Effects and animation.

Part 2.

Particle systems.


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Game
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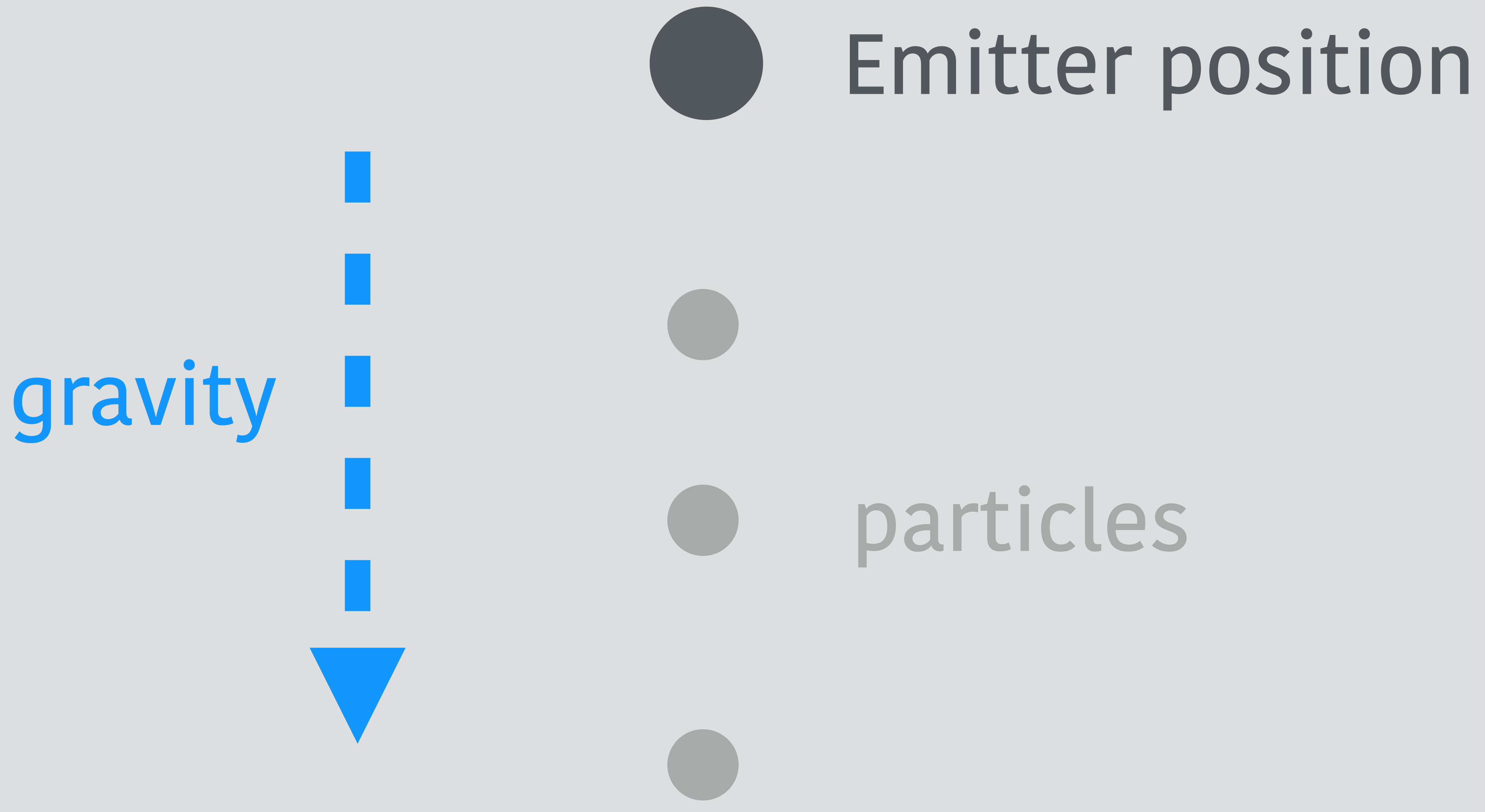
www.gamereactor.se/dk/no

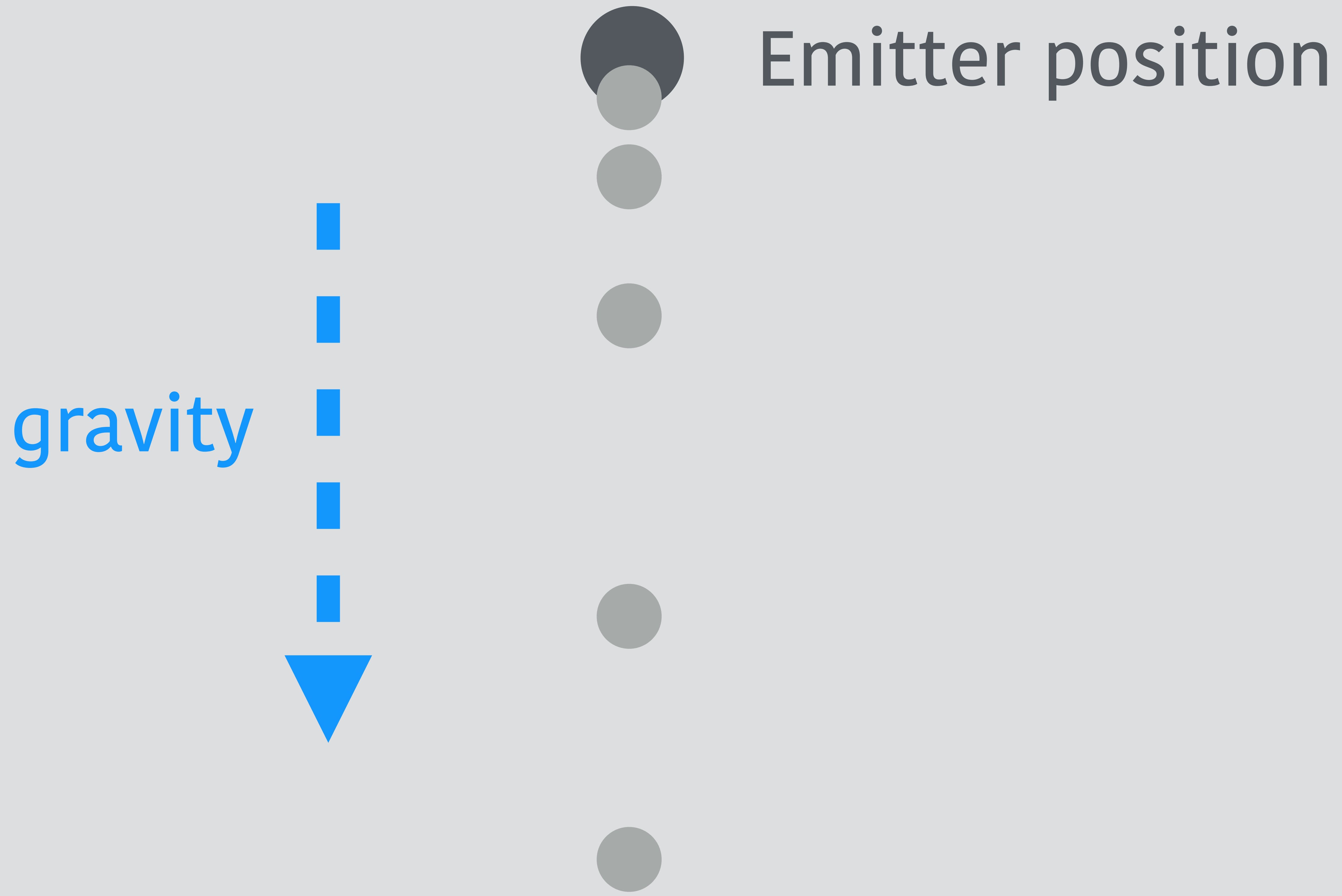
Anatomy of a basic **particle system**.

