# CSE4204

# LAB-4 : Perspective projection, camera transformation and multiple shader

Mohammad Imrul Jubair

# Modularize your code

```
function init() {
    var canvas = document.getElementById("webglcanvas");
    gl = canvas.getContext("webgl");
    initGL();
    model();
    draw();
}
```

- Canvas and WebGL context
- Create and Compile Shaders
- Associate the shader variable
- Define model + color and store it in buffer
- Draw object

```
var vertexShaderSource = ``;

var fragmentShaderSource = ``;

//Global variables

function model(){

function draw() {

function createProgram(gl,
                       vertexShaderSource,
                       fragmentShaderSource) {

function initGL() {

function init() {

init();
```

# Modularize your code

```
function initGL() {
    var prog = createProgram( gl, vertexShaderSource, fragmentShaderSource );
    gl.useProgram(prog);

    a_coords_location = gl.getAttribLocation(prog, "a_coords");
    a_coords_buffer = gl.createBuffer();

    a_colors_location = gl.getAttribLocation(prog, "a_colors");
    a_colors_buffer = gl.createBuffer();

ocation = gl.getUniformLocation(prog, "u_rotate")

= gl.createBuffer();

otateX_location = gl.getUniformLocation(prog, "u_Rx");
otateY_location = gl.getUniformLocation(prog, "u_Ry");
```

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    gl.useProgram(prog);
```

```
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var fragmentShaderSource = ``;

//Global variables
```

```
function createProgram(gl, vertexShaderSource, fragmentShaderSource) {
    var vsh = gl.createShader( gl.VERTEX_SHADER );
    gl.shaderSource( vsh, vertexShaderSource );
    gl.compileShader( vsh );

    var fsh = gl.createShader( gl.FRAGMENT_SHADER );
    gl.shaderSource( fsh, fragmentShaderSource );
    gl.compileShader( fsh );

    var prog = gl.createProgram();
    gl.attachShader( prog, vsh );
    gl.attachShader( prog, fsh );
    gl.linkProgram( prog );

    return prog;
}
```

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# Modularize your code

```
function model(){

        coords = new Float32Array( [  // Front face
                                     -0.5, -0.5,  0.5,
                                      0.5, -0.5,  0.5,
                                      0.5,  0.5,  0.5,
                                     -0.5,  0.5,  0.5] );

        colors = new Float32Array(  [1.0, 0.0, 0.0,
                                     1.0, 0.0, 0.0,
                                     1.0, 0.0, 0.0,
                                     1.0, 0.0, 0.0] );

indices = new Uint8Array([ 0, 1, 2,      0, 2, 3]);
```

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function initGL() {

function init() {

init();
```

# Modularize your code

```
function draw() {
    var rad = thetaX*Math.PI/180;
    var rotateMatX = new Float32Array( [1.0,  0.0,           0.0,           0.0,
                                        0.0,  Math.cos(rad), Math.sin(rad), 0.0,
                                        0.0, -Math.sin(rad), Math.cos(rad), 0.0,
                                        0.0,  0.0,           0.0,           1.0] );

    var rad = thetaY*Math.PI/180;
    var rotateMatY = new Float32Array( [Math.cos(rad), 0.0, -Math.sin(rad), 0.0,
                                        0.0,           1.0,  0.0,           0.0,
                                        Math.sin(rad), 0.0,  Math.cos(rad), 0.0,
                                        0.0,           0.0,  0.0,           1.0] );

    gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
    gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
    gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
    gl.enableVertexAttribArray(a_coords_location);

    gl.bindBuffer(gl.ARRAY_BUFFER, a_colors_buffer);
    gl.bufferData(gl.ARRAY_BUFFER, colors, gl.STATIC_DRAW);
    gl.vertexAttribPointer(a_colors_location, 3, gl.FLOAT, false, 0, 0);
    gl.enableVertexAttribArray(a_colors_location);

    Buffer(gl.ELEMENT_ARRAY_BUFFER, bufferInd);
    erData(gl.ELEMENT_ARRAY_BUFFER, indices, gl.STATIC_DRAW);

    rmMatrix4fv(u_matrix_rotateX_location, false, rotateMatX);
    rmMatrix4fv(u_matrix_rotateY_location, false, rotateMatY);

    rColor(1.0,1.0,1.0,1.0);
    le(gl.DEPTH_TEST);
    le(gl.CULL_FACE);
    r(gl.COLOR_BUFFER_BIT | gl.DEPTH_BUFFER_BIT);

    Elements(gl.TRIANGLES, 3*12, gl.UNSIGNED_BYTE, 0);
```

```
rtexShaderSource = ``;

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on model(){

on draw() {

on createProgram(gl,
      vertexShaderSource,
      fragmentShaderSource) {

on initGL() {

on init() {

;
```

