2017

SIMULATION & PHYSICS – PRACTICAL 6

TRANSFORMATIONS

SJORS GIELEN
500765899

1. repeat the assignment you are implementing;

Create a solar system. With some randomization in it.

Have the camera be controllable.

Create a Michellen man.

Animate the Michellen man via a bone class structure.

2. explain your approach;

For the Solar system I started with an orbital class. This class has a value ready for the object that this object will orbit around.(Execution is not perfect)

For the camera I am simply executing some mathematics.

For the Michellen man I create a bone class to propagate all the transformation matrixes through in a proper way.(This was not perfect)

For animation I only added in blinking as the rest of the code was still not working the way I wanted it too. I hope to improve this for the remedial opertunity.

3. describe your code;

Added a number of new member variables too the sphere class:

```
public Vector3 scalar;
public Vector3 position;
public Vector3 rotationAxisSpeed;//x,y,z
public Vector3 rotationRadiansSpeed;//x,y,z
public Vector3 rotationAxis;//x,y,z
public Vector3 rotationRadians;//x,y,z
```

Axis values are intended for rotation around yourself whereas Radians were rotations around the position. Scalar is straight forward.

Then I utilize these values for matrix transformations.

Orbital class looks similar but has the added value of:

```
protected Sphere orbiting;
```

Which also adds in the transformation matrix of the orbiting's transform.Translation.

The bone class looks mostly similar too the orbiting class but instead has three new member variables:

```
Bone parent;
List<Sphere> children = new List<Sphere>();
Vector3 anchor;
```

If the bone has a parent it will move the parents Transform into itself. However I never got the order here right, then ended up with several messes that did not work, so I went back to a state that kind of worked. The draw method ends by calling each child's draw, this is to ensure that the order of draws is parent first.

For the blink animation I change the colour of certain vertices in the eye bone's,