A dripping faucet.

An **emitter** contains an **array of particles**, which have a **position**, **velocity** and a **lifetime**. Their only **acceleration** is the particle emitter's **gravity** and we **don't care about friction**.



For **each particle**, adjust **velocity** and **position** based on **elapsed time** and add **elapsed time** to the **particle's lifetime**.
When a particle's **lifetime exceeds** the particle system's **max lifetime**, it is **reset to the emitter's position and its lifetime is set to 0**.



Particle Emitter

```cpp
class ParticleEmitter {
    public:
        ParticleEmitter(unsigned int particleCount);

        ParticleEmitter();
        ~ParticleEmitter();


        void Update(float elapsed);
        void Render();

        Vector position;
        Vector gravity;
        float maxLifetime;

        std::vector<Particle> particles;
};
```

```cpp
class Particle {
    public:
        Vector position;
        Vector velocity;
        float lifetime;
};
```

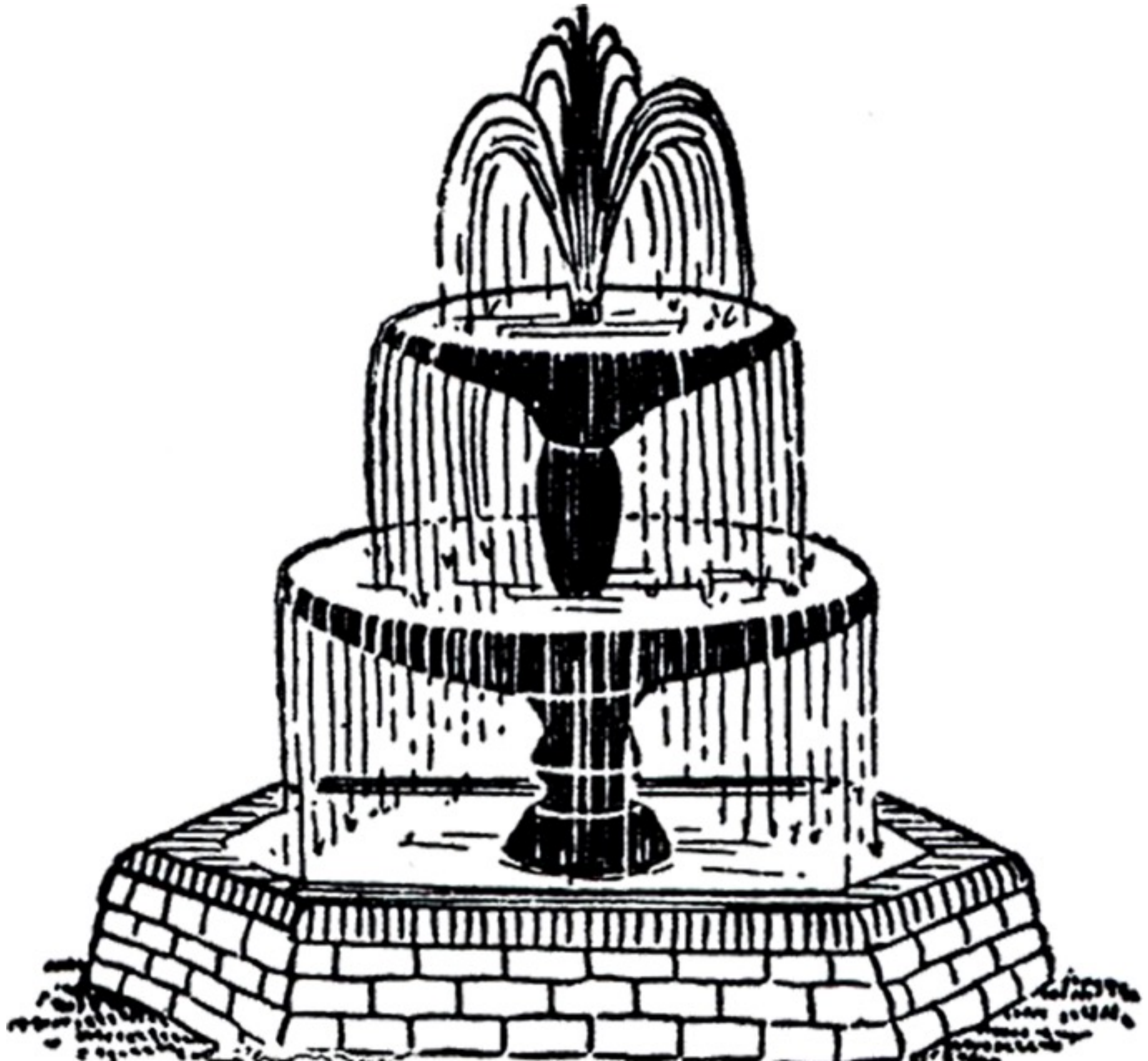
Make sure the **particles’ lifetime** is set to a **random value** up to the maximum lifetime, so they don’t reset all together!

