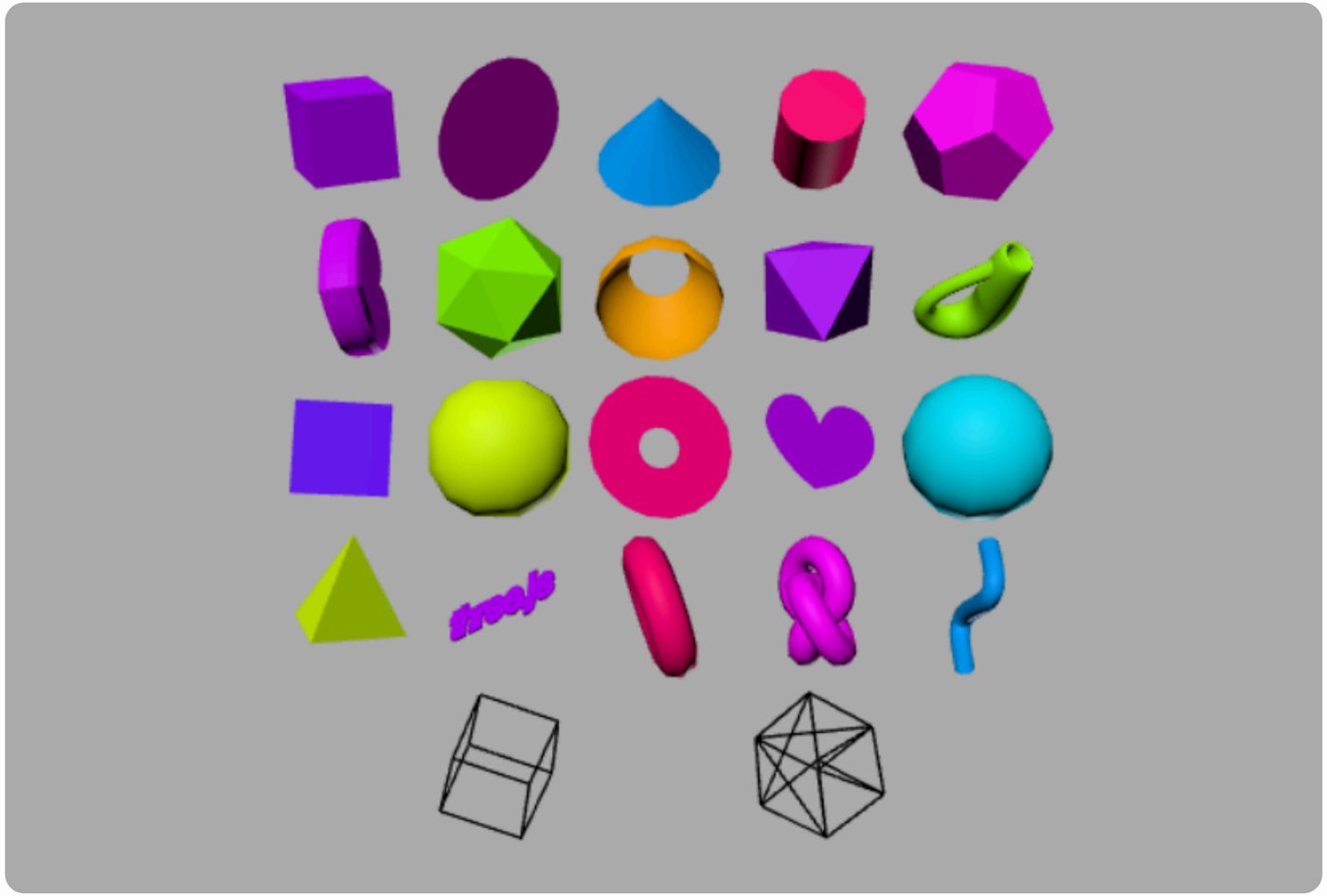
6)
- const cube = new THREE.Mesh(geometry, material);
- scene.add(cube);

7)
- camera.position.set(5, 5, 5); // Posición de la cámara (x, y, z)
- camera.lookAt(0, 0, 0); // Enfocar la cámara en el cubo



8) Primitive figures

What are primitive figures?



8) Primitive figures 

Some primitives:

```
new THREE.BoxGeometry(1, 1, 1),
new THREE.SphereGeometry(0.5, 32, 32),
new THREE.ConeGeometry(0.5, 1, 32),
new THREE.CylinderGeometry(0.5, 0.5, 1, 32),
new THREE.TorusGeometry(0.5, 0.2, 16, 100),
new THREE.TetrahedronGeometry(0.5),
new THREE.OctahedronGeometry(0.5),
new THREE.IcosahedronGeometry(0.5),
new THREE.DodecahedronGeometry(0.5),
new THREE.PlaneGeometry(1, 1),
new THREE.CircleGeometry(0.5, 32),
```

8) Primitive figures

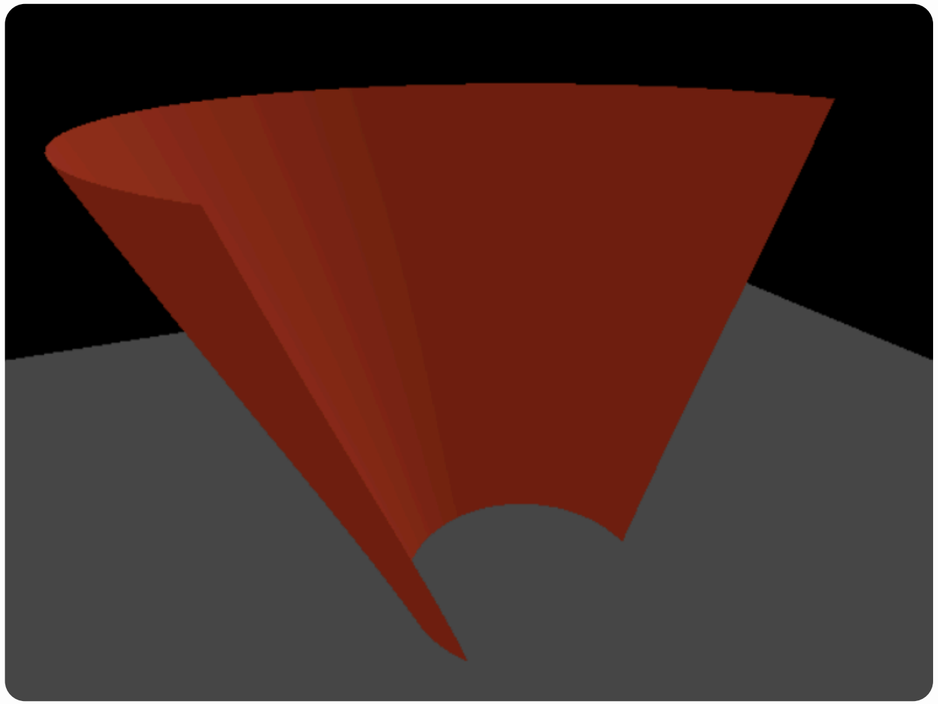
- **Extrusion:**

```
const shape = new THREE.Shape();
shape.moveTo(0, 0);
shape.lineTo(1, 0);
shape.lineTo(1, 1);
shape.lineTo(0, 1);
shape.lineTo(0, 0);

const extrudeSettings = { depth: 1, bevelEnabled: true,
  bevelThickness: 0.2, bevelSize: 0.2, bevelSegments: 1 };
let extrudeGeometry = new THREE.ExtrudeGeometry(shape, extrudeSettings);
```

