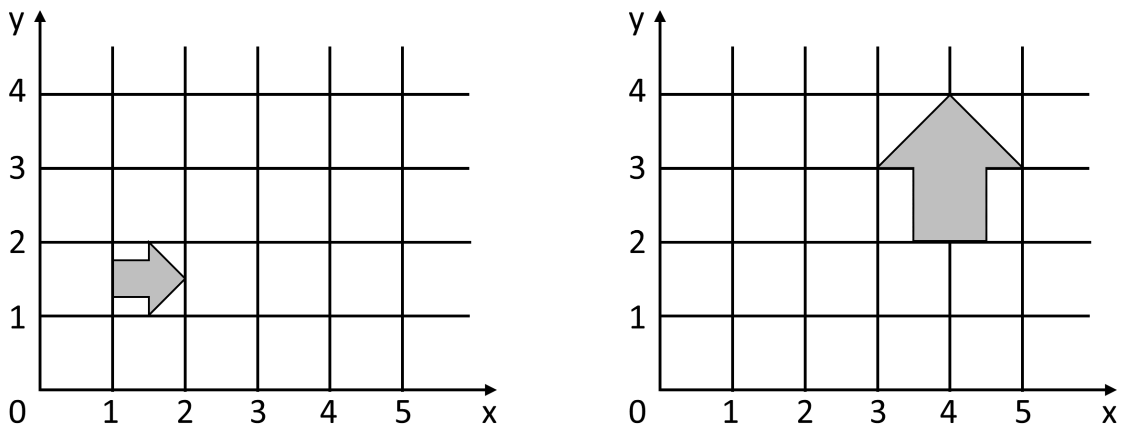
CSC 3260 Midterm Exam, 1st term 2019-2020

1. 2D/3D Math and Transformations (25 %)

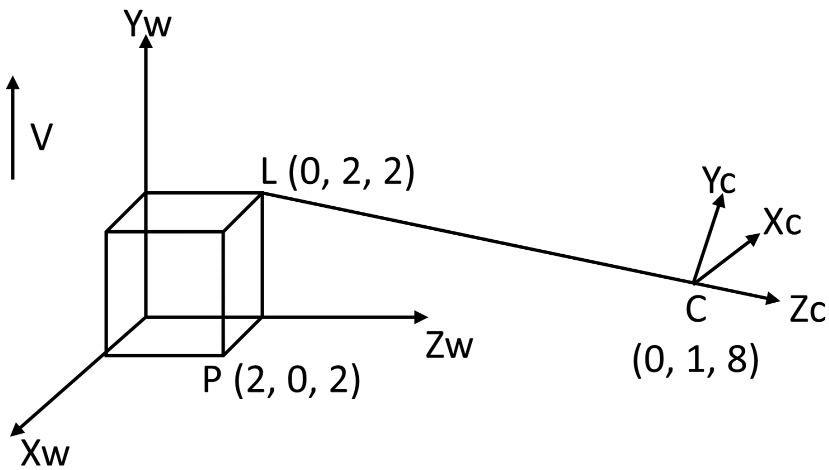
a) Write down the 3 x 3 matrix (as a product of multiple matrices, in post-multiplication order) that will transform the arrow icon from status 1 to status 2. (9%)



status 1 status 2

b) Write down the 3 x 3 matrix that will transform the arrow icon from status 2 to status 1 (also as a product of multiple matrices)? (3%)

c) In the following virtual world, a cube is aligned with the three axes (Xw, Yw and Zw) of the world coordinate system. The edge length of the cube is 2. The virtual camera is located at C (0, 1, 8). The virtual camera looks at cube corner L (0, 2, 2). The view up vector V is (0, 1, 0). The above coordinates are in the world coordinate system. What is the transformation matrix for converting coordinates from the world coordinate system to the camera coordinate system? (9%)