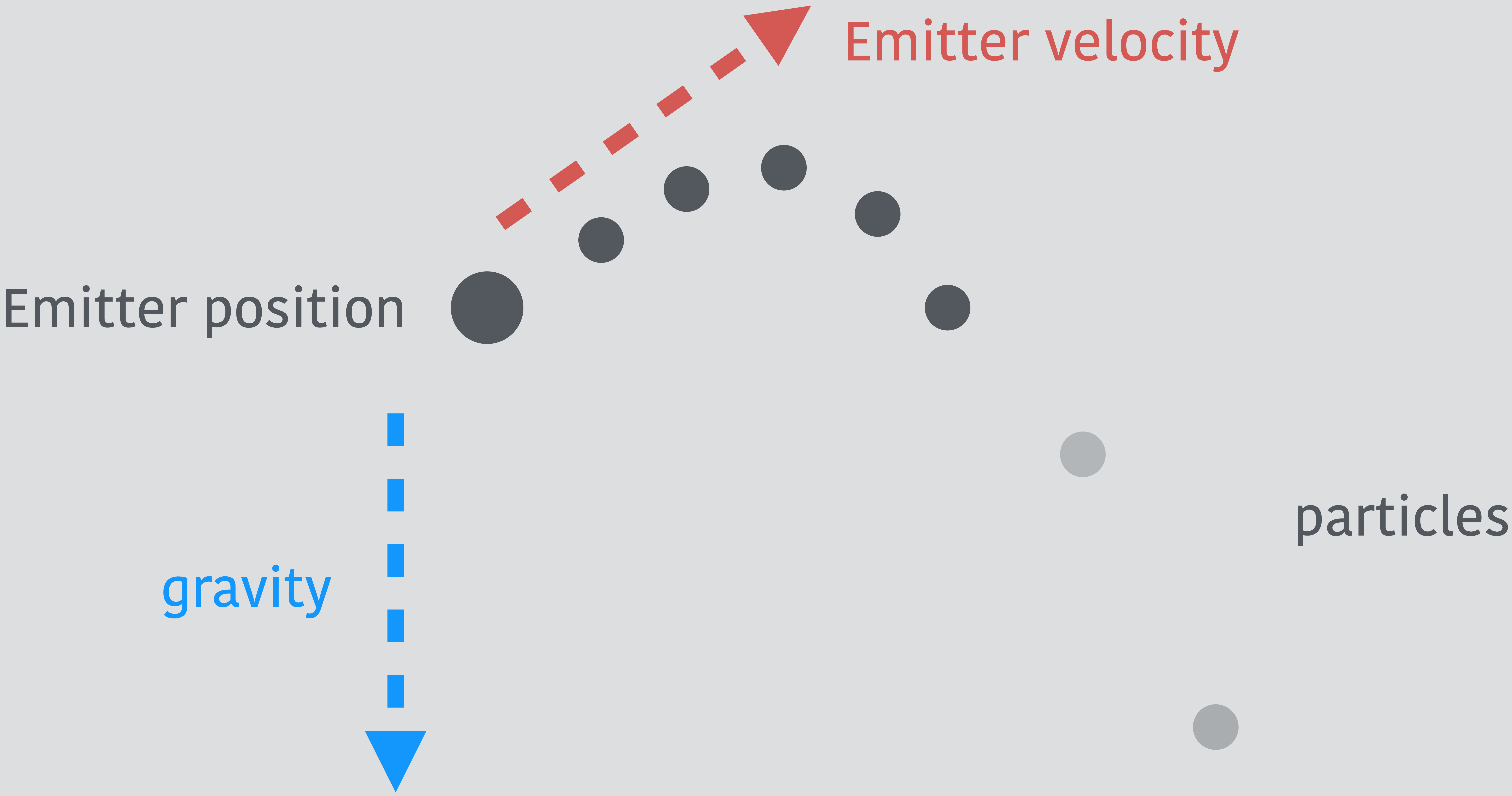
Drawing the particles.

```
std::vector<float> vertices;

for(int i=0; i < particles.size(); i++) {
    particleVertices.push_back(particles[i].position.x);
    particleVertices.push_back(particles[i].position.y);
}

glVertexAttribPointer(program.positionAttribute, 2, GL_FLOAT, false, 0, vertices.data());
glEnableVertexAttribArray(program.positionAttribute);

glDrawArrays(GL_POINTS, 0, vertices.size()/2);
```

Launching particles.

A fountain.