8) Primitive figures

- **Lathe:**

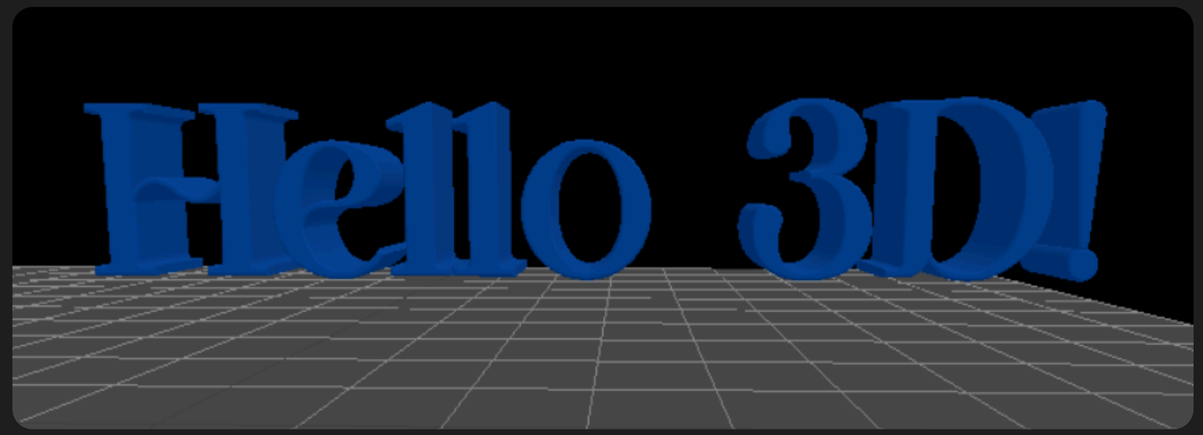
```
const radialPoints: THREE.Vector2[] = [];
let latheGeometry = new THREE.LatheGeometry(radialPoints, 32);
```



8) Primitive figures

- **Text:**

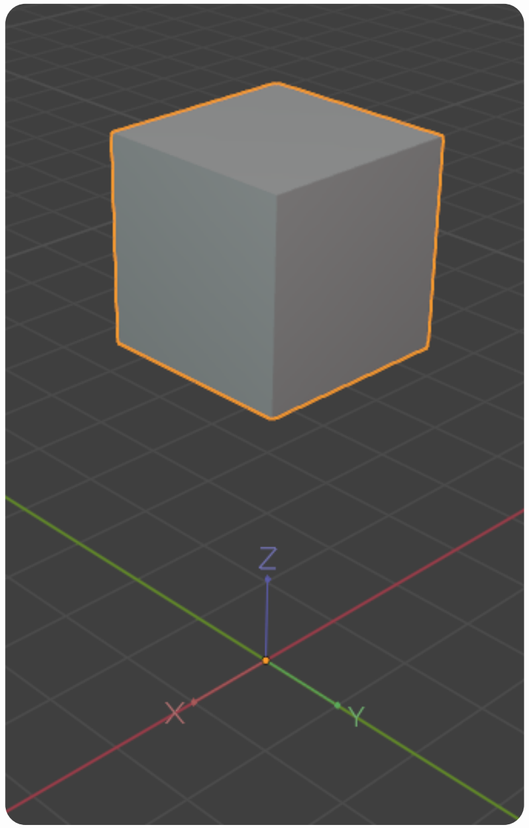
```
const loader = new FontLoader();
loader.load('http://localhost:3000/src/figures/Hefana_Regular.json', (font) => {
  const textGeometry = new TextGeometry('Hello 3D!', {
    font: font,
    size: 1,
    depth: 0.5,
    curveSegments: 12,
    bevelEnabled: true,
    bevelThickness: 0.03,
    bevelSize: 0.02,
    bevelSegments: 5,
  });
});
```

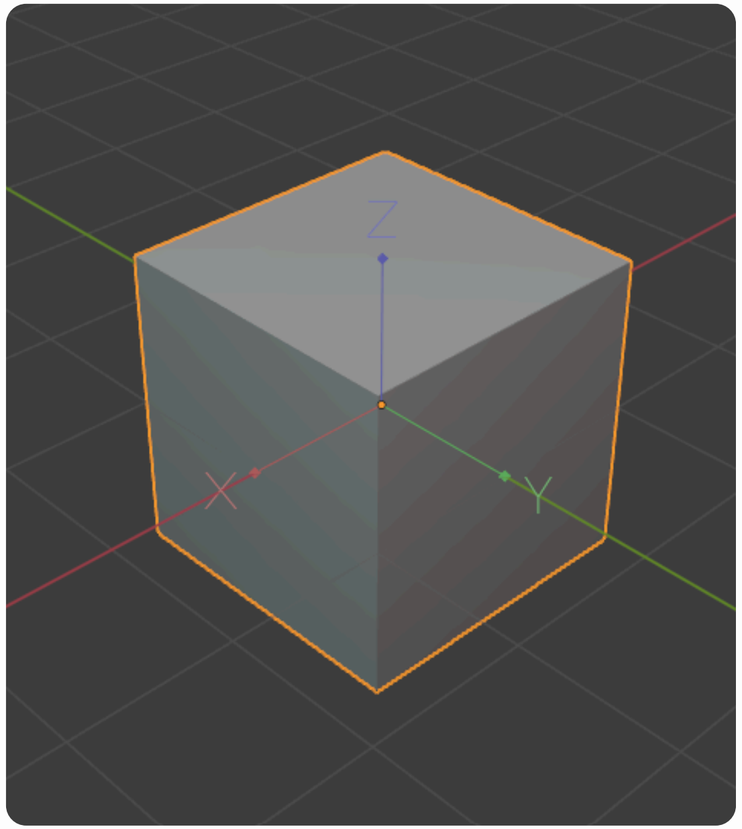


8) Primitive figures

Important property:

- The center of geometry.





9) Materials

- What are materials?