4. show (relevant) code snippets;

```
            // Step 1: Study the way the Sphere class is used in Initialize()
            // Step 2: Scale the sun uniformly (= the same factor in x, y and z directions) by a
factor 2
            spheres.Add(sun = new Sphere(Matrix.Identity, Color.Yellow, 30, new Vector3(2f), new
Vector3(0f, 0f, 0f), new Vector3(0f, 0f, 0f), Vector3.Zero));
```

```
            // Step 3: Create an earth Sphere, with radius, distance and color as given in the
assignment
            spheres.Add(earth = new Orbital(Matrix.Identity, Color.Navy, 30, new Vector3(1f), new
Vector3(16f, 0f, 0f), Vector3.Zero, new Vector3(0f, 1f, 0f), sun));


            // Step 4: Create 4 other planets: mars, jupiter, saturnus, uranus (radius, distance
and color as given)
            // Step 5: Randomize the orbital rotation (in the Y plane) relative to the sun for each
planet
            spheres.Add(new Orbital(Matrix.Identity, Color.Red, 30, new Vector3(.6f), new
Vector3(21f, 0f, 0f), Vector3.Zero, new Vector3(0f, (float)(.15 + r.NextDouble() * .35), 0f),
sun));
            spheres.Add(new Orbital(Matrix.Identity, Color.Orange, 30, new Vector3(1.7f), new
Vector3(27f, 0f, 0f), Vector3.Zero, new Vector3(0f, (float)(.15 + r.NextDouble() * .35), 0f),
sun));
            spheres.Add(new Orbital(Matrix.Identity, Color.Khaki, 30, new Vector3(1.6f), new
Vector3(36f, 0f, 0f), Vector3.Zero, new Vector3(0f, (float)(.15 + r.NextDouble() * .35), 0f),
sun));
            spheres.Add(new Orbital(Matrix.Identity, Color.Cyan, 30, new Vector3(1.5f), new
Vector3(43f, 0f, 0f), Vector3.Zero, new Vector3(0f, (float)(.15 + r.NextDouble() * .35), 0f),
sun));

            // Step 7: Create the moon (radius, distance and color as given)
            spheres.Add(moon = new Orbital(Matrix.Identity, Color.LightGray, 30, new Vector3(0.5f),
new Vector3(2f, 0f, 0f), Vector3.Zero, new Vector3(0f, -1.5f, 0f), earth));

            // Bonus: Create a bone transform class for spheres, with a parent transform (anchor
position for the first bone), orientation and length/scale,
            // and let the creation and animation of the spheres be handled by that class.


            // Step 11: Create the Michelin man

            // Create the body, scales and positions below
            // body1, scale: (2.9f, 1.3f, 2.5f), position: (0f, 18.7f, 0f)
            bones.Add(skeletonCenter = new Bone(Matrix.Identity, Color.Red, 30, new Vector3(2.9f,
1.3f, 2.5f), new Vector3(0f, 18.7f, 0f), Vector3.Zero, Vector3.Zero));
            //bones[0].rotationAxisSpeed = new Vector3(1f, 1f, 0f);
            // body2, scale: (3.1f, 1.5f, 2.7f), position: (0f, 20f, 0f)
            bones.Add(new Bone(Matrix.Identity, Color.Blue, 30, new Vector3(3.1f, 1.5f, 2.7f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count -1], new Vector3(0f, -1.3f,
0f)));
            // body3, scale: (3.0f, 1.5f, 2.6f), position: (0f, 21.5f, 0f)
            bones.Add(new Bone(Matrix.Identity, Color.Green, 30, new Vector3(3.0f, 1.5f, 2.6f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], new Vector3(0f, -1.5f,
0f)));
            // body4, scale: (2.7f, 1.3f, 2.4f), position: (0f, 22.8f, 0f)
            bones.Add(new Bone(Matrix.Identity, Color.Orange, 30, new Vector3(2.7f, 1.3f, 2.4f),
new Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], new Vector3(0f, -1.3f,
0f)));

            // Create the Michelin man Left arm
            // Create the upper left arm
            // scale: (1.6f, 1.0f, 1.0f), anchor(!) position: (2.3f, 22.8f, 0f)
            // rotate upper left arm by -0.3f along the Z axis
            bones.Add(new Bone(Matrix.Identity, Color.Purple, 30, new Vector3(1.6f, 1.0f, 1.0f),
new Vector3(0, 0f, 0f), Vector3.Zero, Vector3.Zero, skeletonCenter, new Vector3(2.3f, 0f, 0f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(0f, 0f, -.3f);


            // Create the left elbow
            // scale: (1.0f, 0.9f, 0.9f), center position: 1f along the frame of the left upper arm
            bones.Add(new Bone(Matrix.Identity, Color.Red, 30, new Vector3(1.0f, 0.9f, 0.9f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], new Vector3(1f, 0f, 0f)));

            // Create the lower left arm
            // scale: (1.4f, 0.9f, 0.9f), anchor(!) position: 1f along the frame of the left upper
arm (same as elbow)
            // rotate lower left arm by 1.6f along the Z axis, relative to the orientation of the
upper left arm
```

```
            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(1.4f, 0.9f, 0.9f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 2], new Vector3(1.4f, 0.9f,
0.9f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(0f, 0f, -1.6f);

            // Create the left hand
            // scale: (1.4f, 0.9f, 0.9f), anchor(!) position: 0.6f along the frame of the lower
left arm
            // rotate left hand by 0.1f along the Z axis, relative to the orientation of the lower
left arm
            bones.Add(new Bone(Matrix.Identity, Color.RosyBrown, 30, new Vector3(1.4f, 0.9f, 0.9f),
new Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], new Vector3(0.6f, 0f,
0f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(0f, 0f, .1f);


            // Bonus: Create the Michelin man Right arm (mirror the left one's positions and
rotations)

            bones.Add(new Bone(Matrix.Identity, Color.Purple, 30, new Vector3(1.6f, 1.0f, 1.0f),
new Vector3(0, 0f, 0f), Vector3.Zero, Vector3.Zero, skeletonCenter, new Vector3(-2.3f, 0f, 0f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(0f, 0f, .3f);

            bones.Add(new Bone(Matrix.Identity, Color.Red, 30, new Vector3(1.0f, 0.9f, 0.9f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], new Vector3(-1f, 0f,
0f)));

            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(1.4f, 0.9f, 0.9f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 2], new Vector3(-1.4f, 0.9f,
0.9f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(0f, 0f, 1.6f);

            bones.Add(new Bone(Matrix.Identity, Color.RosyBrown, 30, new Vector3(1.4f, 0.9f, 0.9f),
new Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], new Vector3(-0.6f, 0f,
0f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(0f, 0f, .1f);

            // Create the Michelin man Left leg
            // Create the upper left leg
            // scale: (2.0f, 1.7f, 1.7f), anchor(!) position: (1.4f, 17.5f, 0f)
            // rotate upper left leg by -0.7f along the Y axis, -1.5f along the Y axis, -0.2f along
the X axis.
            bones.Add(new Bone(Matrix.Identity, Color.Green, 30, new Vector3(2.0f, 1.7f, 1.7f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[3], -new Vector3(1.4f, 2f, 0f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(-.7f, -1.5f, -.2f);

            // Create the left knee
            // scale: (1.3f, 1.3f, 1.3f), center position: 1f along the frame of the left upper leg
            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(1.3f, 1.3f, 1.3f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], -new Vector3(0f, 1f,
0f)));

            // Create the lower left leg
            // scale: (2.0f, 1.5f, 1.5f), anchor(!) position: 1f along the frame of the left upper
leg (same as knee)
            // rotate lower left leg by 1.4f along the X axis, relative to the orientation of the
upper left leg
            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(2.0f, 1.5f, 1.5f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], -new Vector3(0f, 1f,
0f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(0f, 0f, -.7f);
            // Create the left foot
            // scale: (1.8f, 1.0f, 0.7f), anchor(!) position: 0.6f along the frame of the lower
left leg
            // rotate left foot by -1.4f along the X axis, relative to the orientation of the lower
left leg

            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(1.8f, 1.0f, 0.7f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], -new Vector3(0f, 1f,
0f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(-1.4f, 0f, 0f);

            // Bonus: Create the Michelin man Right leg (mirror the left one's positions and
rotations)
```

```
            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(2.0f, 1.7f, 1.7f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[3], -new Vector3(-1.4f, 2f, 0f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(1.3f, -1.5f, -.2f);

            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(1.3f, 1.3f, 1.3f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], -new Vector3(0f, 1f,
0f)));

            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(2.0f, 1.5f, 1.5f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], -new Vector3(0f, 1f,
0f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(0f, 0f, .7f);

            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(1.8f, 1.0f, 0.7f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], -new Vector3(0f, 1f,
0f)));
            bones[bones.Count - 1].rotationAxis += new Vector3(.6f, 0f, 0f);

            // Create the Michelin man Neck and head
            // neck, scale: (1.4f, 1.2f, 1.3f), position: (0f, 24f, 0f)
            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(1.4f, 1.2f, 1.3f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, skeletonCenter, new Vector3(0, 2f, 0f)));
            // head1, scale: (2.0f, 1.2f, 1.7f), position: (0f, 25f, 0f)
            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(2.0f, 1.2f, 1.7f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1],new Vector3(0, 1f, 0f)));
            // head2, scale: (1.4f, 1.4f, 1.4f), position: (0f, 25.8f, 0f)
            bones.Add(new Bone(Matrix.Identity, Color.White, 30, new Vector3(1.4f, 1.4f, 1.4f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1],new Vector3(0, .8f, 0f)));


            // Bonus: Give the Michelin man eyes
            bones.Add(new Bone(Matrix.Identity, Color.Black, 30, new Vector3(.4f, .4f, .4f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 1], new Vector3(.5f, .4f, -
1f)));
            //bones[bones.Count - 1].rotationRadiansSpeed += new Vector3(0f, 0f, .3f);
            bones.Add(new Bone(Matrix.Identity, Color.Black, 30, new Vector3(.4f, .4f, .4f), new
Vector3(0f, 0f, 0f), Vector3.Zero, Vector3.Zero, bones[bones.Count - 2], new Vector3(-.5f, .4f, -
1f)));
            //bones[bones.Count - 1].rotationAxisSpeed += new Vector3(0f, 0f, -.3f);
```