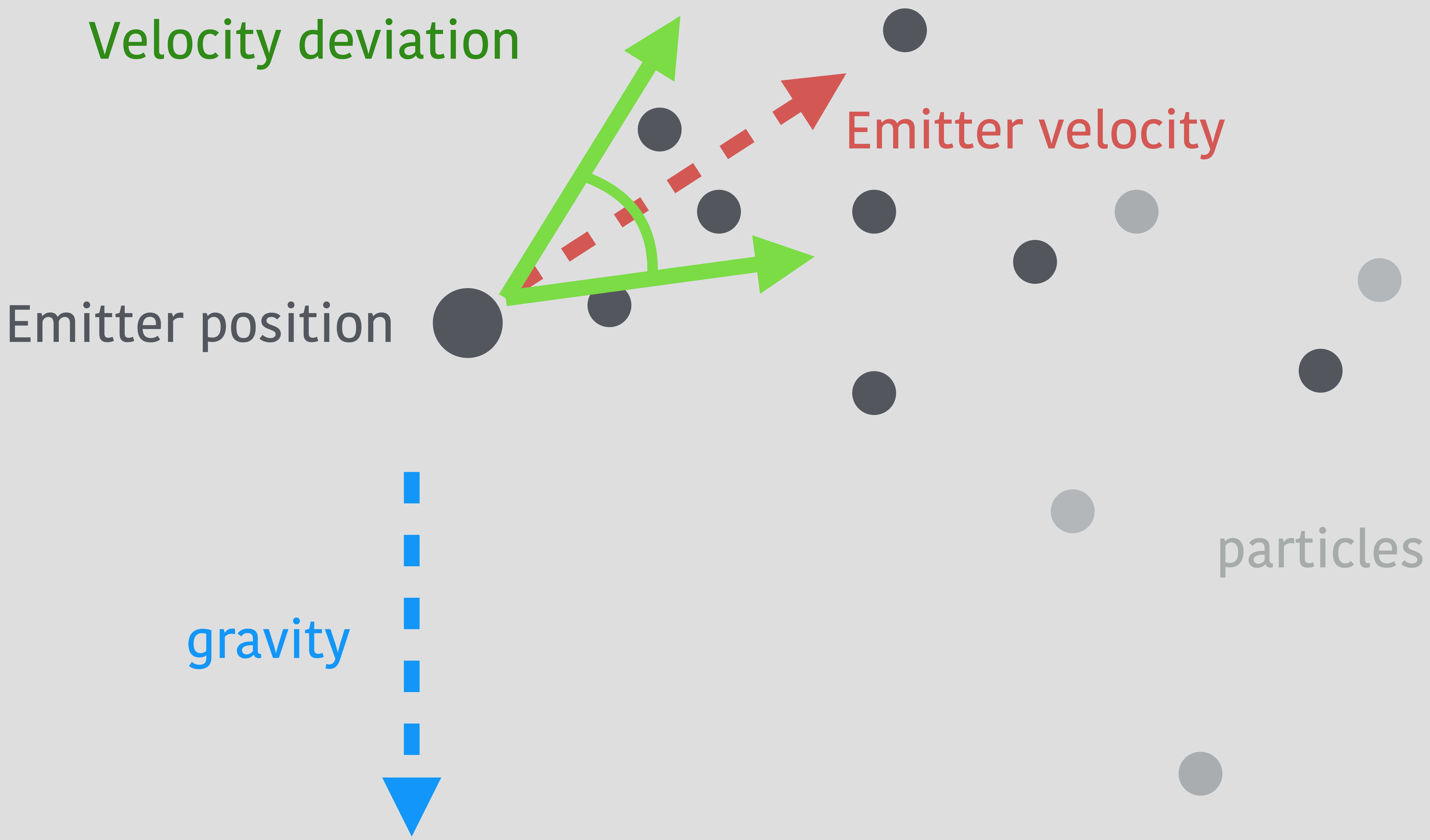

Emitter velocity
Emitter position
gravity
particles

Let’s add a **velocity** to the emitter.

```
class ParticleEmitter {
    public:

        // . . .
        Vector velocity;
};
```

When resetting particles, let ’s now **set their velocity** to the **emitter’s velocity**.

We don’t always want to shoot all particles in a straight line.


Velocity deviation
Emitter velocity
Emitter position
gravity
particles

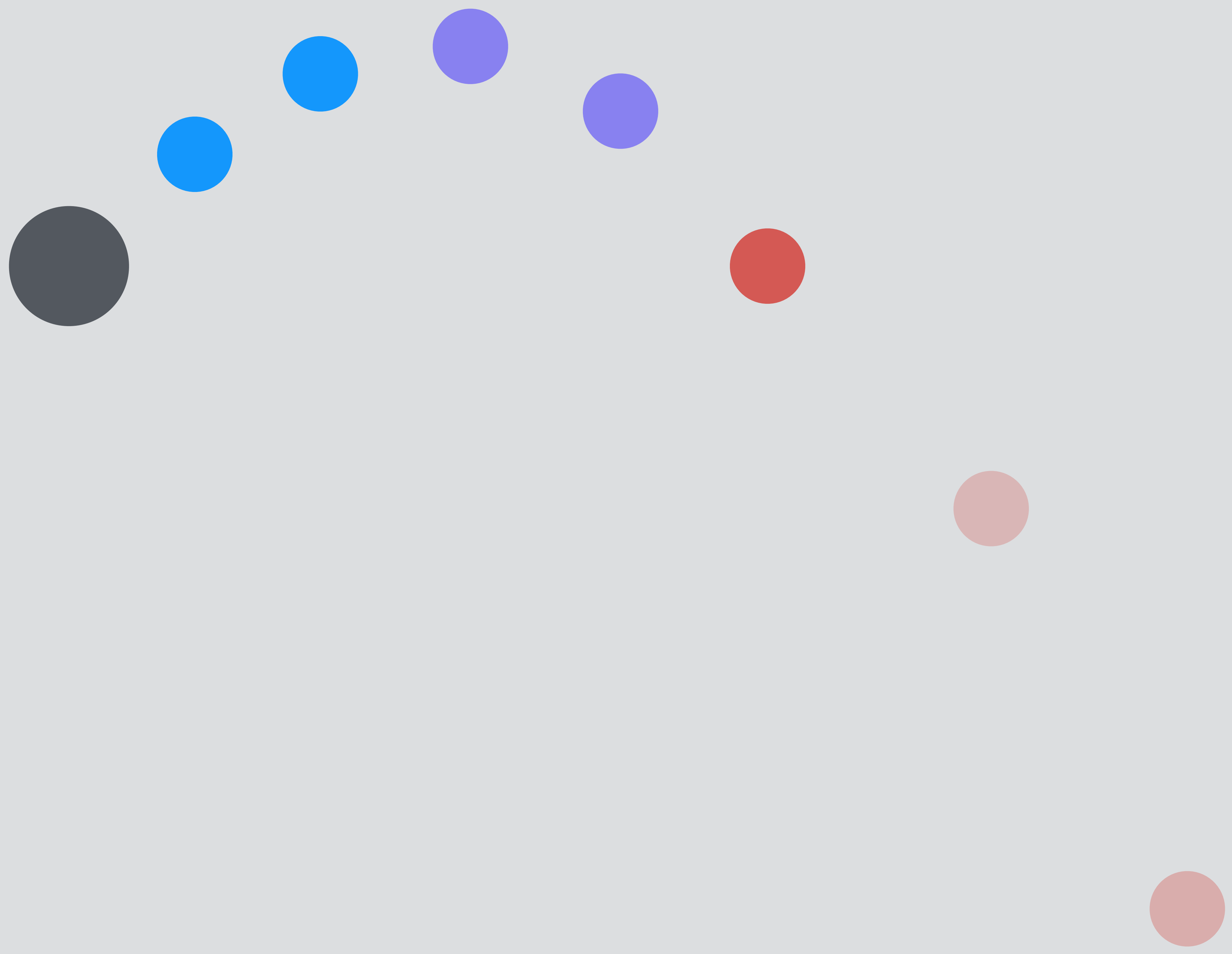
Let’s add a velocity **deviation**.

```
class ParticleEmitter {
    public:

        // . . .
        Vector velocity;
        Vector velocityDeviation;
```