- Canvas and WebGL context
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- Draw object

- Get the code

https://rb.gy/7e2em9

# Multiple shaders

```
function init() {
    var canvas = document.getElementById("webglcanvas");
    gl = canvas.getContext("webgl");

    model();

    initGL_1();
    draw_1();

    initGL_2();
    draw_2();
}
```

```
init();
```

# Multiple shaders

```
var vertexShaderSource_1 =

    `attribute vec3 a_coords;
     attribute vec3 a_colors;
     uniform mat4 u_RotY;
     uniform mat4 u_RotX;
     uniform mat4 u_Scale;
     uniform mat4 u_Trans;
     varying vec3 v_color;

     void main() {

         mat4 M = u_Trans*u_RotX*u_RotY*u_Scale;
         gl_Position = M*vec4(a_coords, 1.0);
         v_color = a_colors;
     }`;


var fragmentShaderSource_1 =

    `precision mediump float;
     varying vec3 v_color;
     void main() {
         gl_FragColor = vec4(v_color, 1.0);
     }`;
```

```
var vertexShaderSource_2 =

    `attribute vec3 a_coords;
     attribute vec3 a_colors;
     uniform mat4 u_RotY;
     uniform mat4 u_RotX;
     uniform mat4 u_Scale;
     uniform mat4 u_Trans;
     varying vec3 v_color;

     void main() {
         mat4 M = u_RotX*u_RotY*u_Scale*u_Trans;
         gl_Position = M*vec4(a_coords, 1.0);
         v_color = a_colors;
     }`;

var fragmentShaderSource_2 =

    `precision mediump float;
     varying vec3 v_color;
     void main() {
         gl_FragColor = vec4((v_color.g + v_color.b)/2.0,
                             (v_color.r + v_color.b)/2.0,
                             (v_color.r + v_color.g)/2.0,
                             1.0);
     }`;
```

# Multiple shaders

```
function initGL_1() {
    var prog1 = createProgram( gl, vertexShaderSource_1, fragmentShaderSource_1 );
    gl.useProgram(prog1);

    a_coords_location = gl.getAttribLocation(prog1, "a_coords");
    a_coords_buffer = gl.createBuffer();

    a_colors_location = gl.getAttribLocation(prog1, "a_colors");
    a_colors_buffer = gl.createBuffer();

    bufferInd = gl.createBuffer();

    u_matrix_rotateX_location = gl.getUniformLocation(prog1, "u_RotX");
    u_matrix_rotateY_location = gl.getUniformLocation(prog1, "u_RotY");
    u_matrix_scale_location = gl.getUniformLocation(prog1, "u_Scale");
    u_matrix_trans_location = gl.getUniformLocation(prog1, "u_Trans");

}
```

