CS450/550 — MIDTERM EXAM — Winter 1996

This exam is open book, open notes. You have 60 minutes to work the exam. The number of points for each problem is shown in square brackets [60] next to each problem. One point = one minute.

1. [5] Suppose we are using Bresenham's circle algorithm to draw a circle of radius 10 centered at (0,0) in absolute device coordinates. The algorithm will set the pixels at (0, 10), (1,10), (2, 10), (3, 10), and (4, 9). Which pixel will it set next?

> We must compute the sign of $f(A) + f(B)$, where $f(x, y) = x^2 + y^2 - r^2$ and the two candidate points are $A = (5, 9)$ and $B = (5, 8)$.
>
> $$\begin{aligned} f(A) &= 106 - 100 = 6 \\ f(B) &= 89 - 100 = -11 \\ f(A) + f(B) &= -5 \end{aligned}$$
>
> Because the sign is negative, we choose (5, 9).

2. [2] Let P be the point (2, 1, 10) and suppose the viewpoint is at $(0, 0, -10)$. If we apply the perspective depth transformation to P, what are its transformed coordinates?

> (1, 0.5, 0.5)

3. [8] Consider a 2-D window defined by

$$\begin{aligned} left &= 2 \\ right &= 4 \\ top &= 0 \\ bottom &= -5 \end{aligned}$$

Suppose this is to be mapped onto an X-window viewport having dimensions of 100 pixels by 100 pixels. (You may assume that the `viewport_t` normalized device coordinates are $(left = 0, right = 1, bottom = 0, top = 1)$).

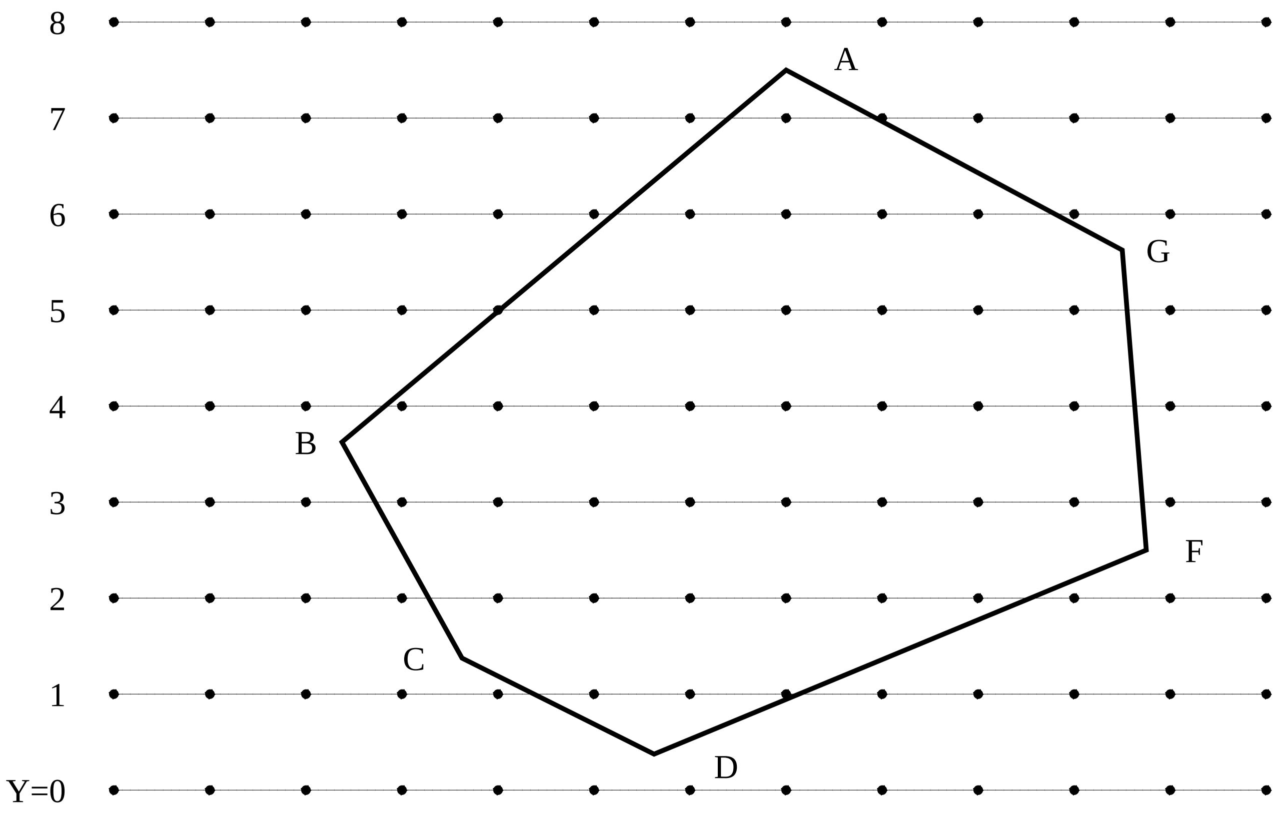
(a) [4] Give the device coordinates for each of the following points (given in world coordinates):

$(8, 5)$	(0,0)
$(8, -5)$	(0,50)
$(9.98, 5)$	(99,0)
$(9.98, -14.8)$	(99,99)

(b) [4] Give the world coordinates for each of the following pixels (given in X-window device coordinates):

(25,25)	$(8.5, 0.0)$
(50,50)	$(9, -5)$
(75,50)	$(9.5, -5)$
(80,80)	$(9.6, -11)$

4. [12] Suppose we wish to fill the following convex polygon.



