

CPSC 314
Assignment 4 (7%)

Due Friday March 9, 2018

Answer the questions in the spaces provided on the question sheets. If you run out of space for an answer, use separate pages and staple them to your assignment.

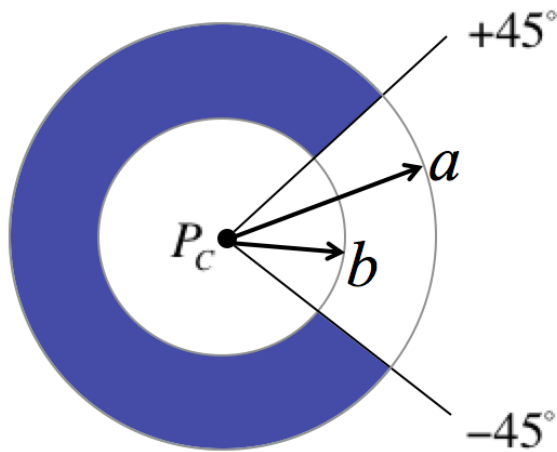
Name: _____

Student Number: _____

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TOTAL	/ 28

1. (6 points) Scan Conversion with implicit functions

Write pseudocode for scan converting the letter 'C' as defined below. The 'C' is centred at location $P_C(x_C, y_C)$, and has an outer and inner radius of a and b , respectively. You can assume that $b < a$. Use implicit equations to develop your solution. Do not use any trigonometric functions. Assume that a pixel is set on using `Image[x][y]=1`, and that the image spans from $(0,0)$ in the bottom left to $(w-1,h-1)$ in the top right, giving an image of $w \times h$ pixels. If part of the letter 'C' is located off-screen, the remainder should still be properly rendered.



2. Barycentric coordinates and interpolation

A triangle has device coordinates $P_1(0, 0)$, $P_2(50, 50)$, $P_3(100, 0)$. We wish to be able to interpolate a value v for an arbitrary point $P(x, y)$ in the triangle, given the values at the vertices.

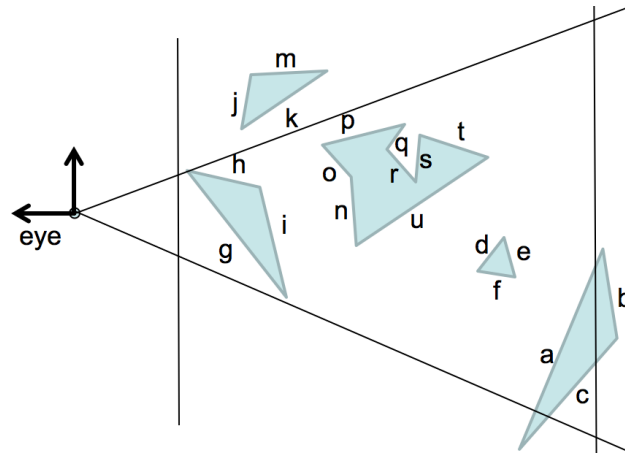
(a) (1 point) Sketch the triangle and the point $P(30, 10)$.

(b) (3 points) For each of the edges: (i) Write an explicit line equation for each of the edges, i.e., $y = f(x)$. (ii) Rearrange the terms of each of these equations to trivially transform these into implicit line equations, i.e., $f(x, y) = 0$; (iii) Lastly, give a scaled implicit line equation so that the implicit line equation evaluates to 1 at the third vertex, i.e., the vertex not on the line segment.

- (c) (2 points) The barycentric coordinates of a point $P(x, y)$ in a triangle are given by $P = \alpha P_1 + \beta P_2 + \gamma P_3$, where $\alpha + \beta + \gamma = 1$.
- (i) On your diagram above, label each of the vertices with their (α, β, γ) values.
 - (ii) Sketch and label lines corresponding to $\alpha = 0, \alpha = 0.5, \alpha = 1$ in the above diagram.
- (d) (2 points) Using your work above, give expressions for computing α, β, γ for a point $P(x, y)$ in the triangle. Verify that $\alpha + \beta + \gamma = 1$ holds true for your expressions.
- (e) (1 point) Compute barycentric coordinates for $P(30, 10)$ and use them to compute v for that point, given the following known values for v at the vertices: $v_1 = 10, v_2 = 20, v_3 = 60$.

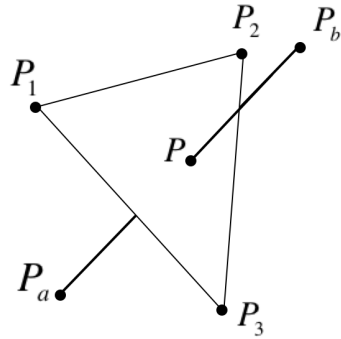
3. Visibility and Culling

Consider the scene below, shown as a side-view of VCS. Assume that all the objects shown are solid, and that the labelled lines represent polygonal faces of the objects.



- (a) (2 points) List, in alphabetical order, the polygons that would be culled by view frustum culling.
- (b) (2 points) List, in alphabetical order, the polygons that would be culled by back-face culling. Note: consider both types of culling independently of each other.
- (c) (2 points) After view-frustum culling and back-face culling, list in alphabetical order the remaining faces that would be completely removed by z-buffer tests.

4. In a number of 3D graphics and 3D simulation algorithms, it is useful to be able to quickly and efficiently detect whether a given line segment, P_aP_b intersects a given triangle, as shown below. This can be done by computing the line-plane intersection at point P , and then determining if point P lies inside the line-segment and inside the triangle.



- (a) (2 points) Develop a parametric expression for a point P in the triangle using only two of the three barycentric coordinates, i.e., $P(\alpha, \beta)$, where α and β are the usual barycentric coordinates, i.e., $P = \alpha P_1 + \beta P_2 + \gamma P_3$.
- (b) (1 point) Give a parametric expression for a point $P(t)$ on the line segment.
- (c) (2 points) Give a set of equations that can be solved for the three unknown parameters, α, β, t that uniquely define the intersection point, P .
- (d) (2 points) Given values for α, β, t , show:
- how to compute the coordinates of P ;
 - how to test whether the line segment does or does-not intersect the triangle.