# Multiple shaders

```
function initGL_2() {
    var prog2 = createProgram( gl, vertexShaderSource_2, fragmentShaderSource_2 );
    gl.useProgram(prog2);

    a_coords_location = gl.getAttribLocation(prog2, "a_coords");
    a_coords_buffer = gl.createBuffer();

    a_colors_location = gl.getAttribLocation(prog2, "a_colors");
    a_colors_buffer = gl.createBuffer();

    bufferInd = gl.createBuffer();

    u_matrix_rotateX_location = gl.getUniformLocation(prog2, "u_RotX");
    u_matrix_rotateY_location = gl.getUniformLocation(prog2, "u_RotY");
    u_matrix_scale_location = gl.getUniformLocation(prog2, "u_Scale");
    u_matrix_trans_location = gl.getUniformLocation(prog2, "u_Trans");
}
```

# Multiple shaders

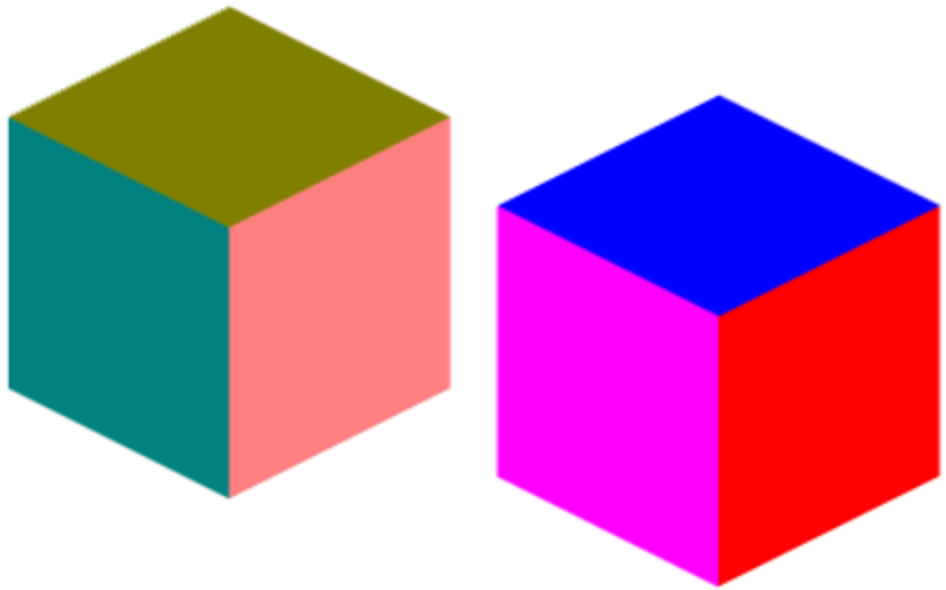
```
function draw_1() {
    gl.clearColor(1.0,1.0,1.0,1.0);
    gl.enable(gl.DEPTH_TEST);
    gl.enable(gl.CULL_FACE);
    gl.clear(gl.COLOR_BUFFER_BIT | gl.DEPTH_BUFFER_BIT);

    gl.drawElements(gl.TRIANGLES, 3*12, gl.UNSIGNED_BYTE, 0);
}
```

```
function draw_2() {

    gl.drawElements(gl.TRIANGLES, 3*12, gl.UNSIGNED_BYTE, 0);
}
```