When setting the particles’ velocity to the emitter’s velocity, let’s **add a random value within the velocityDeviation** to the velocity.

Adding **color**

Let's add a **starting** and **ending colors** to the emitter, so the particles can **change color as they travel**.



```
class ParticleEmitter {
    public:

        // . . .
        Color startColor;
        Color endColor;
};
```

Lerp the **color** based on the **percentage of particle lifetime to the maximum lifetime**.

```
std::vector<float> particleColors;

for(int i=0; i < particles.size(); i++) {
       float m = (particles[i].lifetime/maxLifetime);
       particleColors.push_back(lerp(startColor.r, endColor.r, m));
       particleColors.push_back(lerp(startColor.g, endColor.g, m));
       particleColors.push_back(lerp(startColor.b, endColor.b, m));
       particleColors.push_back(lerp(startColor.a, endColor.a, m));
   }
```

Using **vertex colors**.

```
attribute vec4 position;
attribute vec4 color;

uniform mat4 modelMatrix;
uniform mat4 viewMatrix;
uniform mat4 projectionMatrix;

varying vec4 vertexColor;

void main()
{
  vec4 p = viewMatrix * modelMatrix  * position;
   vertexColor = color;
  gl_Position = projectionMatrix * p;
```

```
varying vec4 vertexColor;

void main()
{
    gl_FragColor = vertexColor;
}
```

Get the color **attribute location**.

```
GLuint colorAttribute = glGetAttribLocation(program->programID, "color");
```

Set the **attribute pointer** to the color data vector.

```
glVertexAttribPointer(colorAttribute, 4, GL_FLOAT, false, 0, colors.data());
glEnableVertexAttribArray(colorAttribute);
```

Color deviation.

We can add a color deviation to the emitter.
Every time we reset a particle, we set its color deviation to a random value within the color deviation range.

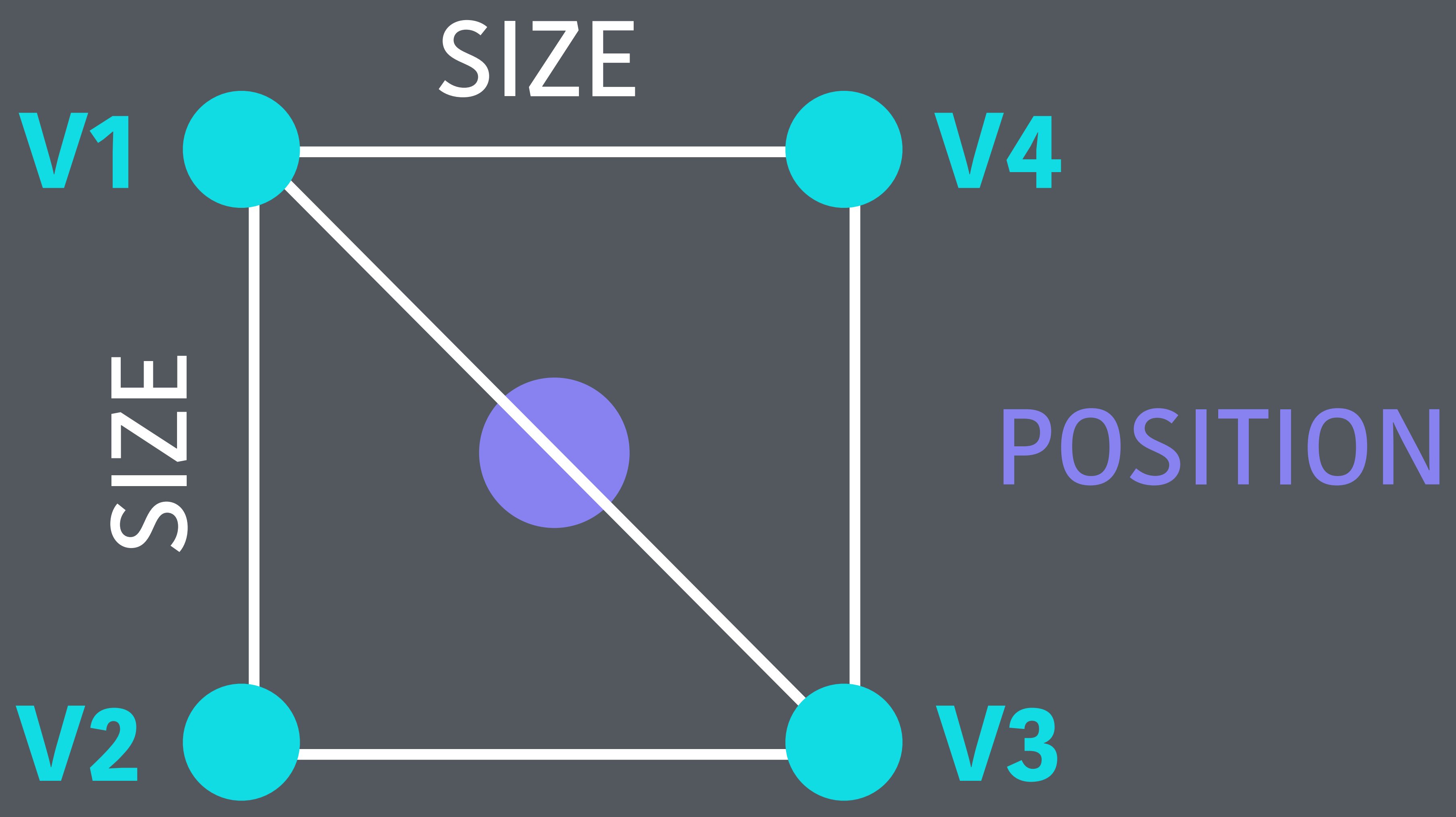
```
particles[i].colorDeviation.r = (-colorDeviation.r * 0.5) + (colorDeviation.r *
((float)rand() / (float)RAND_MAX));
```