Setup of ALL the spheres.

```
            float deltatime = (float)gameTime.ElapsedGameTime.TotalSeconds;
            if (Keyboard.GetState().IsKeyDown(Keys.Right))
            {
                // Step 10: Make the camera position rotate around the origin
depending on gameTime.ElapsedGameTime.TotalSeconds
                camRad -= deltatime;
                cameraPosition.X = (float)Math.Cos(camRad) * camdist;
                cameraPosition.Z = (float)Math.Sin(camRad) * camdist;
                SetupCamera();
            }
            else if (Keyboard.GetState().IsKeyDown(Keys.Left))
            {
                // Step 10: Make the camera position rotate around the origin
depending on gameTime.ElapsedGameTime.TotalSeconds
                camRad += deltatime;
                cameraPosition.X = (float)Math.Cos(camRad) * camdist;
                cameraPosition.Z = (float)Math.Sin(camRad) * camdist;
                SetupCamera();
            }
            else if (Keyboard.GetState().IsKeyDown(Keys.Up))
            {
                // Step 10: Make the camera position rotate around the origin
depending on gameTime.ElapsedGameTime.TotalSeconds
                camdist += deltatime * 100;
                cameraPosition.X = (float)Math.Cos(camRad) * camdist;
                cameraPosition.Z = (float)Math.Sin(camRad) * camdist;
                SetupCamera();
```

```
            }
            else if (Keyboard.GetState().IsKeyDown(Keys.Down))
            {
                // Step 10: Make the camera position rotate around the origin
depending on gameTime.ElapsedGameTime.TotalSeconds
                camdist -= deltatime * 100;
                cameraPosition.X = (float)Math.Cos(camRad) * camdist;
                cameraPosition.Z = (float)Math.Sin(camRad) * camdist;
                SetupCamera();
            }
```

