



[You may use one side of an 8.5×11 inch sheet of paper.] Show all of your work clearly in the space provided or on the additional page at the end of the exam. If the additional page is used, clearly identify to which exam question it is related. Be sure to **read each problem carefully**. You should answer all 8 questions, and you may wish to answer the bonus question if you have time. Note that the exam is double sided.

1. (10 points) How much time is spent scanning across each row of pixels during screen refresh on a raster system with a resolution of 1280×1024 pixels and a refresh rate of 60 frames per second? Be sure to state any assumptions you make.

2. (10 points) What is the corresponding X windows command for `SetPixel(x,y)`? What arguments does it accept?



3. (10 points) When the midpoint circle algorithm is used to plot an origin centered circle with $r = 10$, will the points selected on the x -axis be inside, outside, or on the theoretical circle? Explain your reasoning. (Half credit for appropriately identified guess that is correct.)

4. (10 points) Briefly, in your own words, describe a shadow mask and what it is used for.

5. (10 points) Briefly describe how anti-aliasing techniques can be used to generate a line which appears to be two-fifths of a pixel wide.

6. (15 points) What will the following transformation matrix do?

$$\vec{\mathbf{T}}(t_x, t_y) = \begin{bmatrix} -\cos(30) & \sin(30) & 0 \\ \sin(30) & \cos(30) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Show all your work.

7. (20 points) The following is Bresenham's algorithm for $m \in (0, 1)$. Modify the algorithm for lines with $m \in (-\infty, -1)$. Identify any assumptions made and show all of your work.

1. Input line endpoints (x_ℓ, y_ℓ) and (x_r, y_r)
2. Plot first point—`SetPixel` (x_ℓ, y_ℓ)
3. Precompute $2\Delta y$, $2\Delta y - 2\Delta x$, and $p_0 = 2\Delta y - \Delta x$
4. For $x_k = x_\ell$ to $x_r - 1$ step 1
 - If $p_k < 0$
 - $y_{k+1} = y_k$
 - `SetPixel` (x_{k+1}, y_{k+1})
 - $p_{k+1} = p_k + 2\Delta y$
 - else
 - $y_{k+1} = y_k + 1$
 - `SetPixel` (x_{k+1}, y_{k+1})
 - $p_{k+1} = p_k + 2\Delta y - 2\Delta x$

8. (15 points) Indicate the order in which the interior pixels are filled in a boundary fill using the 4-connected fill pattern. Begin filling at pixel (3,6). Identify any assumptions made and show all of your work.

8	.	.	.	.	.	.	.	.
7	.	.	•	•	.	•	.	.
6	.	•	.	.	•	.	•	.
5	.	•	.	.	.	.	•	.
4	.	•	•	.	.	•	.	.
3	.	.	.	•	•	.	.	.
2	.	.	.	.	.	.	.	.
	0	1	2	3	4	5	6	7

bonus (10 points) What calls are on the stack when pixel (4,4) is considered?



Additional work area for any problem. Clearly identify to which problem the work on this page is related.