9) Materials

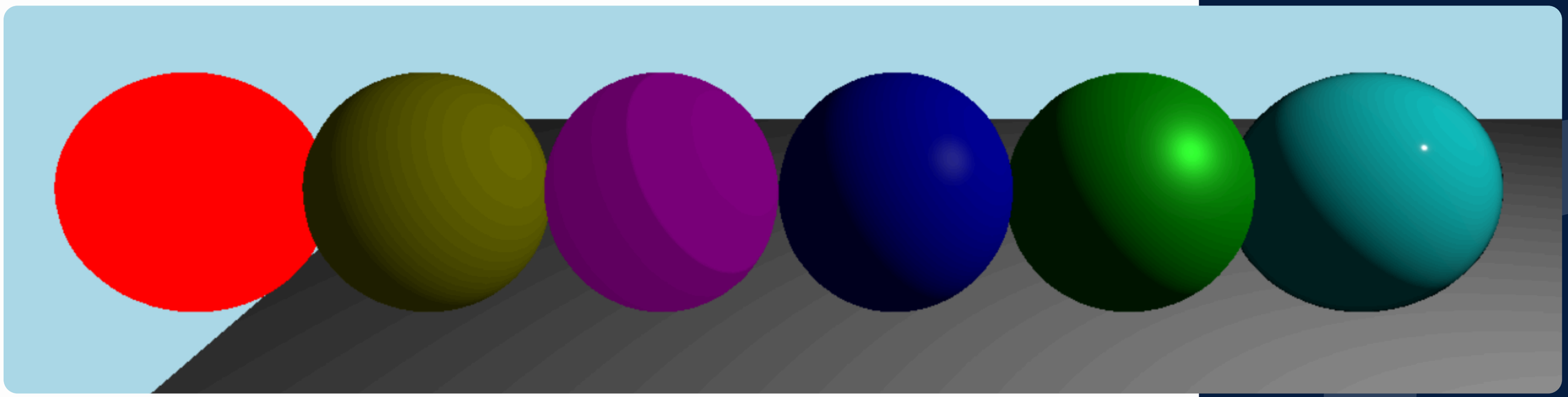
- **Material declaration:**

```
const material = new THREE.MeshBasicMaterial({
  color: 'brown',
  wireframe: true,
});

material.side = THREE.DoubleSide;
material.color = new THREE.Color('lightblue');
```

9) Materials

- **Principal materials:**

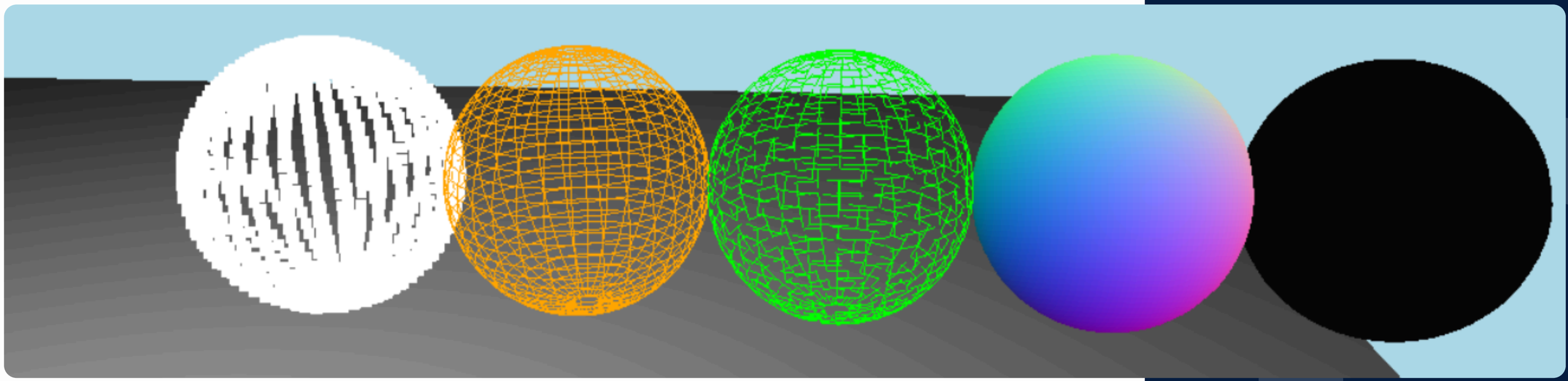
```
new THREE.MeshBasicMaterial({
new THREE.MeshLambertMaterial(
new THREE.MeshToonMaterial({ c
new THREE.MeshPhongMaterial({
new THREE.MeshStandardMaterial
new THREE.MeshPhysicalMaterial
```



9) Materials

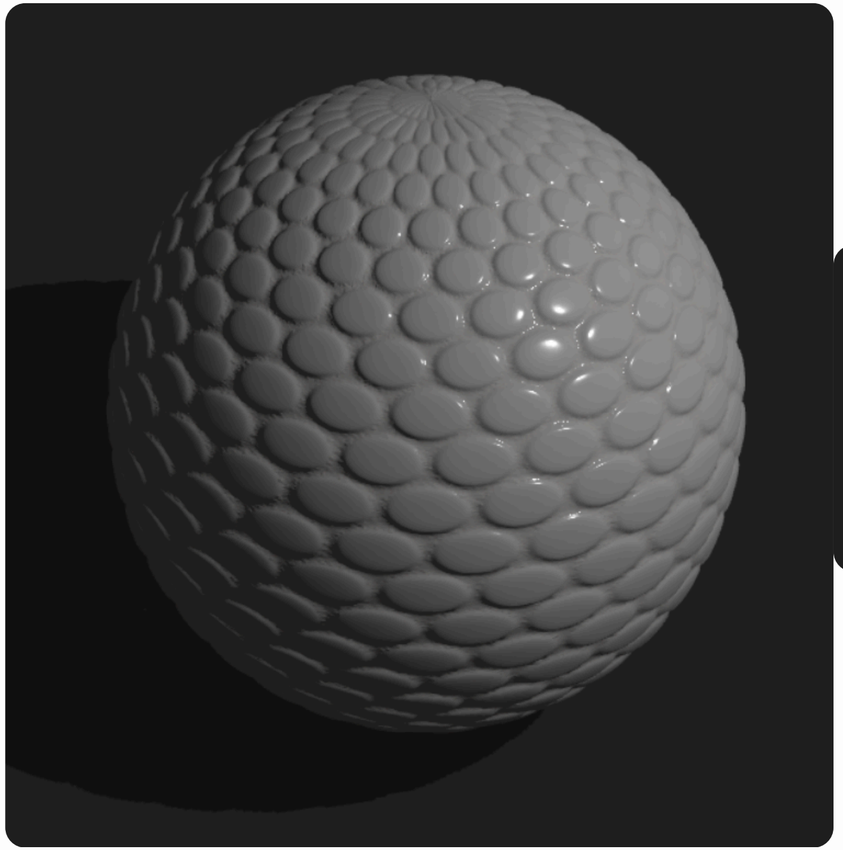
- **Other materials:**

```
new THREE.ShadowMaterial({ opac
new THREE.PointsMaterial({ colo
new THREE.LineBasicMaterial({ c
new THREE.LineDashedMaterial({
new THREE.MeshNormalMaterial(),
new THREE.MeshDepthMaterial(),
```