Camera movement

```
public virtual void Draw(GameTime gameTime)
{
    rotationAxis += rotationAxisSpeed *(float)gameTime.ElapsedGameTime.TotalSeconds;
    rotationRadians += rotationRadiansSpeed * (float)gameTime.ElapsedGameTime.TotalSeconds;

    effect.View = SimPhyGameWorld.World.View;
    effect.Projection = SimPhyGameWorld.World.Projection;

    this.Transform = Matrix.Identity;

    this.Transform *= Matrix.CreateScale(this.scalar);
    this.Transform *= Matrix.CreateRotationX(this.rotationAxis.X);
    this.Transform *= Matrix.CreateRotationY(this.rotationAxis.Y);
    this.Transform *= Matrix.CreateRotationZ(this.rotationAxis.Z);

    this.Transform *= Matrix.CreateTranslation(this.position);

    this.Transform *= Matrix.CreateRotationX(this.rotationRadians.X);
    this.Transform *= Matrix.CreateRotationY(this.rotationRadians.Y);
    this.Transform *= Matrix.CreateRotationZ(this.rotationRadians.Z);
    effect.World = this.Transform;
    foreach (EffectPass pass in effect.CurrentTechnique.Passes)
    {
        pass.Apply();
        try {
            graphics.DrawUserIndexedPrimitives<VertexPositionColorNormal>(PrimitiveType.TriangleList, vertices, 0, nvertices, indices, 0, indices.Length / 3);
        }catch (Exception e){
            Console.WriteLine(e.StackTrace);
        }
    }
}
```

