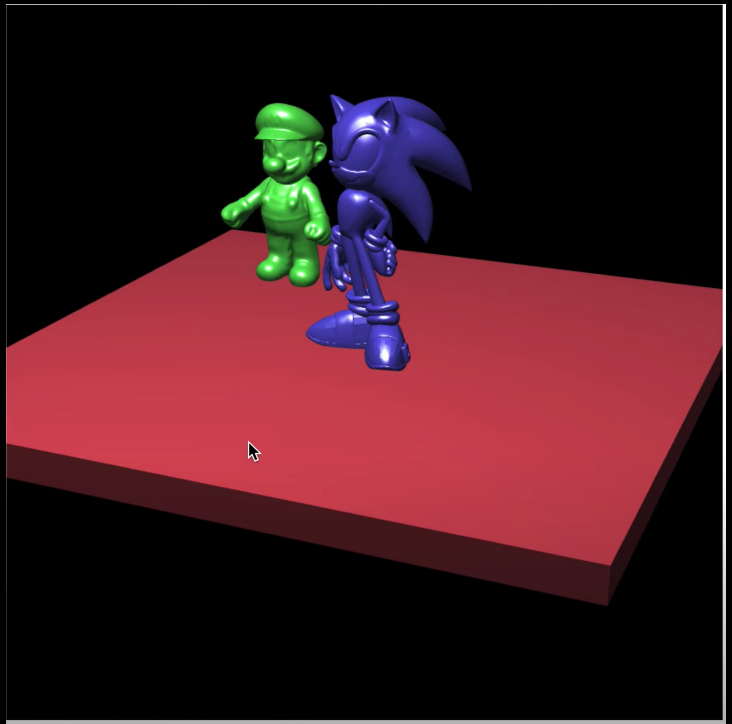
Lab 7

- Download the lab7 template
- You will load the mario and sonic model and create a cube to render the scene
    - You should use scale() to make the cube look like a ground
    - Mario and sonic should stand right on the ground
    - Maio and sonic should be rescaled to the proper size
    - Mario is static
    - User can use sliders to move and rotate the sonic
    - Nice illumination on all objects
- Please check this video, this is the result you should have
    - https://www.youtube.com/watch?v=oIb1jCNwDGE&list=PLsId7efYPyAah0Z64j9DpedSVAcvzOSKb&index=8