Then, when we lerp our color values, we can add the deviation for each color component.

```
  particleColors.push_back(lerp(startColor.r, endColor.r, relativeLifetime) +
 particles[i].colorDeviation.r);
```

Textured particles.

Instead of points, let's draw textured **GL_TRIANGLES**.



Particles now need a **size**.
Like color, we can define **starting** and **ending sizes** and lerp between them when we draw our triangles.

Like colors, we can also add a **size deviation** to the particles and set it to a **random value** within the emitter size deviation range.

```
class ParticleEmitter {
    public:

        // . . .
        float startSize;
        float endSize;
        float sizeDeviation;


class Particle {
    public:
        // . . .
        float sizeDeviation;
};
```

```
for(int i=0; i < particles.size(); i++) {
    float m = (particles[i].lifetime/maxLifetime);
    float size = lerp(startSize, endSize, m) + particles[i].sizeDeviation;

    vertices.insert(vertices.end(), {
        particles[i].position.x - size, particles[i].position.y + size,
        particles[i].position.x - size, particles[i].position.y - size,
        particles[i].position.x + size, particles[i].position.y + size,

        particles[i].position.x + size, particles[i].position.y + size,
        particles[i].position.x - size, particles[i].position.y - size,
        particles[i].position.x + size, particles[i].position.y - size

    });

    texCoords.insert(texCoords.end(), {
        0.0f, 0.0f,
        0.0f, 1.0f,
        1.0f, 0.0f,

        1.0f, 0.0f,
        0.0f, 1.0f,
        1.0f, 1.0f
    });

    for(int j=0; j < 6; j++) {
        colors.push_back(lerp(startColor.r, endColor.r, m));
        colors.push_back(lerp(startColor.g, endColor.g, m));
        colors.push_back(lerp(startColor.b, endColor.b, m));
        colors.push_back(lerp(startColor.a, endColor.a, m));
    }
}
```

```
glVertexAttribPointer(program->positionAttribute, 2, GL_FLOAT, false, 0, vertices.data());
glEnableVertexAttribArray(program->positionAttribute);

glVertexAttribPointer(colorAttribute, 4, GL_FLOAT, false, 0, colors.data());
glEnableVertexAttribArray(colorAttribute);

glVertexAttribPointer(program->texCoordAttribute, 2, GL_FLOAT, false, 0, texCoords.data());
glEnableVertexAttribArray(program->texCoordAttribute);

glDrawArrays(GL_TRIANGLES, 0, vertices.size()/2);
```

```
attribute vec4 position;
attribute vec4 color;
attribute vec2 texCoord;

uniform mat4 modelMatrix;
uniform mat4 viewMatrix;
uniform mat4 projectionMatrix;

varying vec4 vertexColor;
varying vec2 varTexCoord;

void main()
{
  vec4 p = viewMatrix * modelMatrix  * position;
    vertexColor = color;
    varTexCoord = texCoord;
  gl_Position = projectionMatrix * p;
}
```

```
uniform sampler2D diffuse;

varying vec4 vertexColor;
varying vec2 varTexCoord;

void main()
{
    gl_FragColor = texture2D(diffuse, varTexCoord) * vertexColor;
}
```

Particle **rotation**.

Particles now have a **rotation property**, that is increased based on time elapsed for each particle.

```
class Particle {
    public:
        // . . .
        float rotation;
};
```