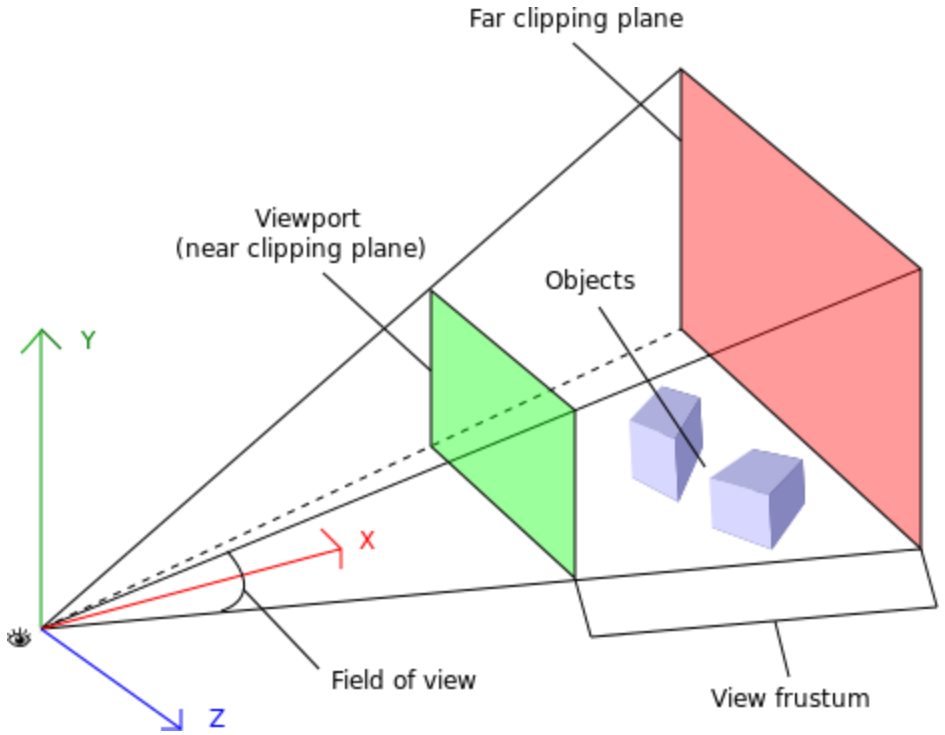
# Multiple shaders



- Get the code

https://rb.gy/pkhnfo

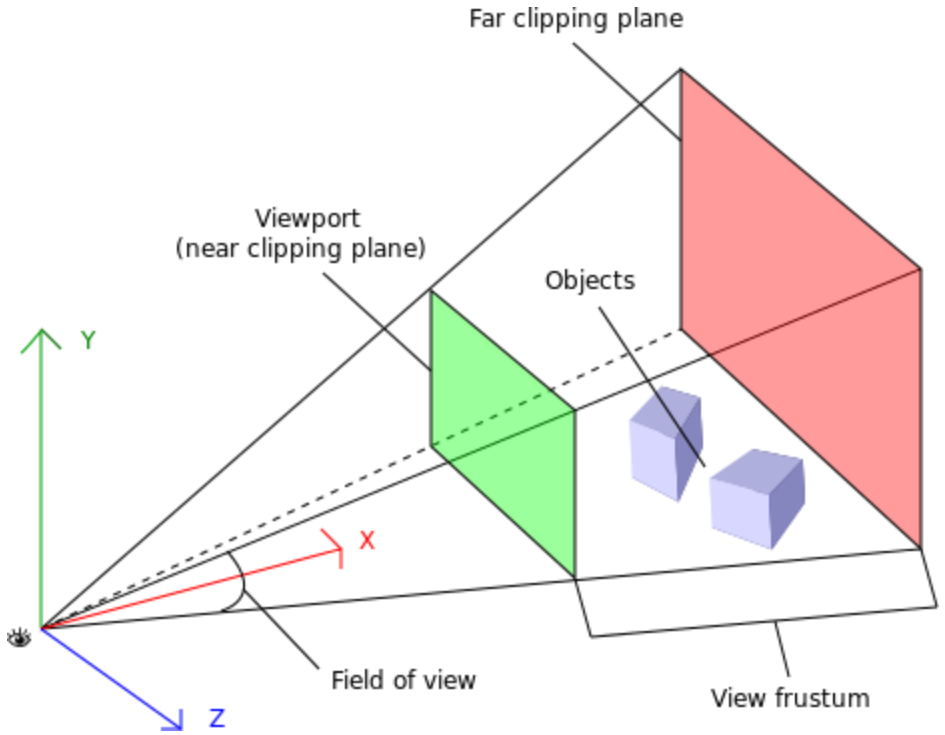
# Perspective Projection




https://www.oreilly.com/library/view/webgl-up-and/9781449326487/ch01.html

# Perspective Projection

$$\text{persMat} = \begin{bmatrix} \frac{1}{aspect * \tan(\frac{fov}{2})} & 0 & 0 & 0 \\ 0 & \frac{1}{\tan(\frac{fov}{2})} & 0 & 0 \\ 0 & 0 & -\frac{far + near}{far - near} & -\frac{2 * far * near}{far - near} \\ 0 & 0 & -1 & 0 \end{bmatrix}$$