9) Textures

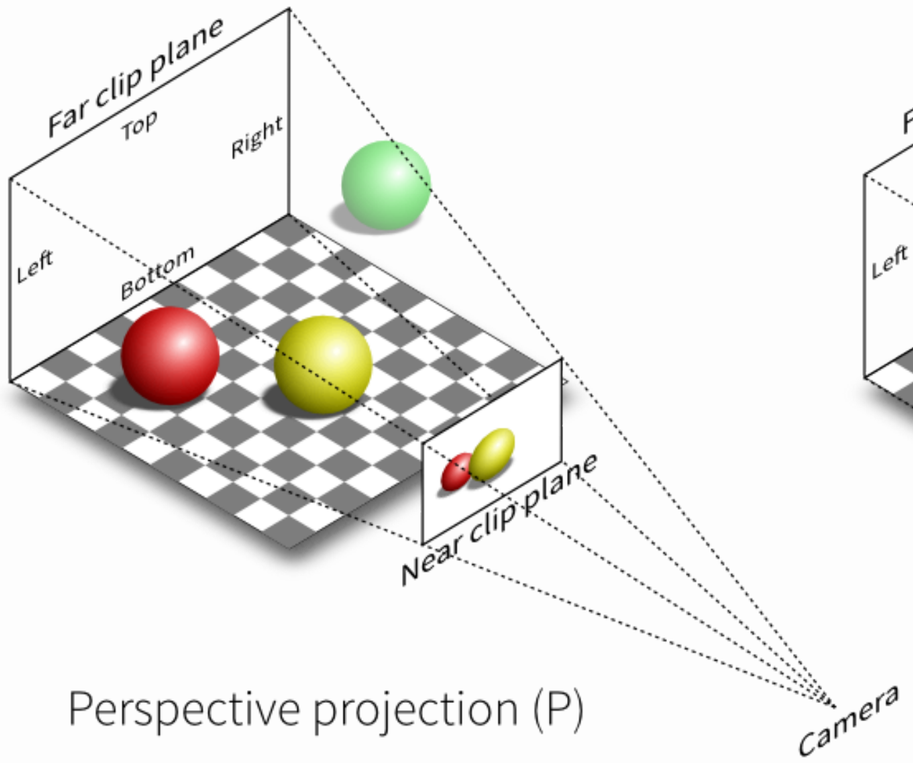
```
const textureLoader = new THREE.TextureLoader();
const colorTexture: THREE.Texture = textureLoader.load('file.png');
```



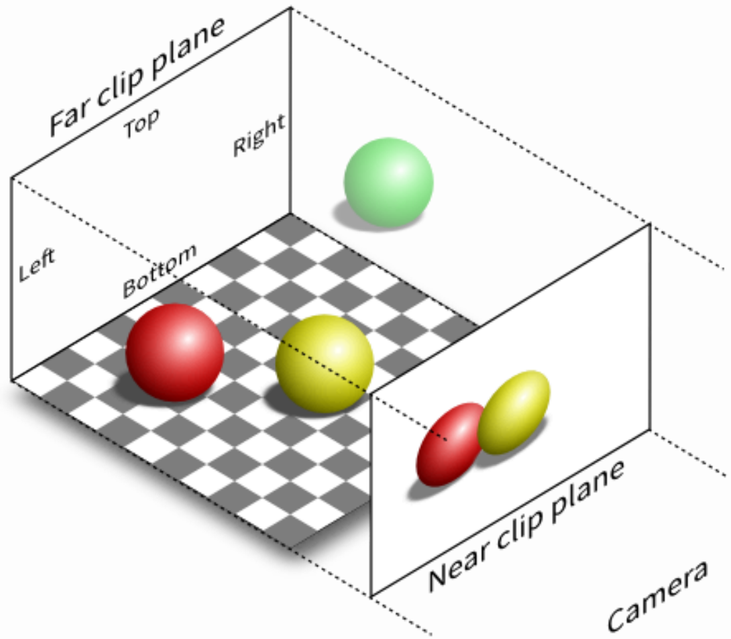
```
material.map = colorTexture;
material.normalMap = normalTexture;
material.roughnessMap = roughnessTexture;
material.displacementMap = displacementTexture;
```

10) Cameras

The view of the scene.



Perspective projection (P)

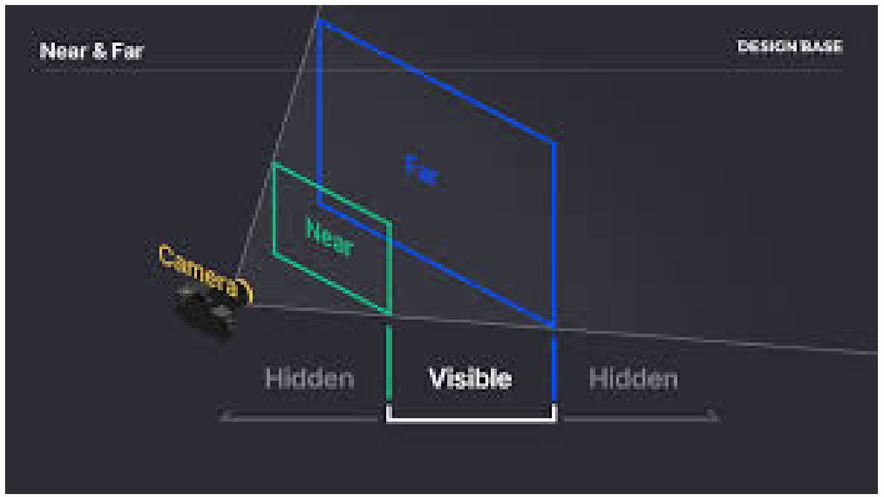


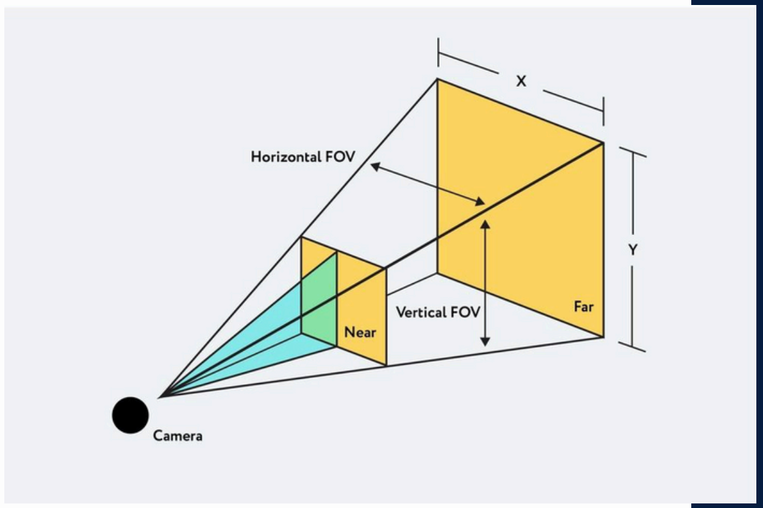
Orthographic projection (O)