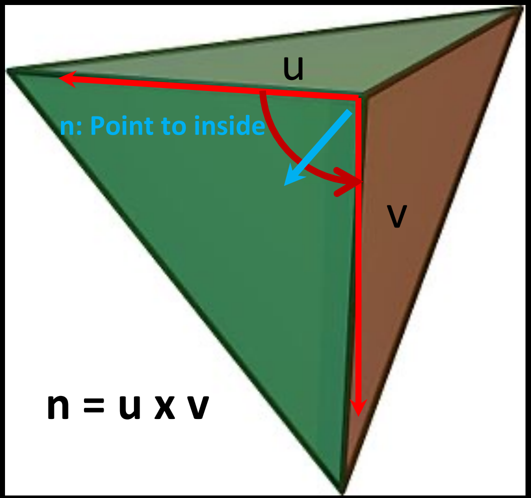
Normal Vector Calculation

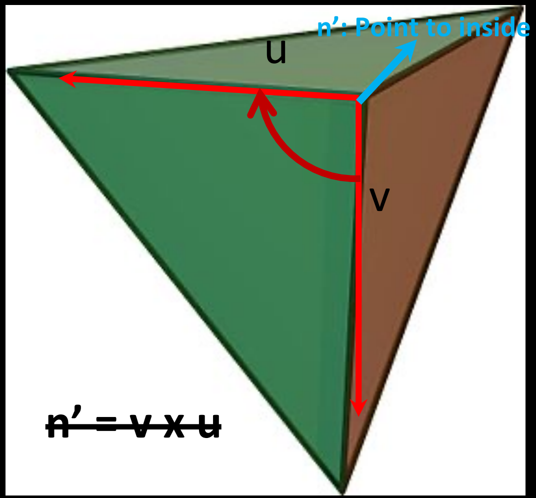
- I have provided the normal vector calculation function for you.
- You can pass all vertices of an object to it and it will return normal vectors on each vertex to you.
  - Input vertices: an array. All vertices of all triangles of the object are separated (e.g. a cube: 36 input vertices)

```
///// normal vector calculation (for the cube)
function getNormalOnVertices(vertices){
  var normals = [];
  var nTriangles = vertices.length/9;
  for(let i=0; i < nTriangles; i ++ ){
      var idx = i * 9 + 0 * 3;
      var p0x = vertices[idx+0], p0y = vertices[idx+1], p0z = vertices[idx+2];
      idx = i * 9 + 1 * 3;
      var p1x = vertices[idx+0], p1y = vertices[idx+1], p1z = vertices[idx+2];
      idx = i * 9 + 2 * 3;
      var p2x = vertices[idx+0], p2y = vertices[idx+1], p2z = vertices[idx+2];

      var ux = p1x - p0x, uy = p1y - p0y, uz = p1z - p0z;
      var vx = p2x - p0x, vy = p2y - p0y, vz = p2z - p0z;

      var nx = uy*vz - uz*vy;
      var ny = uz*vx - ux*vz;
      var nz = ux*vy - uy*vx;

      var norm = Math.sqrt(nx*nx + ny*ny + nz*nz);
      nx = nx / norm;
      ny = ny / norm;
      nz = nz / norm;

      normals.push(nx, ny, nz, nx, ny, nz, nx, ny, nz);
  }
  return normals;
}
```

Normal Vector Calculation

- Normal vector can be calculated by "cross product" of two vectors which come from two edge of the triangle
  - https://en.wikipedia.org/wiki/Cross_product
- Key to correctly calculate normal vector (let's focus on the green triangle)
  - We can get normal vector which point to outside of the object of inside of the object
  - What we want is the normal vector which **points to outside** of the object



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      var ux = p1x - p0x, uy = p1y - p0y, uz = p1z - p0z;
      var vx = p2x - p0x, vy = p2y - p0y, vz = p2z - p0z;

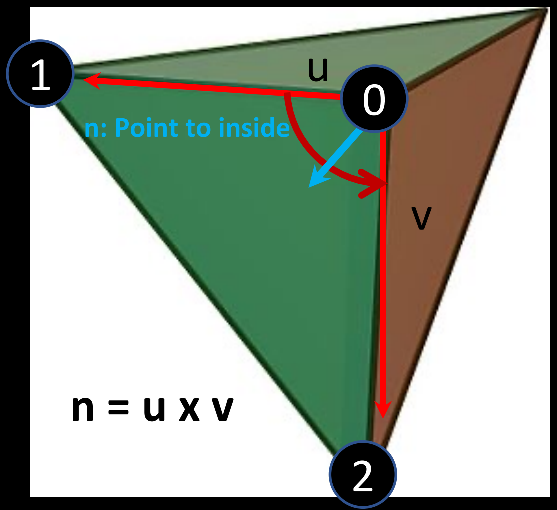
      var nx = uy*vz - uz*vy;
      var ny = uz*vx - ux*vz;
      var nz = ux*vy - uy*vx;

      var norm = Math.sqrt(nx*nx + ny*ny + nz*nz);
      nx = nx / norm;
      ny = ny / norm;
      nz = nz / norm;