https://www.oreilly.com/library/view/webgl-up-and/9781449326487/ch01.html

# Perspective Projection

```
`attribute vec3 a_coords;
 attribute vec3 a_colors;
 uniform mat4 u_RotY;
 uniform mat4 u_RotX;
 uniform mat4 u_Scale;
 uniform mat4 u_Trans;
 uniform mat4 u_Pers;
 varying vec3 v_color;

 void main() {

     mat4 M = u_Trans*u_RotX*u_RotY*u_Scale;
     gl_Position = u_Pers*M*vec4(a_coords, 1.0);
     v_color = a_colors;
 }`;
```

# Perspective Projection

```
u_matrix_pers_location = gl.getUniformLocation(prog, "u_Pers");
```

```
var aspect = 1.0;
var fov = 45.0;
var far = 5.0;
var near = 2.0;

var pa = 1.0/(aspect*Math.tan((fov/2)*Math.PI/180));
var pb = 1.0/(Math.tan((fov/2)*Math.PI/180));
var pc = -(far+near) / (far-near);
var pd = -(2.0*far*near) / (far-near);

var persMat = new Float32Array( [pa,   0.0,  0.0,  0.0,
                                 0.0,  pb,   0,    0.0,
                                 0.0,  0.0,  pc,  -1.0,
                                 0.0,  0.0,  pd,   0.0] );
```

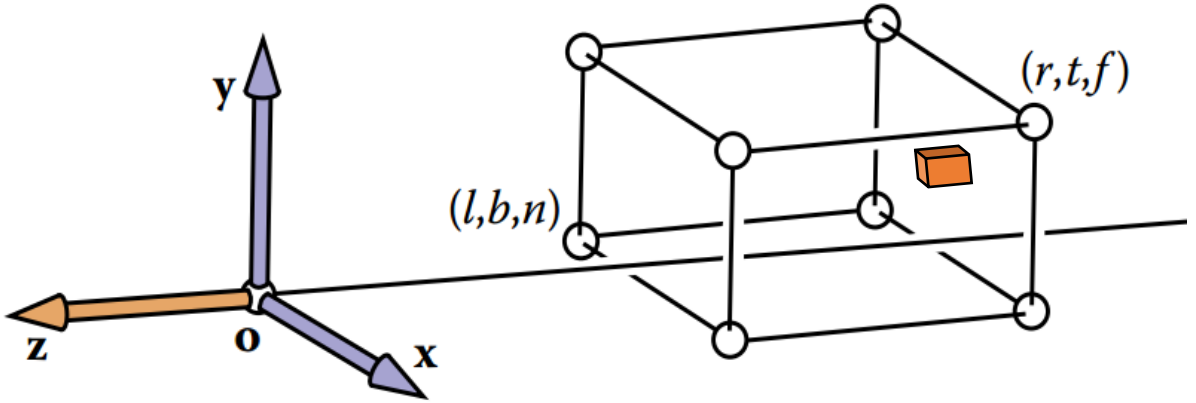
```
gl.uniformMatrix4fv(u_matrix_pers_location, false, persMat);
```