10) Cameras

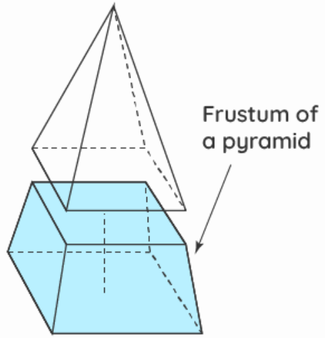
Main properties of camaras:

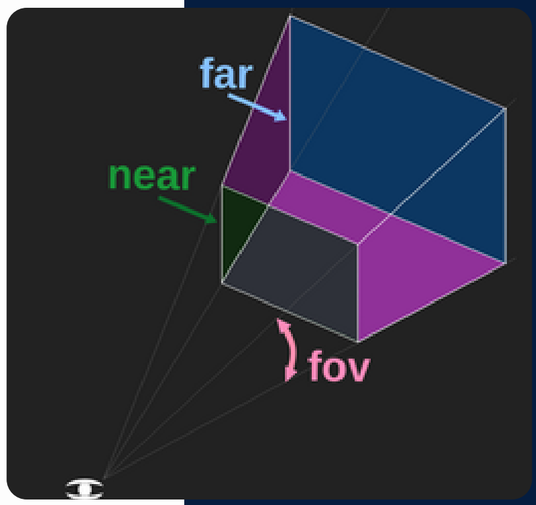
- Near
- Far





10) Cameras





Perspective camera:

- Defined with a frustum (depht).
- **Fov:** field of view in degrees.
- **Aspect :** width / height relationship.

```
const fov = 75;
const aspect = window.innerWidth / window.innerHeight;
const near = 0.1;
const far = 500;
const camera = new THREE.PerspectiveCamera(fov, aspect, near, far);
```

Interactive aplication of prespective camera

10) Cameras

Orthographic camera:

- Defined with a box, (2D view).
- Left, right, top, bottom: Defines visible limits of the box.

```
const near = 0.1;
const far = 500;
const left = -1;
const right = 1;
const top = 1;
const bottom = -1;
const camera = new THREE.OrthographicCamera(left, right, top, bottom, near, far);
```

Interactive aplication of ortographic camera

10) Cameras

Orbit controls:

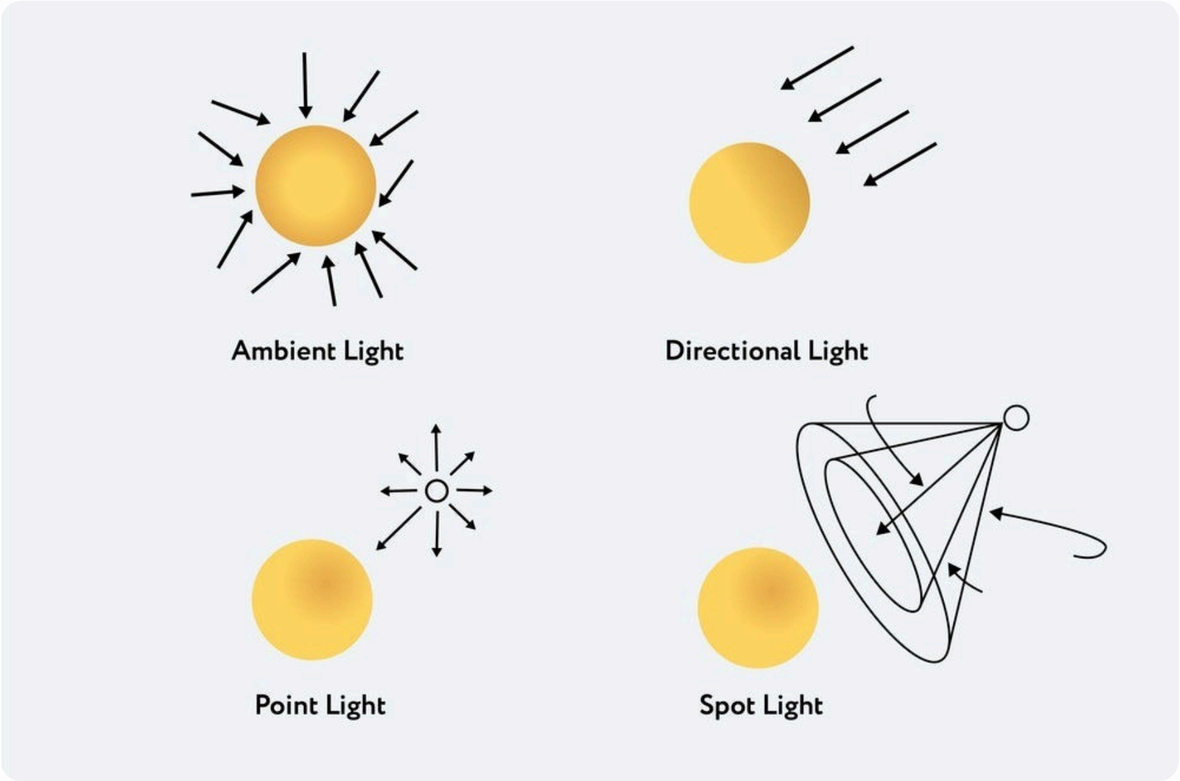
- Allows you to manipulate the camera for the main types of movements:
- **Rotate:** Rotate the camera around a focus point.
- **Zoom:** Zoom in and out.

```
import { OrbitControls } from 'three/examples/jsm/controls/OrbitControls.js';
```

```
const controls = new OrbitControls(camera, renderer.domElement);
```

