

# CPSC 314

## Assignment 3 (6%)

Due Friday March 10, 2017

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.

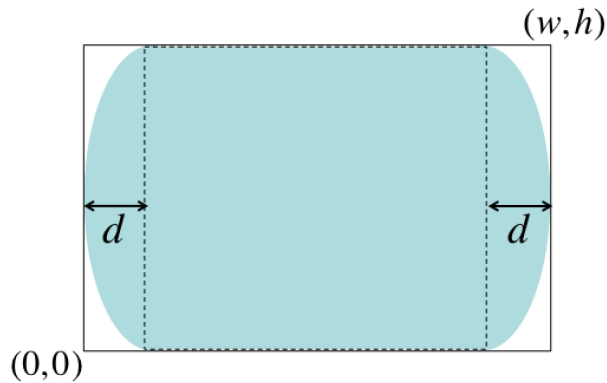
Name: \_\_\_\_\_

Student Number: \_\_\_\_\_

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## 1. (5 points) Scan Conversion

Give the pseudocode for scan converting the solid-shaded region shown below. This consists of a rectangular region of width  $w - 2d$  that is augmented by two half ellipses on the left and the right, as shown below. You can assume that  $d < w/2$ . Use implicit equations to develop your solution. Note: the equation of an ellipse of width  $a$  and height  $b$  that is centred at the origin is given by  $(\frac{x}{a})^2 + (\frac{y}{b})^2 = 1$ .



## 2. Scan Conversion and Interpolation

A triangle has device coordinates  $P_1(40, 90)$ ,  $P_2(10, 70)$ , and  $P_3(60, 10)$ . You wish to interpolate a value  $v$  for point  $P(30, 50)$ , given the value of  $v$  at the vertices:  $v_1 = 10, v_2 = 20, v_3 = 60$ .

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

(b) (3 points) Develop a plane equation for  $v$  as a function of  $x$  and  $y$ . You can use Matlab, online Octave (<https://octave-online.net/>), or an online linear equation calculator (Google this) to solve a set of linear equations for your plane parameters. Compute  $v$  for point  $P$  using the plane equation.

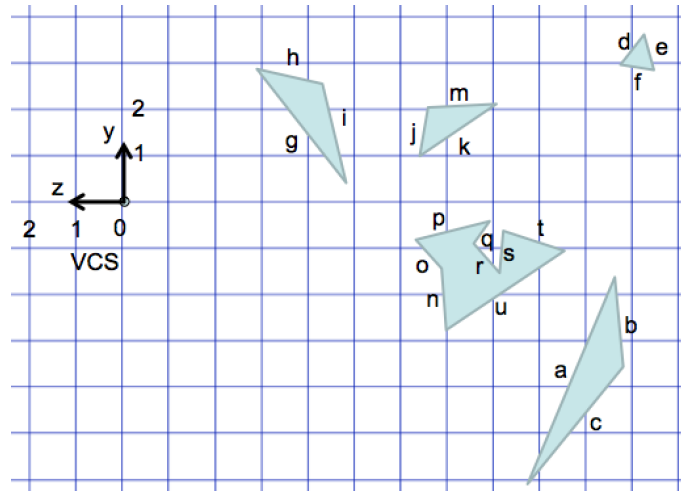
- (c) (4 points) The barycentric coordinates are defined according to:

$$P = \alpha P_1 + \beta P_2 + \gamma P_3.$$

- (i) Sketch the lines corresponding to  $\alpha = 0$ ,  $\alpha = 0.5$ , and  $\alpha = 1$  on your diagram for part (a).
- (ii) Compute the barycentric coordinates for point  $P$ . Hint: compute the first two barycentric coordinates using the scaled implicit line equations, and then use the fact that they sum to 1 to compute the third barycentric coordinate.
- (iii) Compute  $v$  for point  $P$  using the Barycentric coordinates. It should be the same as what you computed previously.

## 3. (8 points) Culling and Clipping

Consider the scene below, shown as a side-view of VCS.  $\text{near}=2$ ,  $\text{far}=10$ ,  $\text{bottom}=-1$ ,  $\text{top}=1$ ,  $\text{left}=-1$ ,  $\text{right}=1$ . Assume that all the objects shown are solid, and that the labelled lines represent polygonal faces of the objects.



(i) On the diagram above, sketch the perspective view volume corresponding to the above parameters.

(ii) List, in alphabetical order, the polygons that would be culled by view frustum culling.

(iii) List, in alphabetical order, the polygons that would be culled by back-face culling. Note: consider both types of culling independently of each other.

(iv) Sketch the line segment  $P_1(0, 0, -4)P_2(0, -5, -3)$  on the above diagram. Give an implicit plane equation for the bottom plane of the perspective view volume that returns positive values for points inside the view volume. Determine the in/out status of  $P_1$  and  $P_2$ . Compute the point where the line segment intersects the bottom plane.

4. (3 points) Suppose that a triangle is defined by three points,  $P_a P_b P_c$ , as listed in counter-clockwise order when seen from above.
  - (a) Give the surface normal,  $N$ , as expressed using a cross product.
  - (b) Show how to compute the parameters of an implicit plane equation,  $F(P) = 0$ , that embeds the three points. Your answer here should be complete, but it can be quite short.