      normals.push(nx, ny, nz, nx, ny, nz, nx, ny, nz);
  }
  return normals;
}
```

Normal Vector Calculation

- By the normal vector calculation function I provide
  - You should give the vertices of a triangles in counter clock wise order (when you look at the triangle from outside)
- n = u x x
  - $n_x = u_y * v_z - u_z * v_y$
  - $n_y = u_z * v_x - u_x * v_z$
  - $n_z = u_x * v_y - u_y * v_x$

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function getNormalOnVertices(vertices){
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      var p0x = vertices[idx+0], p0y = vertices[idx+1], p0z = vertices[idx+2];
      idx = i * 9 + 1 * 3;
      var p1x = vertices[idx+0], p1y = vertices[idx+1], p1z = vertices[idx+2];
      idx = i * 9 + 2 * 3;
      var p2x = vertices[idx+0], p2y = vertices[idx+1], p2z = vertices[idx+2];

      var ux = p1x - p0x, uy = p1y - p0y, uz = p1z - p0z;
      var vx = p2x - p0x, vy = p2y - p0y, vz = p2z - p0z;

      var nx = uy*vz - uz*vy;
      var ny = uz*vx - ux*vz;
      var nz = ux*vy - uy*vx;

      var norm = Math.sqrt(nx*nx + ny*ny + nz*nz);
      nx = nx / norm;
      ny = ny / norm;
      nz = nz / norm;

      normals.push(nx, ny, nz, nx, ny, nz, nx, ny, nz);
  }
  return normals;
}
```
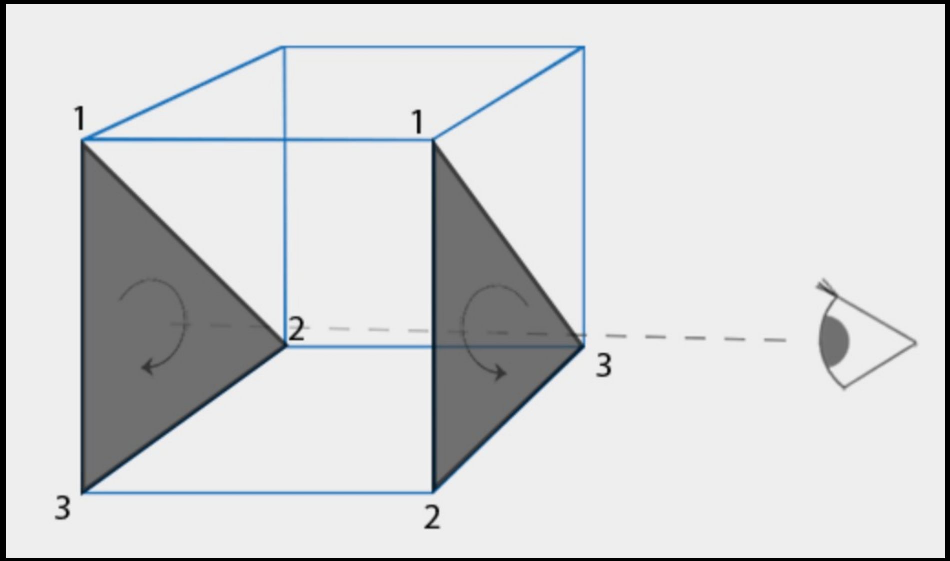

Why the Order of Vertices is Important?

- **(You do NOT need to know this page to complete this practice. I just would like to say why the order of vertices matters in regular webgl rendering pipeline)**
- https://learnopengl.com/Advanced-OpenGL/Face-culling
  - Reading for face culling
- To help GL to save computational time
  - Determine a face a front or back face
  - Ignore the back face for the fragment shader



Check "TODO"s

- In main(), fill the vertices xyz of the cube in "cubeVertices"
- Let getNormalVertices() calculates the correct normal vectors for you

```
/////3D model mario
response = await fetch('mario.obj');
text = await response.text();
obj = parseOBJ(text);
for( let i=0; i < obj.geometries.length; i ++ ){
  let o = initVertexBufferForLaterUse(gl,
                                      obj.geometries[i].data.position,
                                      obj.geometries[i].data.normal,
                                      obj.geometries[i].data.texcoord);
  mario.push(o);
}
```