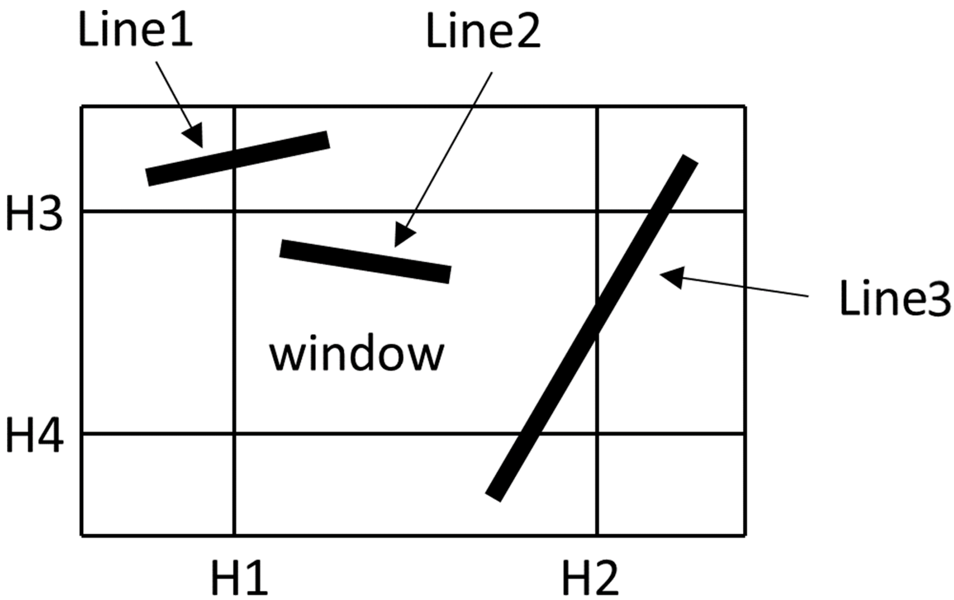


d) The coordinate of cube corner P in the world coordinate system is (2, 0, 2). What is the coordinate of cube corner P in the camera coordinate system? (4%)

2. Projection and Clipping (25%)

a) What are perspective projection, oblique projection, orthogonal projection, and axonometric projection? Use COP (center of projection), PP (projection plane), and DOP (direction of projection) to elaborate their differences. (9%)

b) Work out the end point codes, C1 and C2, for the three lines in the following figure according to the Cohen-Sutherland classification scheme. (6 %)



c) According to these codes, which line(s) is/are trivially in the window? Which line(s) is/are trivially out in the window? (3 %)

d) Which line(s) is/are non-trivial to determine? Please draw figures to show that how to clip the non-trivial line(s). (7 %)

3. Rasterization and Anti-aliasing (25 %)

a) Given the following pseudo-code for performing 2D triangle rasterization:

```
for (int y = yMin; y <= yMax; y++)
{
        for (int x = xMin; x <= xMax; x++)
        {
                float e0 = a0*x + b0*y + c0;
                float e1 = a1*x + b1*y + c1;
                float e2 = a2*x + b2*y + c2;
                if (e0 > 0 && e1 > 0 && e2 > 0)
                        setPixel(x,y);
        }
}
```

If the three vertices of the 2D triangle that we like to scan convert are given as: A (5, 5), B (15, 10) and C (10, 20), compute the values of the following parameters:

(i) a0, b0, c0 (3%)

(ii) a1, b1, c1 (3%)

(iii) a2, b2, c2 (3%)

b) How can we interpolate the color of a point within the triangle formed by A, B and C using barycentric coordinates? （5%）

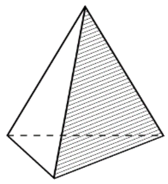
c) Explain pre-filtering and post-filtering concepts for anti-aliasing. (5%)

d) Explain the following anti-aliasing methods: SSAA, MSAA, FSAA. (6%)

4. Hidden Surface Removal (25 %)

a) Describe the procedure of ray-casting algorithm for hidden surface removal. (5%)

b) Given any four 3D points P_1, P_2, P_3, P_4 that are not coplanar (i.e., the four points are not in the same plane), we can form a tetrahedron with four triangular faces in 3D. What is the maximum number of faces that can be removed by backface culling for arbitrary camera location? What is the minimum number of faces that can be removed by backface culling for arbitrary camera location? (5%)



c) If we delete one of the triangular faces from the tetrahedron (i.e., three faces left), is it still valid to use backface culling on the 3D model? Please explain. (5%)

d) True or False (10% - 2% each)

_____ Z-buffering is an object-order method for hidden surface removal.

_____ Z-buffering is a sort-first method for hidden surface removal.

_____ With Z-buffering, we can render half-transparent objects correctly.

_____ Graphics hardware computes backface culling in object space.

_____ The potentially visible set method can be used with the depth buffering or ray casting method to accelerate hidden surface removal.

5. **Lighting, Material, and Shading (25 %)**

Given the following *Phong* illumination model:

$$I = k_e + k_a I_a + \sum_i f(d_i) I_{li} \left[k_d (\mathbf{N} \cdot \mathbf{L}_i)_+ + k_s (\mathbf{V} \cdot \mathbf{R})_+^{n_s} \right]$$

a) Which quantities are spatial vector (3 %)

b) Which quantities are RGB triples (3 %)

c) What is the meaning of $f(d_i)$? Suggest a suitable formula for $f(d_i)$. *(4%)*

d) As n_s gets larger,
   - the dropoff becomes { more , less } gradual
   - gives a { larger , smaller } highlight
   - simulates a { more , less } shiny surface (circle the right one!) (3%)

e) Explain the highlight anomalies in Gouraud Shading, how can this problem be solved? (6%)

f) Explain why there exist interpolation inaccuracies in interpolative shading, how can this problem be solved? (6%)

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