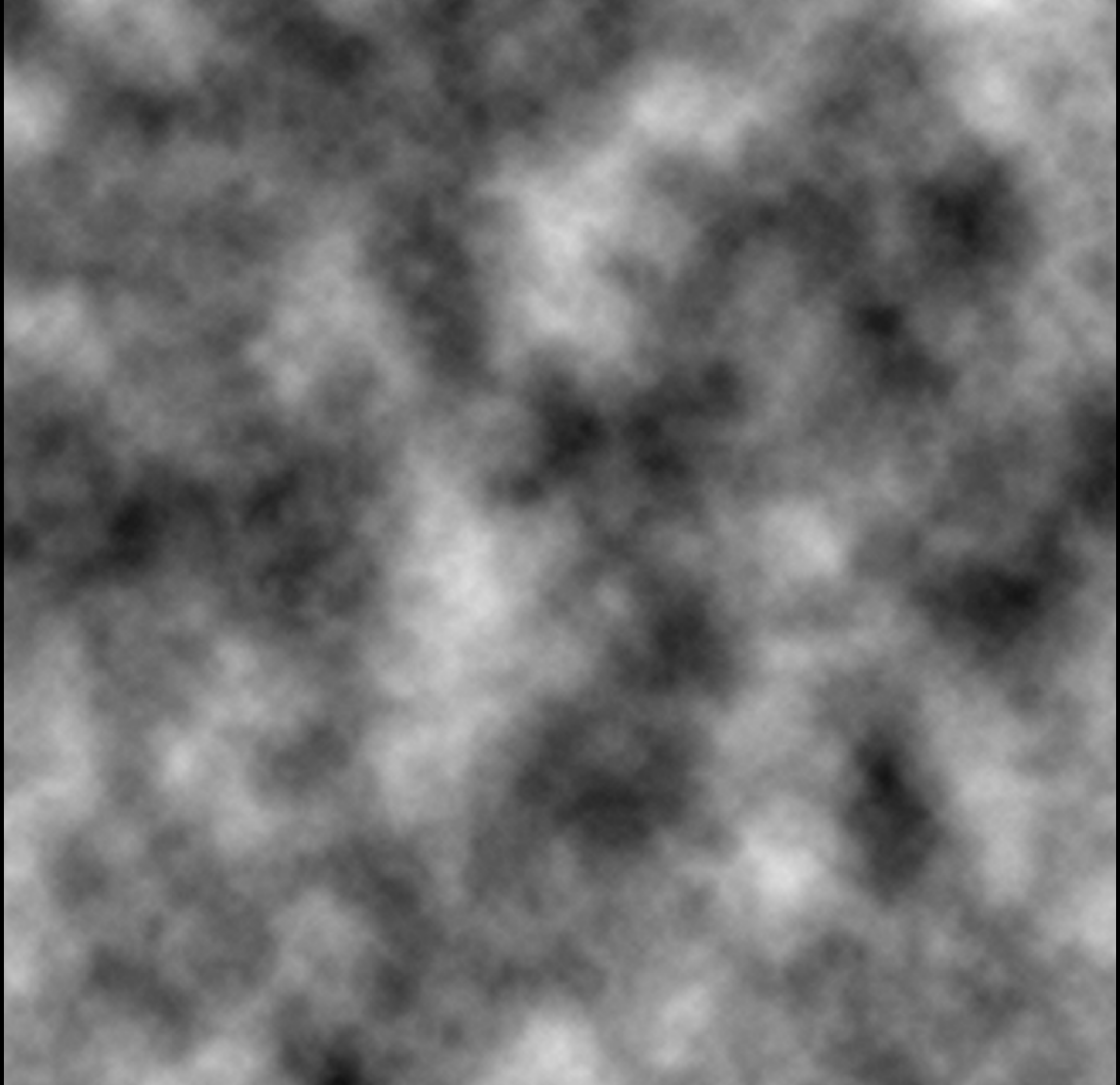
Since we are drawing as a single array,
we cannot use the model matrix to rotate and need to rotate the vertices manually.

$$\begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} x\cos\theta - y\sin\theta \\ x\sin\theta + y\cos\theta \end{bmatrix}$$

```
float cosTheta = cosf(particles[i].rotation);
float sinTheta = sinf(particles[i].rotation);

float TL_x = cosTheta * -size - sinTheta * size;
float TL_y = sinTheta * -size + cosTheta * size;

float BL_x = cosTheta * -size - sinTheta * -size;
float BL_y = sinTheta * -size + cosTheta * -size;

float BR_x = cosTheta * size - sinTheta * -size;
float BR_y = sinTheta * size + cosTheta * -size;

float TR_x = cosTheta * size - sinTheta * size;
float TR_y = sinTheta * size + cosTheta * size;


vertices.insert(vertices.end(), {
            particles[i].position.x + TL_x, particles[i].position.y + TL_y,
            particles[i].position.x + BL_x, particles[i].position.y + BL_y,
            particles[i].position.x + TR_x, particles[i].position.y + TR_y,

            particles[i].position.x + TR_x, particles[i].position.y + TR_y,
            particles[i].position.x + BL_x, particles[i].position.y + BL_y,
            particles[i].position.x + BR_x, particles[i].position.y + BR_y
});
```

Natural particle motion using **perlin noise**.



Add a variable to particles to vary their Perlin noise Y-position and set it to some random value.

```
class Particle {
    public:
        // . . .
        float perlinY;
};
```

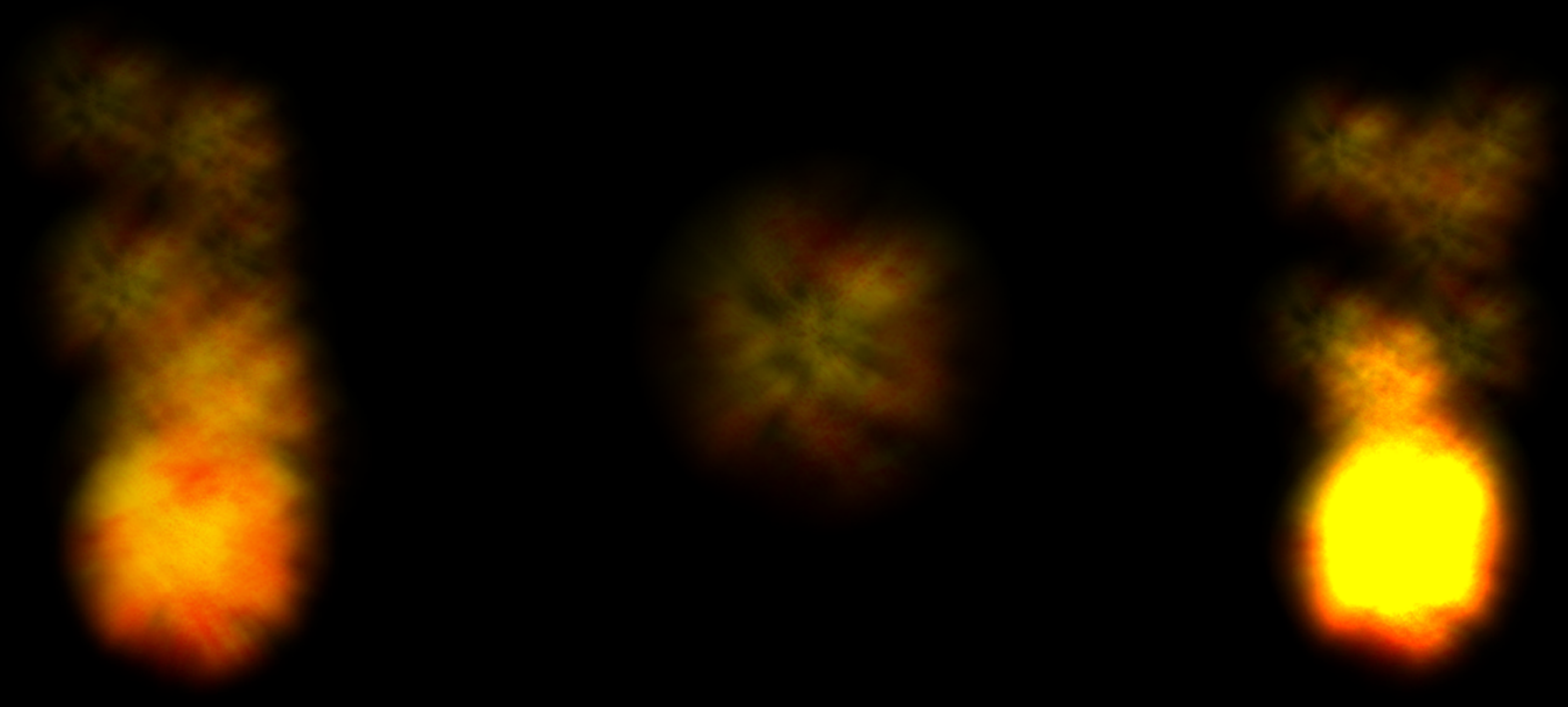
Use the Perlin noise value from their Y-position and current X-position to modify the particles’ movement.

```
perlinValue += elapsed;
// …

float coord[2] = {perlinValue, particles[i].perlinY};
particles[i].position.x += noise2(coord) * perlinSize;
coord[0] = perlinValue * 0.5f;
particles[i].position.y += noise2(coord) * perlinSize;
```