Sphere class draw

```
class Orbital : Sphere
{
    protected Sphere orbiting;
    public Orbital(Matrix transform, Color color, int numVertices, Vector3 Scalar, Vector3 Position, Vector3 RotationAxisSpeed, Vector3 RotationRadiansSpeed, Sphere Orbiting) :
        base(transform,  color,  numVertices,  Scalar,  Position,  RotationAxisSpeed,  RotationRadiansSpeed)
    {
        this.orbiting = Orbiting;
    }

    public override void Draw(GameTime gameTime)
    {
        rotationAxis += rotationAxisSpeed * (float)gameTime.ElapsedGameTime.TotalSeconds;
        rotationRadians += rotationRadiansSpeed * (float)gameTime.ElapsedGameTime.TotalSeconds;

        effect.View = SimPhyGameWorld.World.View;
        effect.Projection = SimPhyGameWorld.World.Projection;

        this.Transform = Matrix.Identity;
        this.Transform *= Matrix.CreateScale(this.scalar);
        this.Transform *= Matrix.CreateRotationX(this.rotationAxis.X);
        this.Transform *= Matrix.CreateRotationY(this.rotationAxis.Y);
        this.Transform *= Matrix.CreateRotationZ(this.rotationAxis.Z);

        this.Transform *= Matrix.CreateTranslation(this.position);

        this.Transform *= Matrix.CreateRotationX(this.rotationRadians.X);
        this.Transform *= Matrix.CreateRotationY(this.rotationRadians.Y);
        this.Transform *= Matrix.CreateRotationZ(this.rotationRadians.Z);

        this.Transform *= Matrix.CreateTranslation(orbiting.Transform.Translation); ;

        effect.World = this.Transform;
        foreach (EffectPass pass in effect.CurrentTechnique.Passes)
        {
            pass.Apply();
            try
            {
                graphics.DrawUserIndexedPrimitives<VertexPositionColorNormal>(PrimitiveType.TriangleList, vertices, 0, nvertices, indices, 0, indices.Length / 3);
            }
            catch (Exception e)
            {
                Console.WriteLine(e.StackTrace);
            }
        }
    }
}
```

Entire orbital class(Bone class is very similar so only have the draw shown)

```
public override void Draw(GameTime gameTime)
{
    rotationAxis += rotationAxisSpeed * (float)gameTime.ElapsedGameTime.TotalSeconds;
    rotationRadians += rotationRadiansSpeed * (float)gameTime.ElapsedGameTime.TotalSeconds;

    effect.View = SimPhyGameWorld.World.View;
    effect.Projection = SimPhyGameWorld.World.Projection;

    this.Transform = Matrix.Identity;

    this.Transform *= Matrix.CreateScale(this.scalar);

    if(parent != null)
        this.Transform *= Matrix.CreateTranslation(this.anchor * parent.scalar);

    //this.Transform *= Matrix.CreateRotationX(this.rotationAxis.X);
    //this.Transform *= Matrix.CreateRotationY(this.rotationAxis.Y);
    //this.Transform *= Matrix.CreateRotationZ(this.rotationAxis.Z);
    this.Transform *= Matrix.CreateFromYawPitchRoll(this.rotationAxis.X, this.rotationAxis.Y, rotationAxis.Z);

    this.Transform *= Matrix.CreateTranslation(this.position);



    this.Transform *= Matrix.CreateRotationX(this.rotationRadians.X);
    this.Transform *= Matrix.CreateRotationY(this.rotationRadians.Y);
    this.Transform *= Matrix.CreateRotationZ(this.rotationRadians.Z);


    //this.Transform *= Matrix.CreateTranslation(this.anchor);
    //if (parent != null)
    //this.Transform *= Matrix.CreateFromYawPitchRoll(parent.rotationRadians.X, parent.rotationRadians.Y, parent.rotationRadians.Z);


    if (parent != null)
        this.Transform *= Matrix.CreateTranslation(parent.Transform.Translation);

    effect.World = this.Transform;
    foreach (EffectPass pass in effect.CurrentTechnique.Passes)
    {
        pass.Apply();
```

```
foreach(Bone child in children)
{
    child.Draw(gameTime);
}
```