We have loaded and setup two external 3D models for you

```
/////3D model sonic
response = await fetch('sonic.obj');
text = await response.text();
obj = parseOBJ(text);
for( let i=0; i < obj.geometries.length; i ++ ){
  let o = initVertexBufferForLaterUse(gl,
                                      obj.geometries[i].data.position,
                                      obj.geometries[i].data.normal,
                                      obj.geometries[i].data.texcoord);
  sonic.push(o);
}
```

```
////cube
//TODO-1: create vertices for the cube whose edge length is 2.0 (or 1.0 is also fine)
//F: Face, T: Triangle, V: vertex (XYZ)
cubeVertices = [//F1_T1_V1,  F1_T1_V2,  F1_T1_V3,  F1_T2_V4,  F1_T2_V5,  F1_T2_V6,   //this row for the face z = 1.0
                //F2_T1_V1,  F2_T1_V2,  F2_T1_V3,  F2_T2_V4,  F2_T2_V5,  F2_T2_V6,   //this row for the face x = 1.0
                //F3_T1_V1,  F3_T1_V2,  F3_T1_V3,  F3_T2_V4,  F3_T2_V5,  F3_T2_V6,   //this row for the face y = 1.0
                //F4_T1_V1,  F4_T1_V2,  F4_T1_V3,  F4_T2_V4,  F4_T2_V5,  F4_T2_V6,   //this row for the face x = -1.0
                //F5_T1_V1,  F5_T1_V2,  F5_T1_V3,  F5_T2_V4,  F5_T2_V5,  F5_T2_V6,   //this row for the face y = -1.0
                //F6_T1_V1,  F6_T1_V2,  F6_T1_V3,  F6_T2_V4,  F6_T2_V5,  F6_T2_V6,   //this row for the face z = -1.0
               ]
cubeNormals = getNormalOnVertices(cubeVertices);
let o = initVertexBufferForLaterUse(gl, cubeVertices, cubeNormals, null);
cube.push(o);
```

TODO-2 -3 -4

- At the end of main(), we have registered the sliders and mouse events
  - When the slides are dragged, we will get the reading and store values into “moveDistance” and “rotateAngle”, then redraw the scene.

```
    mvpMatrix = new Matrix4();
    modelMatrix = new Matrix4();
    normalMatrix = new Matrix4();

    gl.enable(gl.DEPTH_TEST);

    draw();//draw it once before mouse move

    canvas.onmousedown = function(ev){mouseDown(ev)};
    canv  var slider1 = document.getElementById("move");
    canv  (local var) slider1: HTMLElement

    var slider1 = document.getElementById("move");
    slider1.oninput = function() {
        moveDistance = this.value/60.0
        draw();
    }

    var slider2 = document.getElementById("rotate");
    slider2.oninput = function() {
        rotateAngle = this.value
        draw();
    }
}
```

TODO-2 -3 -4

- In draw(), we should set up the model matrix (without considering the mouse(view) rotation) into mdlMatrix and call drawOneObject() to draw an object
  - Cube(ground)
  - Mario
  - Sonic

```
/////Call drawOneObject() here to draw all object one by one
////   (setup the model matrix and color to draw)
function draw(){
    gl.clearColor(0,0,0,1);
    gl.clear(gl.COLOR_BUFFER_BIT | gl.DEPTH_BUFFER_BIT);

    let mdlMatrix = new Matrix4(); //model matrix of objects

    //Cube (ground)
    //TODO-1: set mdlMatrix for the cube
    drawOneObject(cube, mdlMatrix, 1.0, 0.4, 0.4);

    //mario
    //TODO-2: set mdlMatrix for mario
    //drawOneObject(mario, mdlMatrix, 0.4, 1.0, 0.4);

    //sonic
    //TODO-3: set mdlMatrix for sonic (include rotation and movement)
    //drawOneObject(sonic, mdlMatrix, 0.4, 0.4, 1.0);
}
```

```
//obj: the object components
//mdlMatrix: the model matrix without mouse rotation
//colorR, G, B: object color
function drawOneObject(obj, mdlMatrix, colorR, colorG, colorB){
    //model Matrix (part of the mvp matrix)
    modelMatrix.setRotate(angleY, 1, 0, 0);//for mouse rotation
    modelMatrix.rotate(angleX, 0, 1, 0);//for mouse rotation
    modelMatrix.multiply(mdlMatrix);
    //mvp: projection * view * model matrix
    mvpMatrix.setPerspective(30, 1, 1, 100);
```

What You Should Do for “Submission”

Submission Instruction

- Create a folder
  - Put the html and js files in the folder
  - Zip the folder
  - Rename the zip file to your student ID
    - For example, if your student ID is "40312345s", rename the zip file to "40312345s.zip"
  - Submit the renamed zip file to Moodle

- Make sure
  - you put all files in the folder to zip
  - You submit the zip file with correct name
- You won't get any point if
  - the submitted file does not follow the naming rule,
  - TA cannot run your code,
  - or cannot unzip your zip file.