CPSC 314
Midterm 2

March 17, 2017

Answer the questions in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page.

Name: Solutions

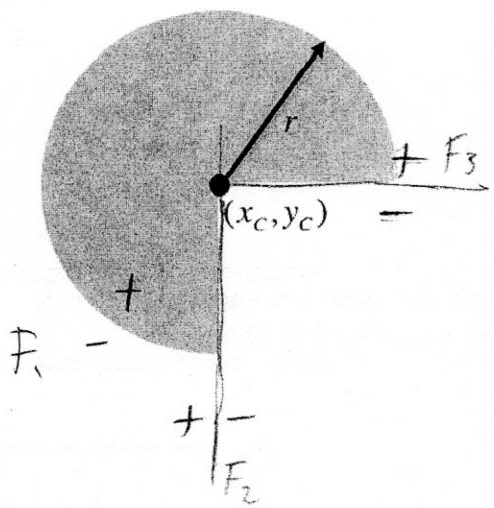
Student Number:

Question 1	/ 5
Question 2	/ 6
Question 3	/ 7
Question 4	/ 5
Question 5	/ 4
TOTAL	/ 27

This exam has 5 questions, for a total of 27 points.

1. (5 points) Scan Conversion

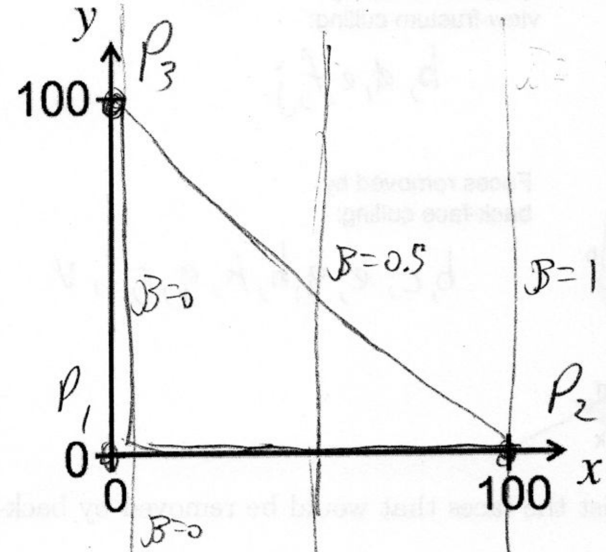
Write the pseudcode needed to scan-convert the given shape below. Use implicit functions for lines and circles to construct your solution. Use `setPixel(x,y)` to set a given pixel "on".




```
Xmin = Xc - r
Xmax = Xc + r
ymin = yc - r
ymax = yc + r
for (x = Xmin; x ≤ Xmax; x++) {
    for (y = ymin; y ≤ ymax; y++) {
        F1 = r^2 - (x-xc)^2 - (y-yc)^2
        F2 = x - xc
        F3 = yc - y
        if ((F1 > 0) and ((F2 > 0) or (F3 > 0)))
            setPixel(x,y)
    }
}
```

2. Barycentric coordinates

Consider the triangles vertices with device coordinates $P_1(00, 00)$, $P_2(100, 0)$, $P_3(0, 100)$, which also have the associated attribute values $v_1 = 10$, $v_2 = 0$, $v_3 = 20$. Assume that the barycentric coordinates are modeled according to: $P = \alpha P_1 + \beta P_2 + \gamma P_3$.



(a) (0 points) Sketch the triangle in the space above.

(b) (2 points) Sketch three lines that correspond to $\beta = 0, 0.5, 1$.

(c) (1 point) Give α, β, γ for point P_2. Give α, β, γ for the point $P(50, 50)$.

$(\alpha, \beta, \gamma) = (0, 1, 0)$ for P_2 $(\alpha, \beta, \gamma) = (0, 0.5, 0.5)$ for $P(50, 50)$

(d) (1 point) Give the interpolated value of v for point P specified by $\beta = 0.2$ and $\gamma = 0.3$.

$\alpha = 1 - \beta - \gamma = 0.5$

$v = \alpha v_1 + \beta v_2 + \gamma v_3 = (0.5)(10) + (0.2)(0) + (0.3)(20) = 11.$

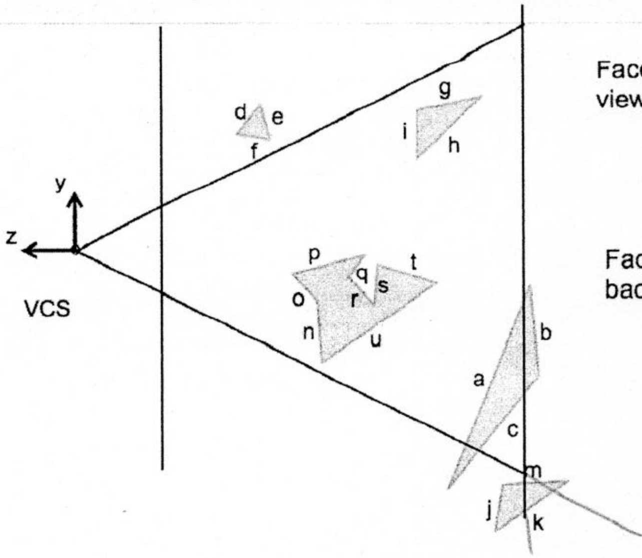
(e) (1 point) Give the expression to compute β for the given triangle, i.e., $\beta(x, y)$.

