

# CS 559: Computer Graphics

## Detailed Syllabus

This document outlines the set of things you should know or be able to do by the time the midterm comes around on March 22nd. Recall that for the midterm you are allowed one double-sided 8.5x11 page containing anything (notes, diagrams). Items are listed roughly by topic.

- Color:**
- From a physics point of view, color is specified by a spectrum.
  - Be able to describe some of the things that affect color perception.
  - Understand the experimental evidence for and mathematical implications of the principle of trichromacy.
  - Understand color matching functions.
  - Understand the idea of a color space.
  - Be familiar with RGB color space. There is no need to know the wavelengths of the primaries.
  - Be familiar with CIE-XYZ and CIE-xy color space.
  - Know how to go from one linear color space to another.
  - Understand the problems with perceptually non-uniform color spaces.
  - Be familiar with HSV color space.
  - Be familiar with the advantages of the Yu'v' color space.

- Color Quantization:**
- Understand how indexed color works.
  - Understand the issues involved in color quantization algorithms, including perceptual issues, Mach bands, and quantization error.
  - Know how uniform quantization, populosity and median cut work.

- Dithering:**
- Understand why dithering is important.
  - Know how to go from color to grayscale.
  - Know how threshold dithering, random dithering, ordered dithering and Floyd-Steinberg dithering work, and their relative strengths and weaknesses.

- Signal Processing:**
- Know that an image can be represented in the spatial domain or the frequency domain.
  - Know how certain features in the spatial domain manifest themselves in the frequency domain, and vice-versa. For example, what do high frequencies look like in the spatial domain?
  - Know that a periodic signal only needs harmonic wavelengths, while a general signal may need components of all wavelengths.
  - Know the representations for various common functions in the spatial and frequency domain: box & sinc, delta & constant, spikes (shah) & spikes (shah), Gaussian & Gaussian. Know that knowing one direction also gives you the other direction. For example a box in spatial is a sinc in frequency, and a box in frequency is a sinc in spatial.
  - Understand what it means for a function to be band-limited.
  - Know that filtering is multiplication in the spatial domain and convolution in the frequency domain.

- Know that reconstruction is multiplication in the frequency domain and convolution in the spatial domain.
- Understand sampling, ideal reconstruction and the causes of aliasing.
- Know what the Nyquist frequency is.

**Filtering:**

- Know the basic shapes of some common filters (box, Gaussian, Bartlett, spikes, edge detection, enhancement) and the results of applying them to an image.
- Understand how to construct a 2D filter from a 1D filter.
- Understand the principles of image enlargement and reduction.
- Know how to filter in color.

**Compositing:**

- Understand what  $\alpha$  represents.
- Understand what is meant by pre-multiplied  $\alpha$  colors.
- Know the basic compositing equation,  $c_o = Fc_f + Gc_g$ , and know the F and G values for the over, in, out, atop, xor and clear operations.
- Know a couple of ways to get  $\alpha$  values for an image.

**Transformations:**

- Understand the basics of coordinate systems and transformations.
- Know what an affine transformation is, and some of its properties.
- Understand the idea of homogeneous coordinates, and how to go from regular to homogeneous coordinates and back.
- Know the basic form of the transformation matrices for common transformations, in both regular and homogeneous form, in both 2D and 3D.
- Know how to rotate about an arbitrary point or axis, and scale about an arbitrary point.
- Be able to state the various ways of representing rotation transformations, and their relative benefits and weaknesses.

**Viewing Transformations:**

- Know the coordinate systems employed in a typical graphics pipeline, and be familiar with the transformations that take points from one end of the pipeline to the other. That means all the transformations from object space right through to window coordinates, including perspective transformations.
- Know which parameters are required to specify a view, including the viewing volume and the viewport, and how they influence what is seen and how it looks.
- Understand the distinction between orthographic and perspective views, and the general properties of each.

**Clipping:**

- Know how Sutherland-Hodgman clipping works, and be able to do an example.
- Understand how to do inside/outside testing, and find intersection points.
- Know how Cohen-Sutherland and Liang-Barsky line clipping works, and be able to do examples.
- Understand the high-level ideas in Nicholl-Lee-Nicholl and Weiler-Atherton clipping, but you don't need to be able to do examples.

**Rasterizing:**

- Understand Bresenham's algorithm, although there is no need to know the equations.

- Understand sweep-fill polygon filling, including the basic rules for deciding whether a pixel is inside or outside a simple polygon. There is no need to know the equations for updating the  $x$  values along edges using only integer arithmetic.
- Understand the basic approaches to anti-aliasing, particularly the distinction between pre-filtering and post-filtering.

**Visibility:**

- Understand the distinction between object-precision and image-precision algorithms.
- Be familiar with several visibility algorithms: painters, z-buffer, a-buffer, scan-line z buffer, depth sorting, Warnok's algorithm, BSP-Trees.
- Be able to identify the relative strengths and weaknesses of the various visibility algorithms.