

Mechanical Engineering

Computer Graphics and Image Processing

1. Describe, in detail, an algorithm that will draw a one-pixel wide outline of a circle of integer radius centred on the origin. [10 marks]
2. Describe the modifications required to your algorithm in part (a) to make it draw a filled circle. [3 marks]
3. Describe the modifications required to your algorithm in part (a) to make it draw the outline of a circle centred at arbitrary integer coordinates. [2 marks]
4. Describe the modifications required to your algorithm in part (c) to make it draw the outline of a circle centred at arbitrary non-integer coordinates and of non-integer radius. [5 marks]
5. Explain what a MIPmap is, how to create one, why one would want to use one, where one would be used, and how one is used. [8 marks]
6. Describe an algorithm that converts a greyscale image into a black and white image using halftoning. Assume that the black and white image has eight times the resolution of the greyscale image in each dimension. [6 marks]
7. Various types of visual artifact (“aliasing”) occur if images are rendered using only one sample per pixel.
 - i. Describe at least three different artifacts that occur. [3 marks]
 - ii. Describe a straightforward method to ameliorate these artifacts. [3 marks]
8. Most liquid crystal displays divide a pixel into three sub-pixels colored red, green, and blue. Explain why this is so. [4 marks]
9. Some liquid crystal displays divide a pixel into four sub-pixels colored red, green, blue, and white. Explain why this might be useful, what advantages it has, and what limitations it has. [6 marks]
10. Compare and contrast half-toning and error diffusion. Include in your answer an explanation of the situations in which each is superior to the other. [6 marks]
11. One method of anti-aliasing is to sample at high resolution, $n \times n$ higher than the final image, and then to average each block of $n \times n$ pixels to give a single pixel value. Discuss the advantages and disadvantages of using
 - i. Gaussian blurring, and

ii. median filtering

in place of simple averaging. [4 marks]

12. Describe in detail an algorithm that returns the minimum distance from a point to a line segment in two dimensions. Ensure that you include all of your assumptions and all necessary mathematical calculations. [7marks]
13. A quadratic Bezier curve is defined by three points, P_1 , P_2 , P_3 , and a parameter, t :
$$P(t) = (1 - t)^2P_1 + 2t(1 - t)P_2 + t^2P_3, 0 < t < 1$$

Describe an algorithm that draws the quadratic Bezier curve, using straight lines only, to within a tolerance ϵ . You may use the algorithm from part (a) and you may assume that you already have an algorithm for drawing a straight line. [8 marks]
14. Consider the control of detail in a curve that is represented by a sequence of many straight lines segment. Describe how Douglas and Pucker's algorithm can be used to remove superfluous points. You may use the algorithm from part (a). [5 marks]
15. Assume that you have an algorithm that can fill 3D triangles with a constant color. Explain what additional information and additions to the algorithm are required to Grouard shade the triangles. [6 marks]
16. Given the algorithm in (a), explain what additional information and additions to the algorithm are required to texture map the triangles using bilinear interpolation, including an explanation of how the bilinear interpolation is done. [6 marks]
17. Explain the advantages and disadvantages of using nearest-neighbors interpolation compared with bilinear interpolation. [3 marks]
18. Explain why a MIPmap would be useful for texture mapping and how one could be incorporated into the algorithm from (b). [5 marks]
19. Describe an algorithm that draws a Bezier cubic curve to a specified tolerance using straight lines. [7 marks]
20. Describe an algorithm for clipping a line against a rectangle. [7 marks]
21. A Bezier cubic curve could be clipped and drawn using the algorithm in part (a) to produce straight lines and the algorithm in part (b) to do the clipping. Describe a more efficient algorithm that draws a Bezier cubic curve clipped against a rectangle. [6 marks]

22. Describe the A-buffer polygon scan conversion algorithm using 4 x 4 sub-pixels for each pixel. [10 marks]
23. It is possible to represent continuous tone greyscale images using just black ink on white paper because of limitations in the human visual system. Explain how and why. [4 marks]
24. Describe an algorithm that, given a greyscale image, will produce a black and white (bi-level) image of four times the resolution in each dimension which provides a good approximation to the greyscale image. [6 marks]
25. Give an outline description of the painter's algorithm, Z-buffer and BSP tree methods for rendering a set of 3D polygons. [3 x 4 marks]
26. Compare and contrast the three methods. [8 marks]