11) Lights

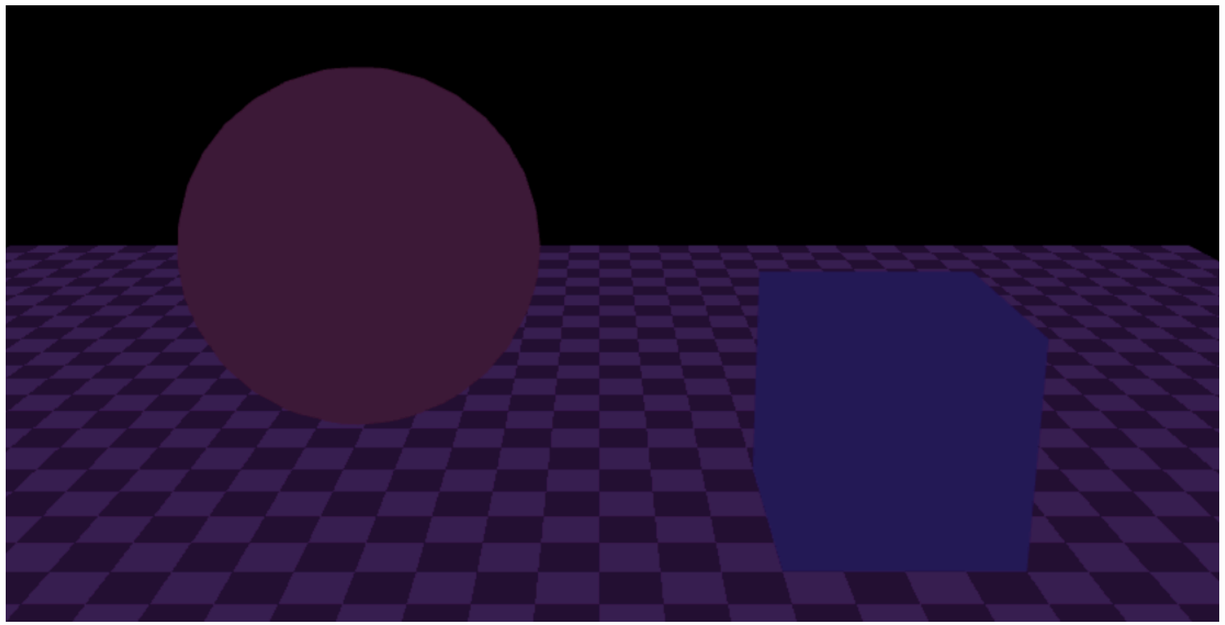
Responsible for lighting the scene.



11) Lights

Main properties of lights:

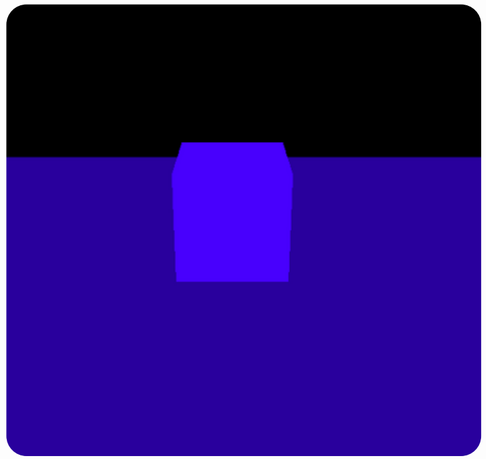
- Color.
- Intensity.

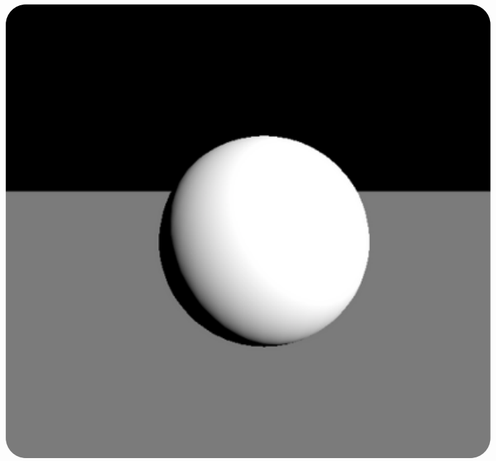


11) Lights

Some type of lights:

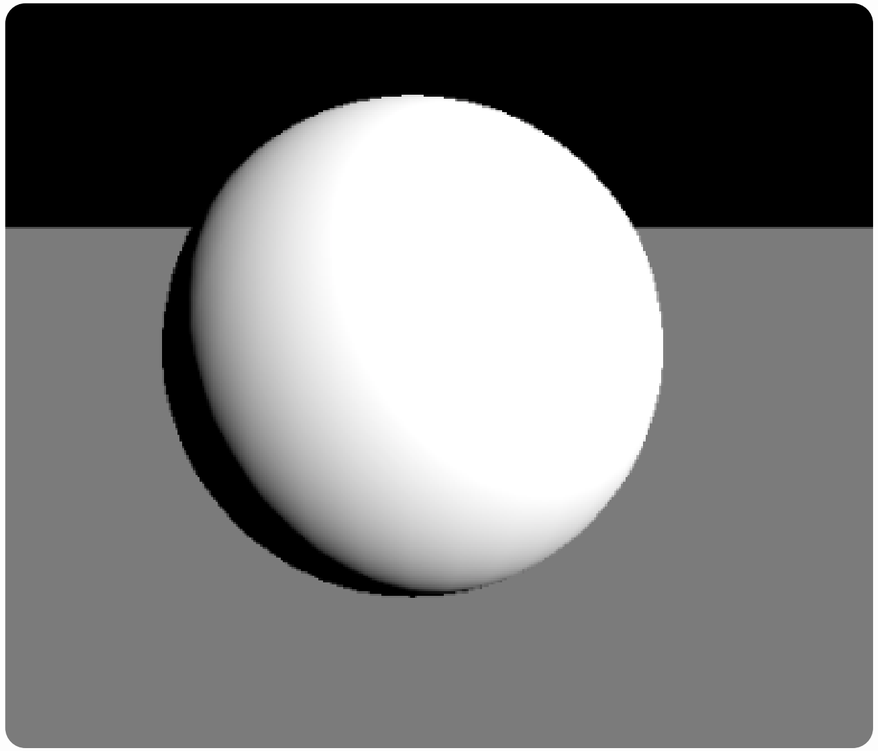
- Ambient. Interactive aplication of ambient light
- Directional. Interactive aplication of directional light
- Hemispheric. Interactive aplication of hemispherical light
- Point. Interactive aplication of point light
- Spot. Interactive aplication of spot light