- Get the code

https://rb.gy/wmjdic

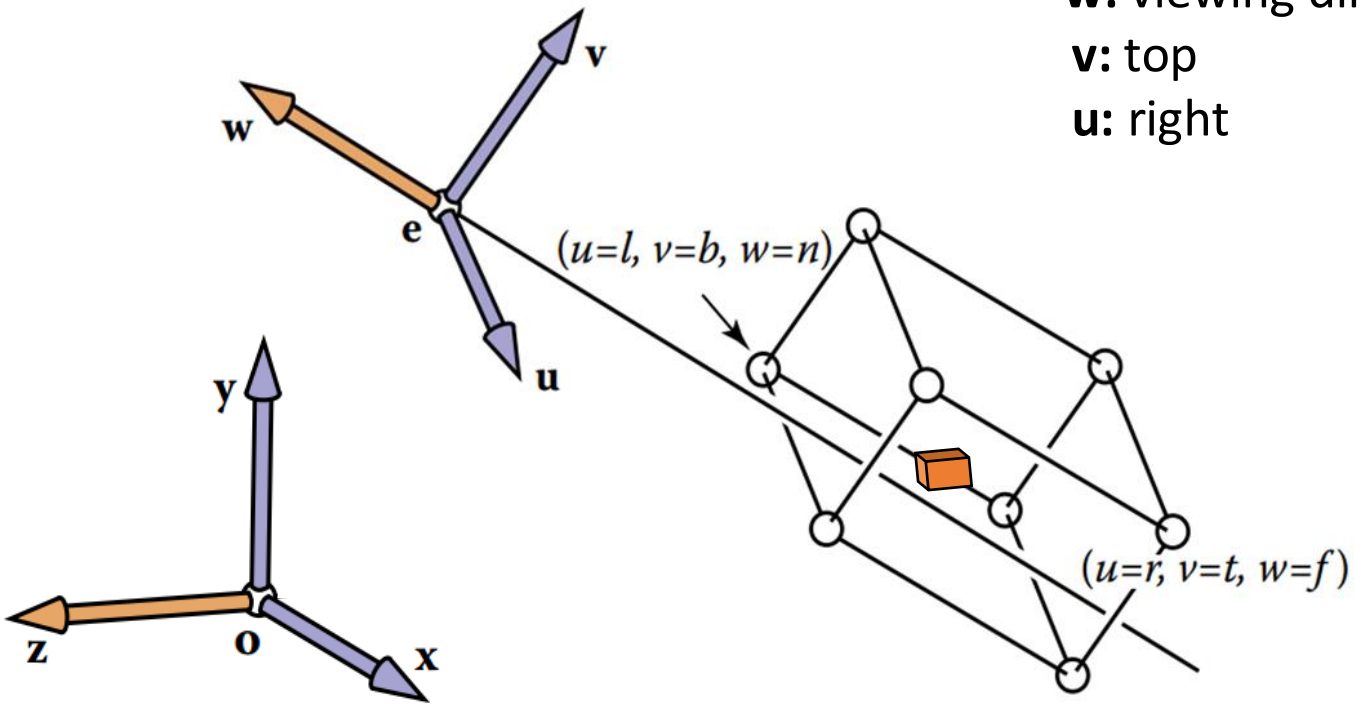
# Camera

- We'd like to be able to change the viewpoint in 3D and look in any direction.



