CSC 240: Computer Graphics
Midterm: Fall 2020
Due: Friday, October 16 at 11:59 pm (on Moodle)

- This is a take-home exam with unlimited time from when it is out to when it is due. I don't expect you to work on it the entire time; it should take you just a few hours.
- It is open-notes, so you may use any course materials. If you use any online resources that haven't been part of this class, please cite them explicitly.
- You may not communicate or consult about the exam with anyone in the class (or outside the class, including requesting help by posting questions on the internet).
- You can email me if you need clarification on any question. If there is a clarification I think should be made to the entire class, I'll post it on Piazza.
- I will still have office hours as usual, but I might not say much about the exam!
- Turn in your exam by scanning it and submitting on Moodle.
- If you are unable to make progress on any part of the exam, tell me what you tried: describe your thought process. I may be able to grant partial credit.
- When your exam is complete, before submitting it, please copy, sign, and date the statement below:
  "I certify that my work on this exam adheres to the Smith Honor Code and the instructions given above. I have explicitly cited any resources used beyond my own notes and the materials available from the course web page."

Signed: Date:

Name:	
Part 1	/20
Part 2	/20
Part 3	/20
Part 4	/20
Part 5	/20
Total	/100

Part 1: Pixels and Coordinates

A line is to be drawn on a screen from (30,20) to (90,50) using antialiased graphics.

a.) Does the length of the drawn line change under the pixel center origin vs. corner origin conventions? Why or why not?

b.) Does the position of the drawn line change under the pixel center origin vs. corner origin conventions? Why or why not?

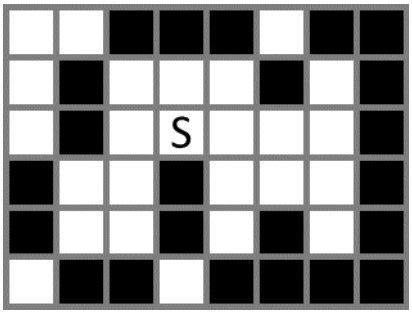
c.) If you examine a small window of pixels near the center of the line, will it be possible to distinguish between lines drawn under the pixel center origin vs. corner origin conventions? Why or why not?

d.) If you examine a small window of pixels near an end of the line, will it be possible to distinguish between lines drawn under the pixel center origin vs. corner origin conventions? Why or why not?

e.) Which of your answers above would change if the line were drawn using simple graphics (no antialiasing) instead?

Part 2: Fill Algorithms

To avoid a call stack overflow with the recursive fill algorithm, the important statistic to track is the recursion depth, or the number of invocations of a recursive function that are active (have not yet returned) at any given moment. An error will occur when the recursion depth reaches a predefined limit set by the system. For the image at right, and the specified recursion order below, give the maximum recursion depth that would occur. You may show your work for partial credit.



a.) Recursion order {North, South, East, West}.

b.) Recursion order {East, South, West, North}

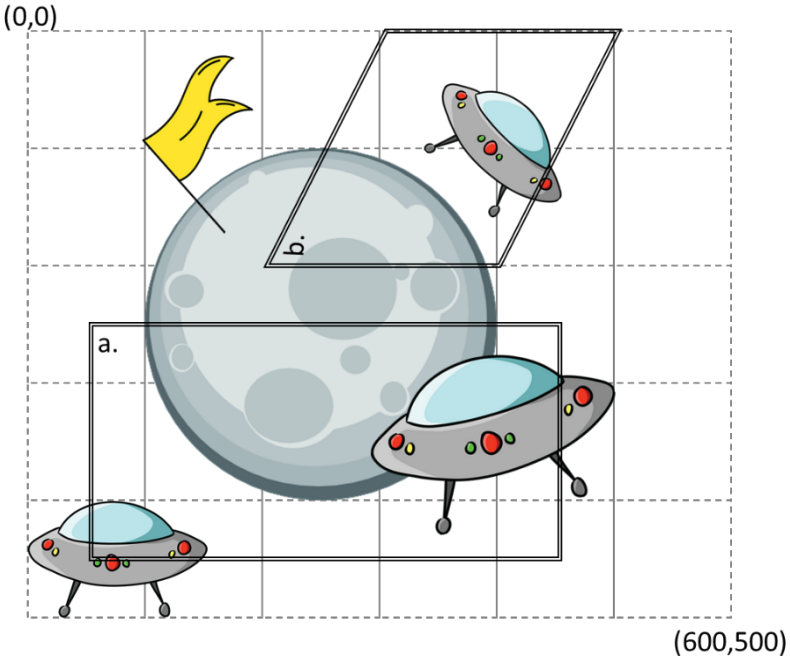
c.) Recursion order {Northwest, Northeast, Southeast, Southwest, North, East, South, West}.

d.) Using sweep fill with 4-connection, and recursion order {North, South}, what is the maximum recursion depth?

e.) Using sweep fill with 8-connection, and recursion order {Northwest, North, Northeast, Southwest, South, Southeast}, what is the maximum recursion depth?