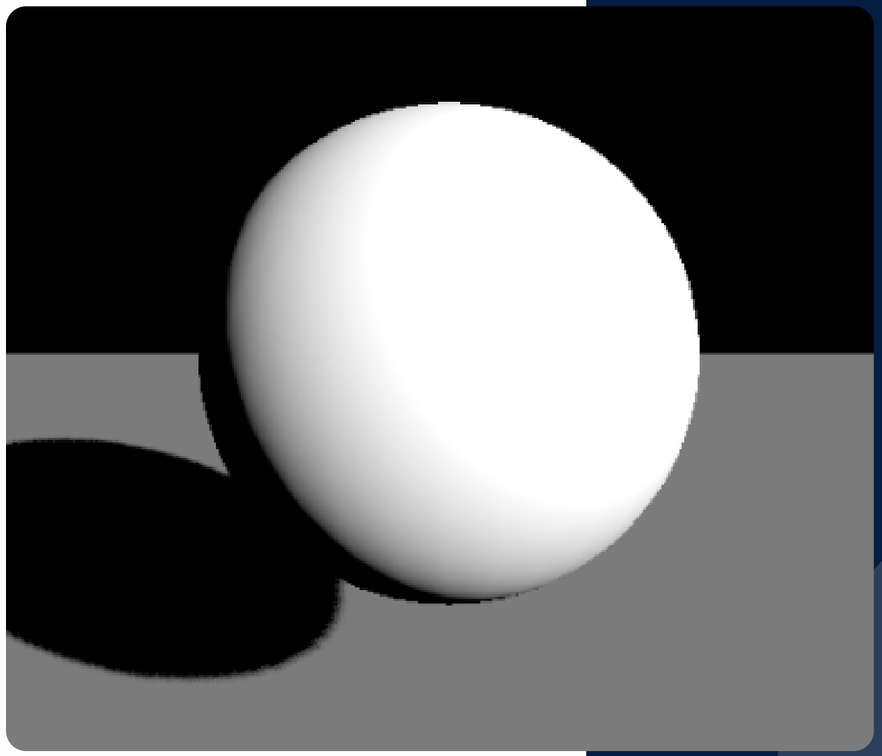




12) Shadows

Difference between a lighting effect and a shadow in Three.js.





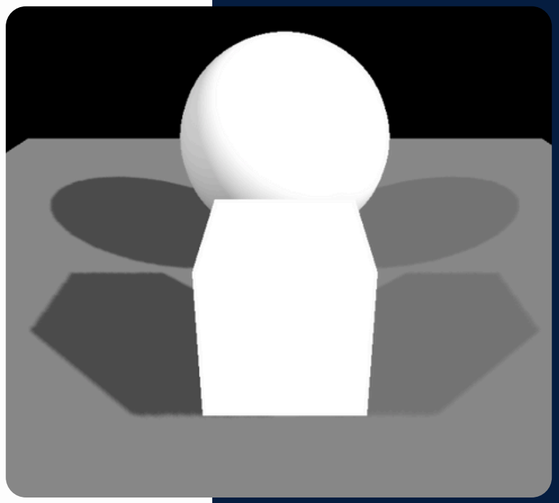
12) Shadows

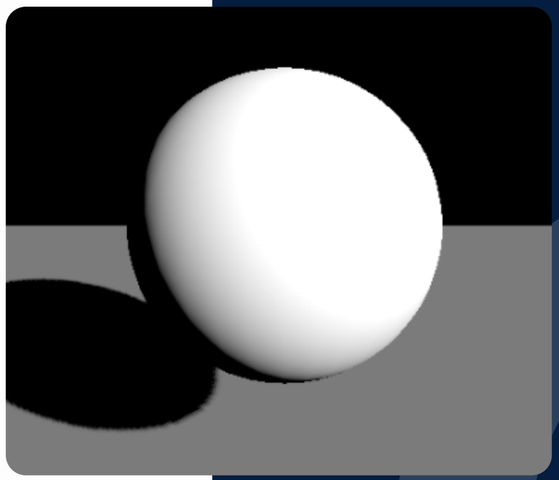
Steps for enable shadows:

1. Enable shadowMap at renderer.
2. Enable light cast shadows.
3. Enable Objects cast or recive shadows.

Some type of shadows (Set at thre renderer):

- BasicShadowMap.
- PCFShadowMap.
- PCFSoftShadowMap.

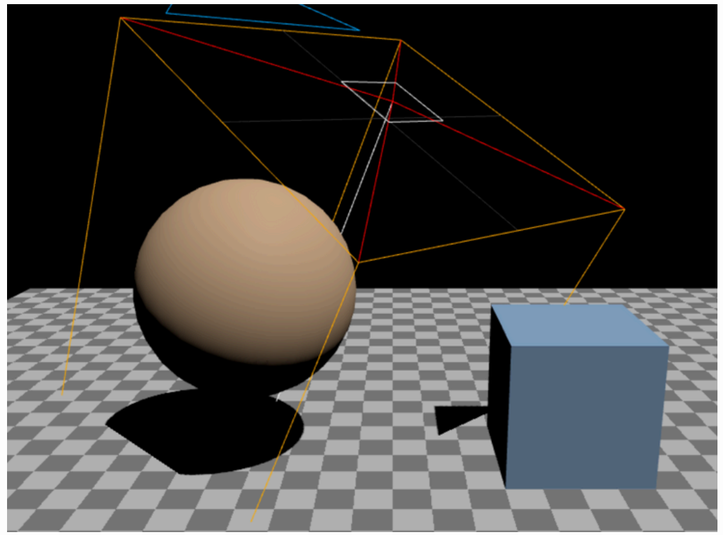


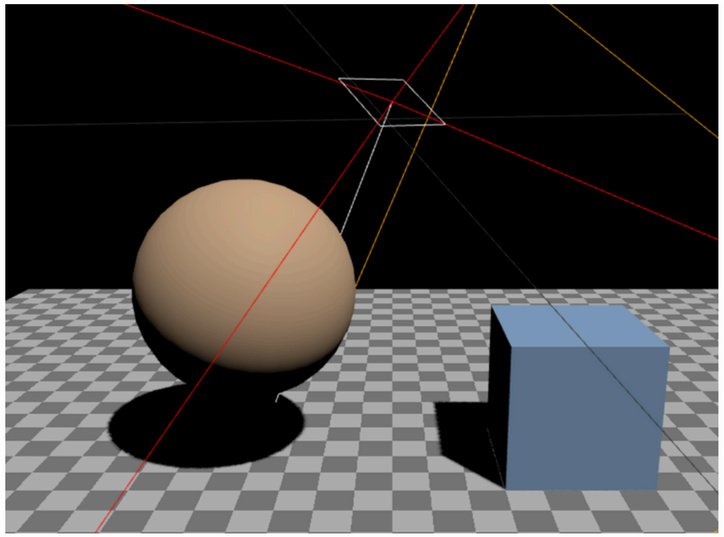


Interactive aplication of Shadows

12) Shadows

Light shadow camera:
Is the shadow range generated by the light.