$\beta = x/100$

(f) (1 point) For what kind of 3D triangles would normal barycentric interpolation yield the same result as perspective-correct interpolation?

Triangles that are parallel to the xy-plane, i.e., that have constant Z_{VCS} values.

3. Clipping and Culling Consider the viewing frustum shown below. Assume that all the labeled edges represent faces of solid objects. Consider back-face culling and view-frustum culling as happening independently of each other.



Faces removed by view-frustum culling:

b, d, e, f, j

Faces removed by back-face culling:

b, c, e, g, h, k, q, r, t, v

(a) (2 points) In alphabetical order, list the faces that would be removed by back-face culling.

(b) (2 points) In alphabetical order, list the faces that would be removed by view-frustum culling.

(c) (1 point) After view-frustum culling and back-face culling, which remaining faces would be completely removed by z-buffer tests? s, m

(d) (1 point) Consider a detailed model of a statue that consists of a million triangles that will not be visible on screen because it is occluded by another object. Briefly describe how an occlusion culling test could be performed for the object, therefore avoiding the need to transform and render all its triangles.

Compute a bounding box or sphere, then render that using an "occlusion test mode, where fragments are not rendered but the z-buffer tests are applied. If no fragments pass the z-buffer test, then the object can be culled.

(e) (1 point) At what point does the line $P_A(1,1,1)P_B(6,5,-2)$ intersect the plane given by $x + 2y + z - 9 = 0$?

$$P(t) = P_A + t(P_B - P_A) = (1,1,1) + t(5,4,-3)$$

$$(1+5t) + 2(1+4t) + (1-3t) - 9 = 0$$

$$10t = 5$$

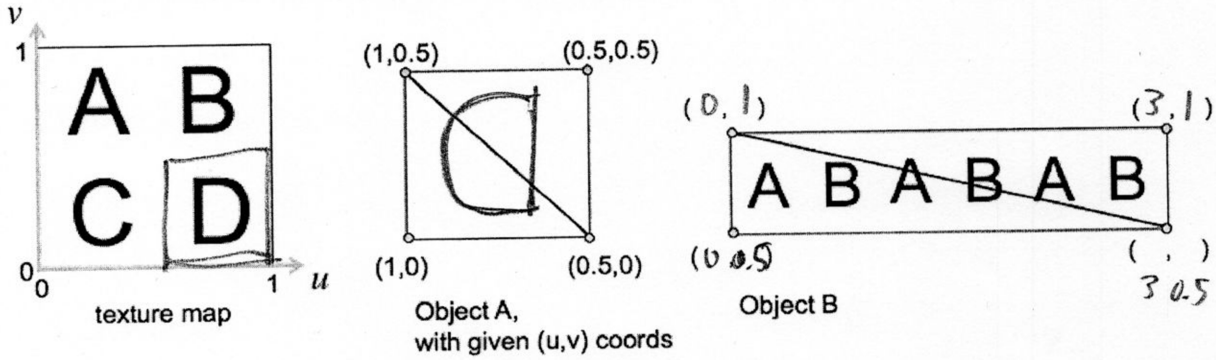
$$t = 1/2$$

$$P(5/6) = (1,1,1) + \frac{1}{2}(5,4,-3) = (3.5, 3, -0.5)$$

$(3.5, 3, -0.5)$

4. Texture Mapping

Consider the texture map below, which is to be mapped to Objects A and B. Assume that the REPEAT texture mode is being used.



(a) (2 points) In the Object A diagram above, sketch the image that would appear for Object A for the assigned texture coordinates.

(b) (2 points) In the Object B diagram above, assign texture coordinates to Object B so that it would yield the given image.

(c) (1 point) Why are texture coordinates defined using normalized coordinates, i.e., $u, b \in [0, 1]$, as opposed to directly using the pixel coordinates of the texture map?

This allows the assignment of texture coordinates in a way that is independent of the texture map image resolution.

5. Short answer

(a) (1 point) Where clipping can clipping be done? Circle any of: VCS CCS NDCS

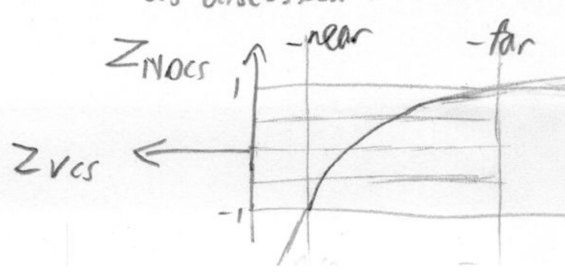
(b) (1 point) Where can back-face culling be done? Circle any of: VCS NDCS

(c) (1 point) If points are transformed using $P' = MP$, how should normals be transformed?

$N' = (M^{-1})^T N$ see p.8 of visibility notes, and as discussed in class.

(d) (1 point) The effective ability of the z-buffer to distinguish which of two objects is "in front" is worse when those objects are close to the back of the viewing frustum Circle one of: True False

As per the non-linear relationship between Z_{VCS} and Z_{NDCS}, as discussed in class. (equivalently Z_{DCS}:)



$Z_{NDCS} = -C - \frac{D}{z}$

(p.11 of notes on viewing and projection)

equal Z_{NDCS} "bins" give unequal Z_{VCS} "bins".