Part 3: Transformations.

Suppose that we have the scene shown below, with world coordinates as specified at the corners. Our viewport is 100x100 pixels.

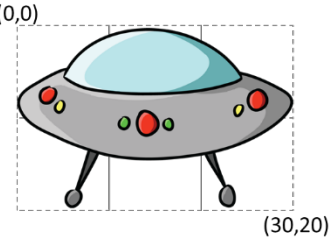


a.) Give the rendering transform matrix (in homogeneous coordinates) that would display the portion of the scene enclosed by the box marked a above. Assume that the scene will be oriented with the a label at the top left.

b.) Give the rendering transform matrix (in homogeneous coordinates) that would display the portion of the scene enclosed by the box marked b above. Assume that the scene will be oriented with the b label at the top left.

c.) On the image above, draw a box showing the portion of the viewport that would be shown if the rendering transform was $\begin{bmatrix} 0 & 0.33 & -50 \\ -0.33 & 0 & 150 \\ 0 & 0 & 1 \end{bmatrix}$. Label the top left corner c.

d.) Assume that we have the object template shown at right, with scale given by the coordinates in the corners. Give the modeling transform that would place this object into the scene at the position of the UFO at the lower left.



e.) Suppose that the object is placed into the world with a modeling transform of $\begin{bmatrix} 2 & 0 & 200 \\ 0 & -2 & 300 \\ 0 & 0 & 1 \end{bmatrix}$, and the world is displayed with a rendering transform of $\begin{bmatrix} 0.2 & 0 & -100 \\ 0 & 0.2 & 100 \\ 0 & 0 & 1 \end{bmatrix}$. What single matrix would transform points in object coordinates to viewport coordinates?

Part Four: Curves

Answer the questions below concerning curves.

a.) Given a third-order Bézier curve with $p_0 = (0,7)$, $p_1 = (1,2)$, $p_2 = (4,6)$, and $p_3 = (5,-1)$, what point would lie on the curve at $t = 0.4$?

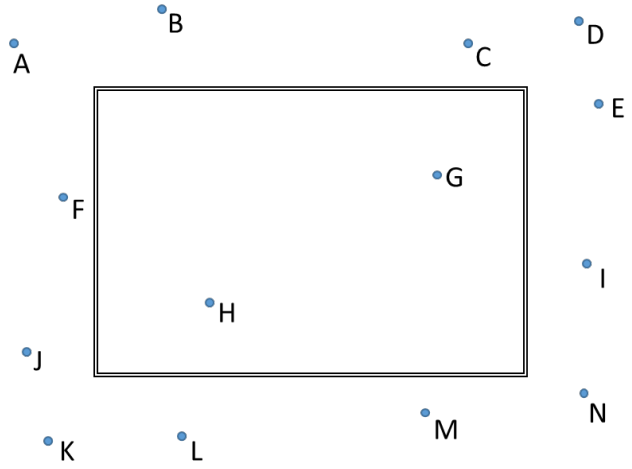
b.) Given a first-order Bézier curve with $p_0 = (3,3)$ and $p_1 = (5,8)$, what is the t value for the point (3.7,4.75)?

c.) Given a second-order Bézier curve with $p_0 = (-2,0)$, $p_1 = (3,6)$, and $p_2 = (4,1)$, what is the t value at the point (3.44,2.56)? *(Hint: you can use the quadratic equation.)*

d.) Suppose we want a second-order Bezier curve with $p_0 = (0,4)$ and $p_2 = (4,0)$ to be symmetric around the line $y = x$ and pass through the point (4,4). Where should we place p_1?

Part 5: Line Clipping

Consider the diagram at right while answering the questions below. For each question you are asked to give the endpoints of a line or lines that would satisfy the given description, or state that no such line exists using the available endpoints shown. (Assume that the first endpoint given is p_0 and the second is p_1.) You should reference the case breakdown in the revised handout on Cohen-Sutherland line clipping.



a.) Any line or lines that immediately trigger Case 1.
b.) Any line or lines that immediately trigger Case 2, starting from F.
c.) Any line or lines that do not trigger Case 2 immediately, but eventually do trigger Case 2 during evaluation of a recursive call.
d.) Any line or lines that will immediately trigger Case 3e, followed by Case 3h.
e.) Any line or lines that will immediately trigger Case 3f, followed by Case 3h.
f.) Any line or lines that will immediately trigger Case 3a, followed by Case 3f.
g.) Any line or lines that will immediately trigger Case 3g, followed by Case 3d.
h.) Any line or lines that will trigger five or more cases in total.