Interactive aplication of shadows camera

12) Shadows 

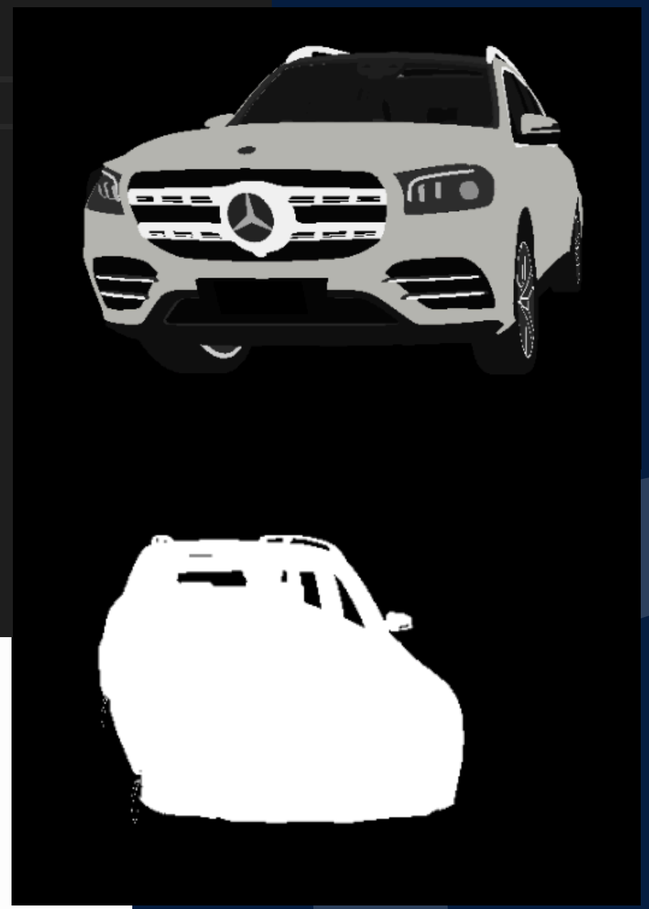
Not all lights and materials generates shadows:

Light	Cast Shadows
Ambient	✗
Directional	✓
Hemispheric	✗
Spot	✓
Point	✓

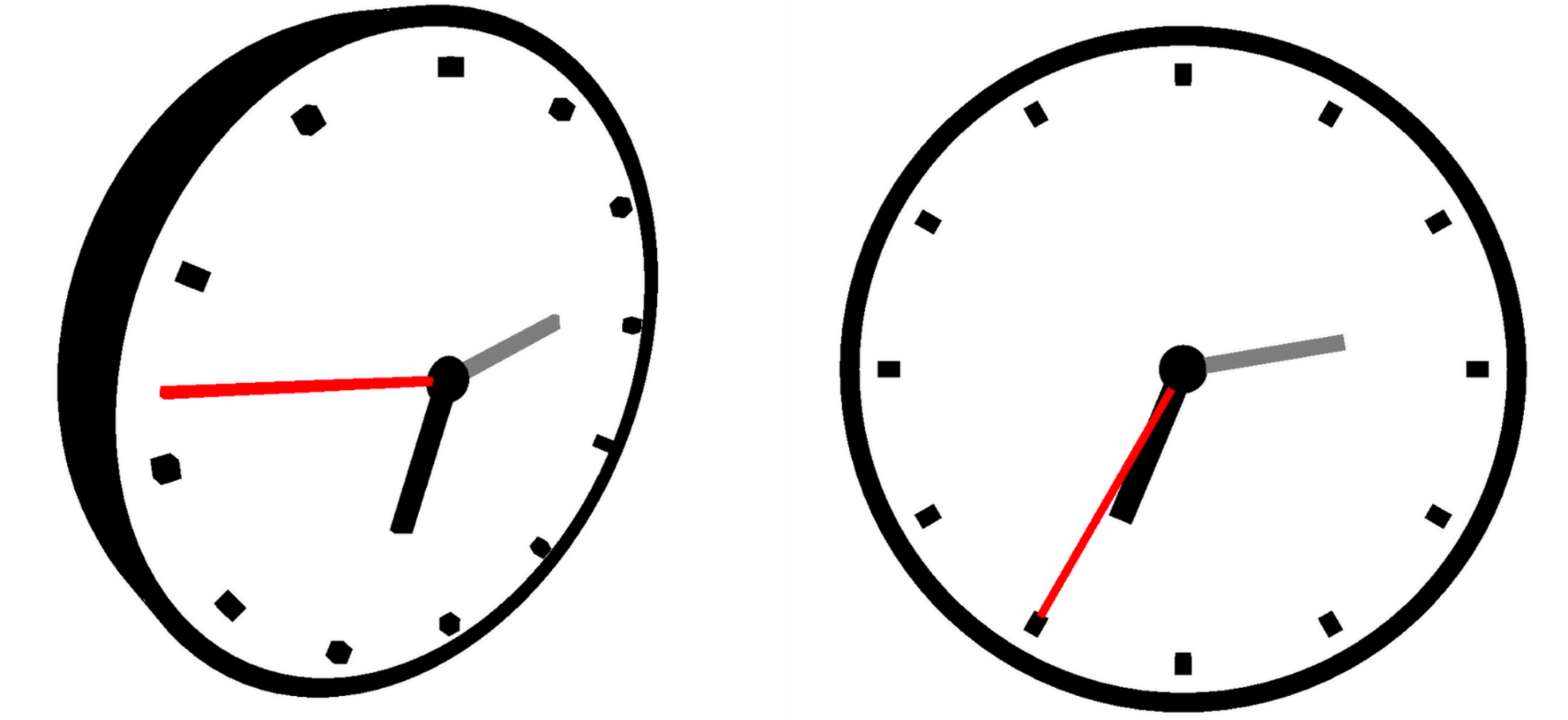
Material	Cast Shadows
Basic	✗
Phong	✓
Lambert	✓
Standard	✓
Physical	✓

13) Loading OBJ and FBX

```
import { OBJLoader } from 'three/examples/jsm/loaders/OBJLoader.js';
import { FBXLoader } from 'three/examples/jsm/loaders/FBXLoader.js';

const loader = new FBXLoader();
loader.load('Mercedes-model/Mercedes.fbx', (fbx) => {
  fbx.scale.set(0.05, 0.05, 0.05);
  fbx.position.set(-7, 0, 0);
  scene.add(fbx);
});

const objLoader = new OBJLoader();
objLoader.load('./Mercedes-model/Mercedes.obj', (obj) => {
  scene.add(obj);
});
```



14) Clock at Three.js



Clock at three js

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- 3D Graphics: A WebGL Tutorial: https://www.toptal.com/javascript/3d-graphics-a-webgl-tutorial
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- Animating Textures in WebGL: https://developer.mozilla.org/en-US/docs/Web/API/WebGL_API/Tutorial/Animating_textures_in_WebGL
- Three.js documentation: https://threejs.org/docs/
- Three.js video tutorial: https://www.youtube.com/watch?v=Y4PvekQUIqk&list=PLDllzmccetSPVF3JN6OFazp39N00yHE3A&index=3

Thank you