Name:

Mid-term examination

Computer Graphics 1 (15-462)

Grade value: 13%

Duration: 1 hour 10 minutes

Answer all questions for full credit

Question 1: Constructive Solid Geometry - CSG (again) (27)

(a) Explain what a parametric function is. Give an example and say what parametric functions are useful for and why. (3)

(b) Explain what an implicit function is. Give an example and say what implicit functions are useful for and why. (3)

(c) What are the geometric primitives of CSG? Give some examples. (2)

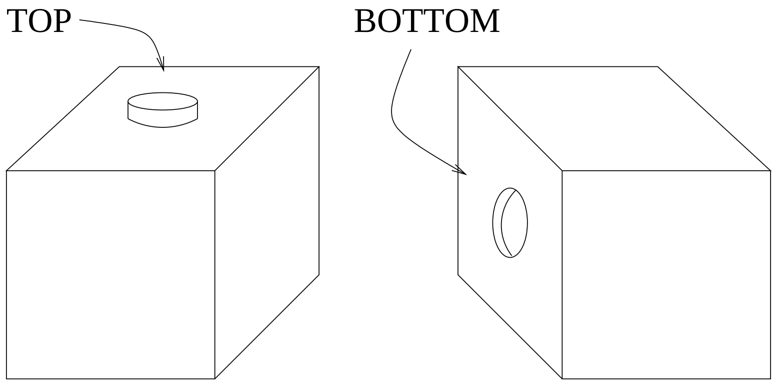
(d) What are the three basic operations of CSG? (2)

(e) What boolean operations implement the basic CSG operations? (2)

(f) What implicit functions implement the basic CSG operations? (2)

(g) Explain how the implicit functions achieve these operations. (3)

(h) Imagine a set of building blocks that interlock at the top and bottom faces. Explain what boolean functions would be used to form a piece of this building block set - you should use all three CSG operations. Assume that your basic building blocks are cubes and that you are given the implicit form of the surface that defines the interlocking shape. (5)



(i) To display these building blocks on screen without ray tracing we require the polygonal mesh of each block. Explain how to generate the polygonal mesh for a single block using the method that you explained in part (h). Assume that you are given the polygonal meshes for a cube and for the surface that defines the interlocking shape. (5)

Question 2: Image processing (24)

(a) Explain what point processing is. (1)

(b) Given the point processing function $f(v) = v^p$, what is its effect on the image if $p > 1$? How does it work? What condition must be applied to v? (3)

(c) Filtering can be applied to any kind of signal. What kind of signal is an image? (1)

(d) What is a linear, shift-invariant filter? (2)

(e) Convolution implements a linear, shift-invariant filter. Explain what convolution is. What is a convolution matrix? (1)

(f) Blurring is a convolution. Give a convolution matrix for a 3x3 blur. (1)

(g) Other examples of convolution matrices are shown below. Describe what they do and what the resulting image would look like. (4)

$$\begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix}$$

(h) The above convolutions form a significant part of the edge filter. What is an image edge? Why is the full edge filter a non-linear filter? (3)

(i) Convolve the following image patch with the blurring filter and the two convolution matrices above. Apply each convolution to the original image patch (not the new convolved one). Explain what you do at the edge of the image patch. (10)

100	110	120	123	120
100	110	120	97	101
90	100	80	120	134
85	90	72	100	152
75	102	68	111	112

Question 3: Clipping (30)

(a) Why is the image forming process from the world to an image known as a projective transformation? (1)

(b) This projective transformation is expensive to compute, and so only the viewable world should be projected. What part of the world is visible in an image? Illustrate with a diagram. You should include 6 clipping planes in the diagram. (4)

(c) What is the name of this viewable region of space? (1)

(d) There are two approaches to ensuring that only the viewable regions of space are projected. Briefly describe what they are. (2)

(e) What are the three different conditions for the end points of a line when it is being clipped? What are the implications of each of these conditions? (6)

(f) The Cohen-Sutherland algorithm uses the concept of *out-codes* for each end of the line. What are out-codes? (1)

(g) Define the out-codes for a typical rectangular clipping area and show all the possible values. (6)

(h) Explain how out-codes are used to calculate the visible parts of lines. Describe in detail how the algorithm determines the visible section of a line that can not be trivially accepted or rejected. (8)