# Camera

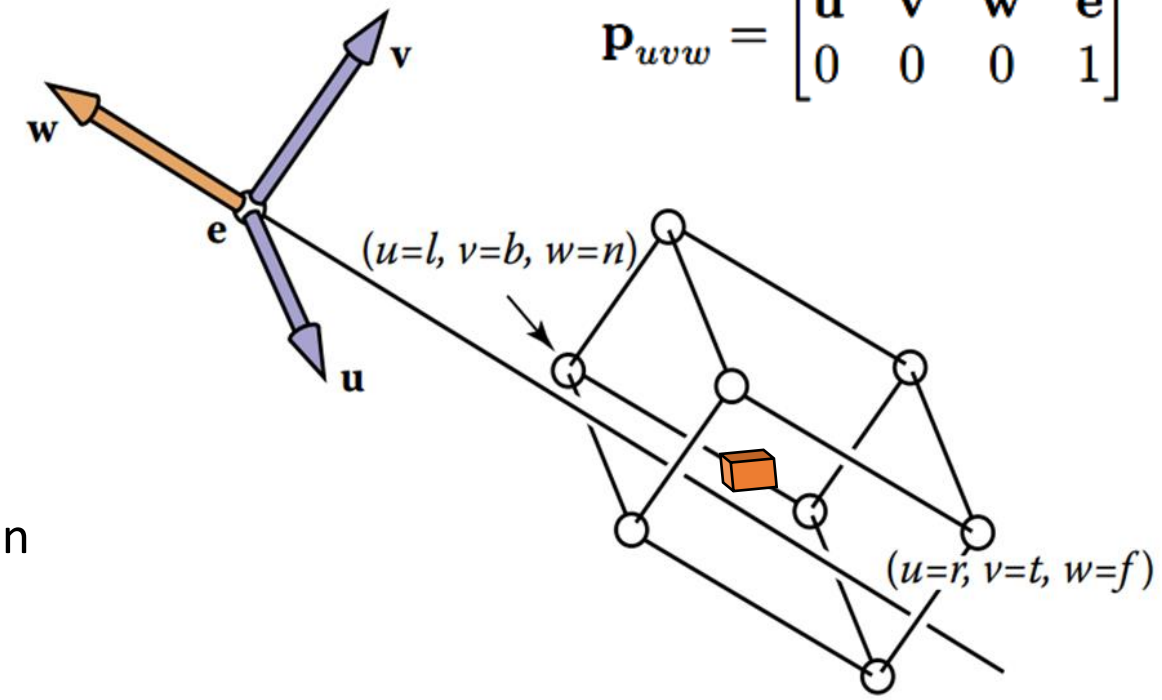
**e:** camera/eye position
- **w:** viewing direction
**v:** top
**u:** right



# Camera

$$\begin{bmatrix} u_p \\ v_p \\ w_p \\ 1 \end{bmatrix} = \begin{bmatrix} x_u & y_u & z_u & 0 \\ x_v & y_v & z_v & 0 \\ x_w & y_w & z_w & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & -x_e \\ 0 & 1 & 0 & -y_e \\ 0 & 0 & 1 & -z_e \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_p \\ y_p \\ z_p \\ 1 \end{bmatrix}$$

$$\mathbf{p}_{uvw} = \begin{bmatrix} \mathbf{u} & \mathbf{v} & \mathbf{w} & \mathbf{e} \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1} \mathbf{p}_{xyz}.$$




**e:** camera/eye position

- **w:** viewing direction

**v:** top

**u:** right

# Camera

```
var vertexShaderSource =

    `attribute vec3 a_coords;
     attribute vec3 a_colors;
     uniform mat4 u_RotY;
     uniform mat4 u_RotX;
     uniform mat4 u_Scale;
     uniform mat4 u_Trans;
     uniform mat4 u_Basis;
     uniform mat4 u_Eye;
     uniform mat4 u_Pers;
     varying vec3 v_color;

     void main() {

         mat4 M = u_Trans*u_RotX*u_RotY*u_Scale;
         mat4 V = u_Basis*u_Eye;
         mat4 P = u_Pers;
         mat4 MVP = P*V*M;
         gl_Position = MVP*vec4(a_coords, 1.0);
         v_color = a_colors;
     }`;
```

# Camera

```
u_matrix_basis_location = gl.getUniformLocation(prog, "u_Basis");
u_matrix_eye_location = gl.getUniformLocation(prog, "u_Eye");
```

```
var basisMat = new Float32Array([ 1, 0, 0, 0,
                                  0, 1, 0, 0,
                                  0, 0, 1, 0,
                                  0, 0, 0, 1]);

var xe = 0.5;
var ye = 1.0;
var ze = 3.0;
var eyeMat = new Float32Array([1,   0,   0,   0,
                               0,   1,   0,   0,
                               0,   0,   1,   0,
                              -xe, -ye, -ze,  1]);
```

```
gl.uniformMatrix4fv(u_matrix_basis_location, false, basisMat);
gl.uniformMatrix4fv(u_matrix_eye_location, false, eyeMat);
```

- Get the code

https://rb.gy/4vmkdg