READ ME FIRST

- Don't spend too much time on any one problem.
- Amount of time spent on a problem is not necessarily proportional to the points.
- Scan through the entire test and do the easy problems first.
- If something is not clear, ASK.
- BE NEAT. We cannot give you points for something that we can't read.
- Write down your assumptions.
- Write an outline of your solution for each problem.

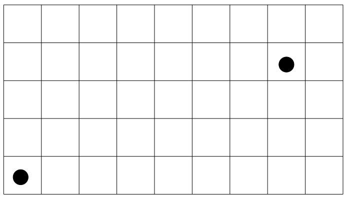
1	20 points	Line Drawing	
2	20 points	Vectors	
3	15 points	Matrices	
4	15 points	Transformations	
5	10 points	OpengGL	
6	20 points	Clipping	
7	0 points	Bonus	
	100 points	GRAND TOTAL	

1. **Line Drawing (20 points)**

   (a) (**13 points**) Calculate the first three points of the line drawn from the point (0,0) to (7,3) using the Bresenham algorithm as discussed in class. Fill in the table below!

   Recall that $P_1 = 2\Delta y - \Delta x$. For $m <= 1$, if $P_i < 0$, a sideway move is generated and $\Delta P_i = 2\Delta y$, else, a diagonal move is generated and $\Delta P_i = 2\Delta y - 2\Delta x$.

i	x_i	y_i	P_i	ΔP_i
1	0	0		
2				
3				
4				n/a



   (b) (**7 points**) Write the OpenGL code to draw a line segment from (0,0) to (7,3). Assume window and viewport coordinates are the same.

2. **Vectors (20 points)**
   (a) (**5 points**) What is the angle between the following vectors: [1,1,1] and [1,2,3]?

   (b) (**5 points**) What is the cross product between the following vectors: [1,1,1] and [1,2,3]?

   (c) (**10 points**) Given the plane $x + 2y + 3z = 0$ and the point (1, 1, 1), find the equation of the plane that is perpendicular to the given plane, goes through the origin, and contains the given point.

3. **Matrices (15 points)**

   You are given the matrix below.

$$M = \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & 0 \\ \frac{-1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

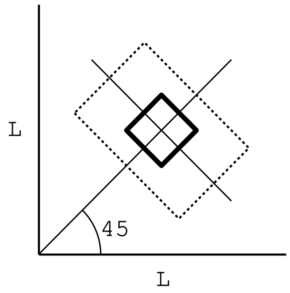
   (a) (**5 points**) What does this matrix do? Be precise/complete.

   (b) (**5 points**) What is the inverse of this matrix?

   (c) (**5 points**) What is the determinant of this matrix?

4. **Transformations (15 points)**

   What is the 2D composite matrix M that will scale objects relative to the rotated axes. In the illustration below, we want to scale the solid box twice along one side and three times along the other side into the dashed rectangle. That is, it is being scaled relative to the axes that has been rotated 45 degrees. Assume the box is centered at (L, L). Fill in each component matrix with as much information as possible. You do not need to multiply the matrices out.



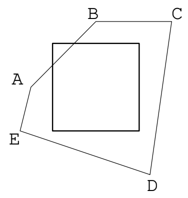
5. **OpenGL (10 points)**

   What is the effect of the following routine? Be careful with your coordinates!

```
glOrtho( 0, 20, 20, 0, 0, 0 );
glViewport( 0, 0, 300, 300 );
glBegin( GL_POINTS );
    glVertex2i( 150, 150 );
glEnd();
```

6. **Clipping (20 points)**

   Given polygon ABCDE below, find the intermediate polygon as it is *successively* clipped against the following bounderies using the Sutherland-Hodgman algorithm. Redraw the intermediate polygon at each step and label any new vertices that may have been introduced.



   (a) (**5 points**) Clipped against the left edge:

   (b) (**5 points**) Clipped against the bottom edge:

   (c) (**5 points**) Clipped against the right edge:

   (d) (**5 points**) Clipped against the top edge:

7. **Tricky One (0 points)** What is your favorite animal to have as a pet? Cats, dogs, or something else? Be sure to answer this one correctly.