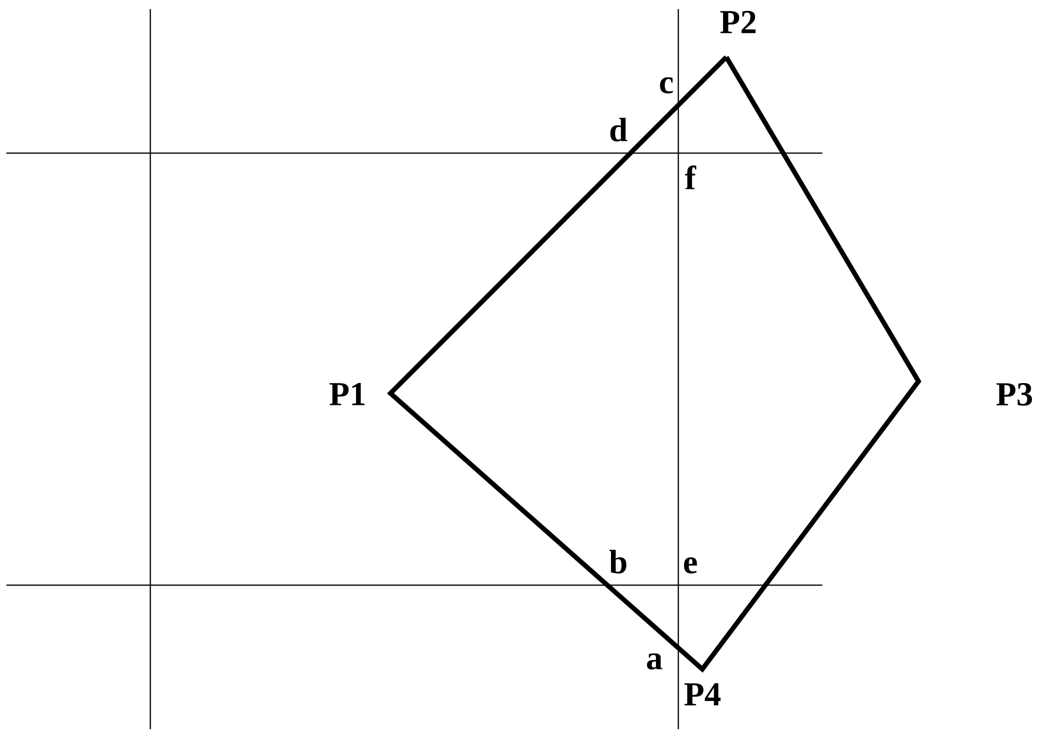
(a) [6] Fill out the following table giving the initial list of edges (in proper order) constructed by the polygon filling algorithm. Describe each list by its end-points (which may be given in either order).

from point	to point
A	B
A	G
G	F
B	C
D	F
C	D

(b) [6] When the algorithm is ready to draw the scan line at Y=3, which edges are still in the edge list?

from point	to point
G	F
B	C
D	F
C	D

5. [12] Hand-execute both passes of the polygon clipping algorithm on the following polygon. Name any new vertexes using lower case letters and mark them on the drawing.



First Pass:

	L	R	B	T
P4	P4	P4	P4	
P1	P1	a	a	a
		P1	b	b
			P1	P1
P2	P2	c	c	d
P3	P3	XXX		
P4	P4	XXX		

Second Pass:

	L	R	B	T
P4	P4	c	c	
P1	P1	a	e	f
				e
		P1	b	b
			P1	P1
P2	P2	c	c	d
P3	P3	XXX		
P4	P4	XXX		

6. [2] In the figure from Problem 4, suppose that the world coordinates of P1 are (5, 4) and the

world coordinates of P2 are (12, 11). Let the top of the window have the equation $y = 9$. What are the coordinates of the point where the line connecting P1 to P2 intersects the top of the window?

(10, 9)

7. [2] Let P1 be as in Problem 5. If we scale P1 by 2 (with respect to the origin) and then translate it by $(-5, -6)$, what are its new coordinates?

$$2(5,4) + (-5,-6) = (5,2)$$

8. [8] Write down the view transformation matrix for the situation where the new origin it at (5, 5, 0), the reference point is at (5, 5, 5), and the up direction is (0, 1, 0). Hint: Draw a picture first.

The coordinate axes in the new system are the same as the old, so all we need to do is translate by $(-5, -5, 0)$:

$$\begin{array}{cccc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -5 & -5 & 0 & 1 \end{array}$$

9. [9] Suppose one of the faces of a `tmesh_t` lies in the plane defined by the equation $4x - 3z - 5 = 0$.

(a) [3] What is the unit normal vector for this plane?

First we convert the equation to canonical form: $5^2 = 4^2 + 3^2$, so the normalized equation is

$$\frac{4}{5}x + 0y - \frac{3}{5}z - 1 = 0$$

The surface normal is therefore $(\frac{4}{5}, 0, -\frac{3}{5})$.

(b) [3] If the camera is at position $(0, 0, -10)$, is this plane a "front face" or a "back face"? (show your work)

If we plug this into the left-hand-side of the normalized equation, we get $\frac{4}{5} \cdot 0 + 0 \cdot 0 - \frac{3}{5} \cdot (-10) - 1$ which simplifies to 5. This is positive so the face is visible.

(c) [3] What C++ class would be used in the code to store this equation?

The `plane_t` class, which in turn is part of a `triangle_t` structure.