Additive blending.

Regular

Additive



Alpha blending

```
glBlendFunc(GL_SRC_ALPHA, GL_ONE_MINUS_SRC_ALPHA);
```

Additive blending

```
glBlendFunc (GL_SRC_ALPHA, GL_ONE);
```

Changing emitter **size**.

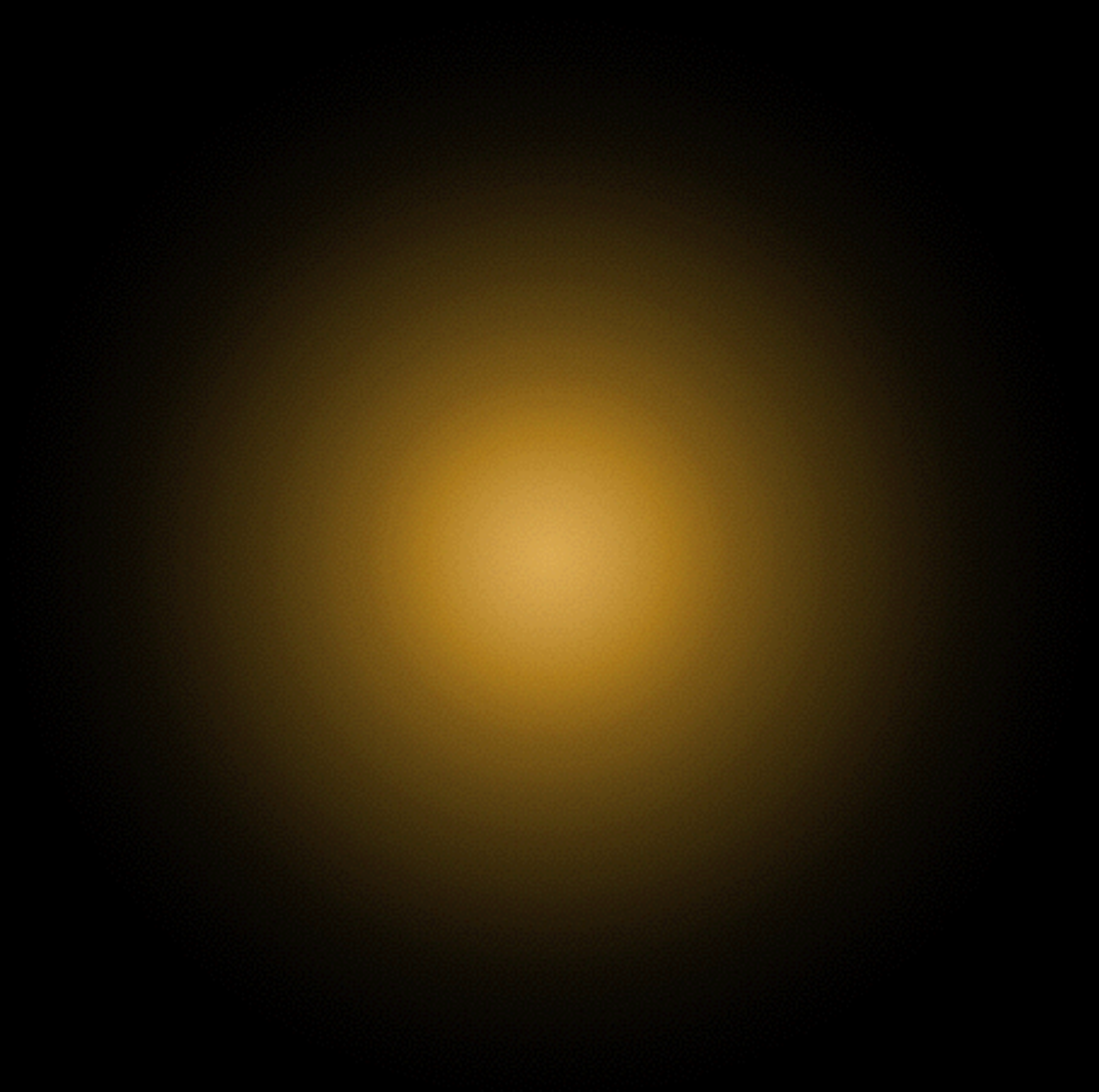
When resetting a particle, set its **position** to emitter position + **random value within emitter size range**.

Triggered particle emitters.

For a triggered emitter, simply do not reset particles after their lifetime is maxed out. Add a **Trigger** method to the emitter, to reset all of the particles instead.

Making things **glow**.

Drawing a glow texture using additive blending on top of other graphics.



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