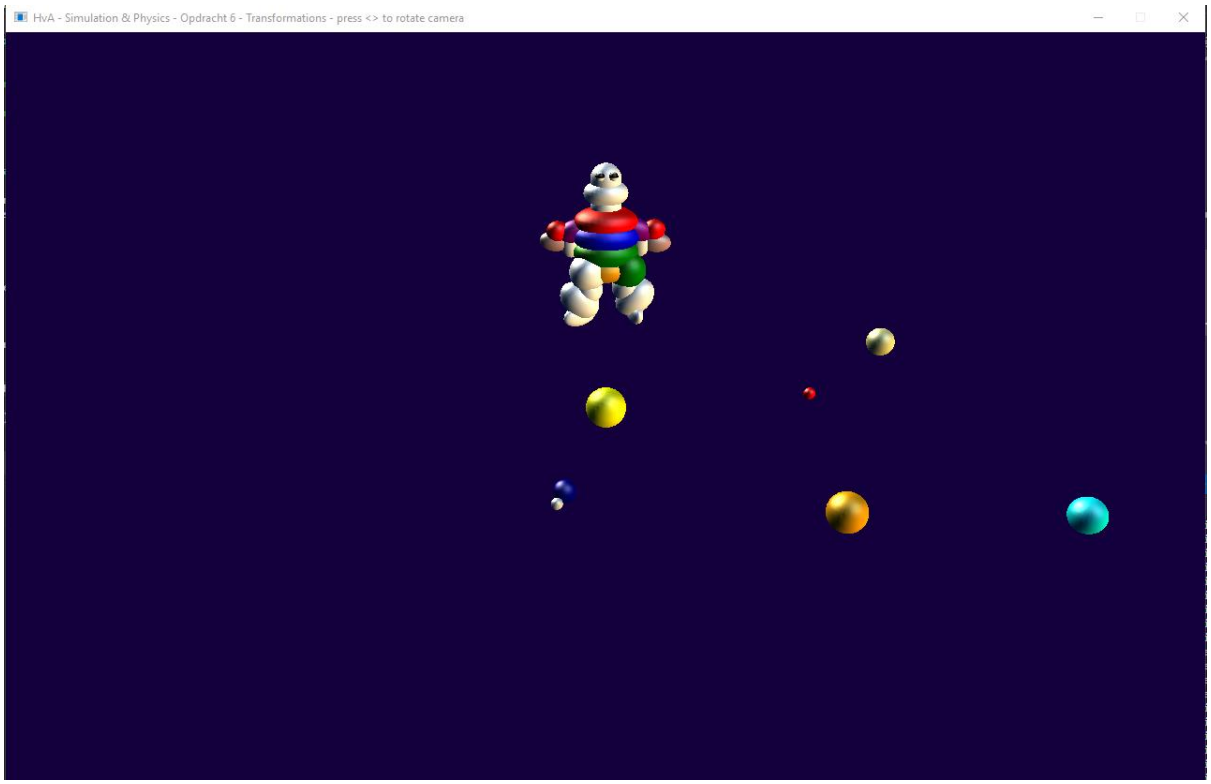
Bone class draw stuff

```
// Bonus: the eyes must blink at random intervals between 2 and 5 seconds
blinkTimer -= deltatime;
if (blinkTimer < 0)
{

    for (int i = skeletonCenter.vertices.Length - 1; i > 0; i--)//set all vertices to white for "closed eyes"
    {
        bones[bones.Count - 1].vertices[i].Color = Color.White;//the eyes are added last so are bones.count -1 and -2
        bones[bones.Count - 2].vertices[i].Color = Color.White;
    }
    blinkframes++;
    if(blinkframes > 20)
    {
        for (int i = (skeletonCenter.vertices.Length - 1) / Math.Abs(blinkframes - 15); i > 0; i--)//change vertices open over-time to make it look like the eyes opening
        {
            bones[bones.Count - 1].vertices[i].Color = Color.Black;
            bones[bones.Count - 2].vertices[i].Color = Color.Black;
        }
        blinkframes = 0;
        blinkTimer = nextBlink(r);
    }
}
```

Blinking code.

5. include a screenshot of your program



Again I have made video's for the class as well These are found here:
https://www.youtube.com/watch?v=YYU0BukxEn8&index=8&list=PLARkMALdMekM6EMkY0gcQSKvADVAx9zK5