CSE 287: Practical Learning Objectives

The following is a list of practical instructional objectives for CSE 287. Each describes some action or task that students should be able to perform. Several include the conditions under which the action or task should be performed.

Chapter Four (Ray Tracing)

1. State whether ray tracing is an image-order or object-order algorithm.
2. Write pseudo code that describes the basic ray tracing algorithm.
3. List or identify the two basic types of projection.
4. Identify the principle characteristics of an orthogonal projection.
5. Identify the principle characteristics of a perspective projection.
6. Write a mathematical expression that defines aspect ratio.
7. Given two rectangles and the dimensions of one or them, set the dimensions of the other to make the aspect ratios equal.
8. Given the heights, widths, and points of origin for two rectangles, create a mapping from one to the other.
9. Given two points, create a ray that will pass through the points going in a specified directions.
10. Given and origin and a direction, create a corresponding parametric description of a ray.
11. Given the parametric description of a ray and a value for the parameter, *t*, describe the location of the point associated with the parameter value relative to the origin of the ray.
12. Given the parametric description of a ray and solutions for the parameter, *t*, that are associated the intersections with a surface, identify which surface is closest to the origin of the ray.
13. Describe the general procedure for determining the point of intersection between a parametric ray and a surface that is described by a quadratic polynomial.
14. Given two points on a line and a third point that is in the same plane as the other points, determine whether the third point is “left” or “right” of the line described by the two points.

Chapter Four (Shading)

15. Identify or give correct descriptions for ambient, diffuse, and specular reflection.
16. Describe how emissive materials impact the results of local lighting calculations.
17. Given the color and intensity of an ambient light source and the material properties of a surface, correctly include the emissive material properties in the total calculation.
18. Given the color and intensity of an ambient light source and the material properties of a surface, correctly calculate the ambient reflection for that surface.
19. Given the color and intensity of a light source, the material properties of a surface, either the direction to the light source or the position of the light source, and a surface normal, correctly calculate the diffuse reflection for that surface.
20. Given the color and intensity of specular light, the material properties of a surface, either the direction to the light source or the position of the light source, either the direction to or the position of the view point, and a surface normal, correctly calculate the specular reflection for that surface.
21. Simulate light attenuation based on constant, linear, and quadratic attenuation factors and the distance to a point of intersection or the distance to a positional light source.
22. Correctly combine the diffuse and specular reflections for multiple light sources, to calculate the total illumination for a pixel (fragment).
23. Given the direction of a ray that intersects a surface and the surface normal at the point of intersection, calculate a reflection vector for the ray.
24. Describe the purpose of a shadow feeler. State under what conditions a light source will not contribute to the illumination for a pixel (fragment) resulting in the rendering of a shadow.

25. Describe how reflection vectors are used to create mirror-like inter object reflections.
26. Correctly combine the results of tracing a reflection vector with the calculations associated with direct illumination for a point of intersection or a fragment.

Refraction and Texture Mapping

27. State how transparent surfaces differ from opaque surfaces in how they interact with light.
28. Name the effect that determines how much light is transmitted and how much light is reflected by a transparent surface.
29. State what occurs when the angle of incidence with a transparent surface is exceeded.
30. State the name of the law that determines the direction of refraction.
31. State the name of the law that determines how light passing through a material is colored and absorbed.
32. State the name of the discrete elements that a texture is composed of.
33. Given a picture of a texture image, identify the s and t coordinates of a specified position.
34. Given an image of a texture mapped object, state whether Planar, Cylindrical, or Spherical Mapping was used to generate the texture coordinates for the object.

Chapter Five (Matrices)

35. Identify the main diagonal of a square matrix.
36. Given a square matrix, create the *transpose* of the matrix.
37. Given two matrices, state whether or not the matrices can be multiplied together based on their dimensions. If they can be multiplied together, state what the dimensions of the product will be.
38. Given two matrices, calculate their product.
39. Given a matrix and a column vector, calculate their product.
40. State whether or not matrix multiplication is communitive.
41. Show how the transpose of the product of two matrices relates to the product of their transposes.
42. Given the dimension, construct an identity matrix with that dimension.
43. State what the product of the identity matrix and a square matrix with the same dimension will be equal to regardless of the order of the matrices.
44. Using matrix multiplication, show how a matrix is related to its *inverse*.
45. State what condition is necessary for a matrix to be invertible.
46. Describe what value the *determinant* of a matrix will be equal to if a matrix is *singular*.
47. Show how the inverse of the product of two matrices relates to the product of their inverses.

Chapter Six (Transformations)

48. Given a description of a desired translation, write a statement that uses a GLM function to construct the 4 x 4 homogenous transformation matrix that can produce the translation.
49. Use the right hand rule to correctly determine the positive and negative directions of rotations in a right handed coordinate system.
50. Given a description of a desired rotation about the x, y, or z axes, construct the 4 x 4 homogenous transformation matrix that can produce the rotation.
51. Given a description of an angle of rotation and the axis about which the rotation is to be performed, write a statement that uses a GLM function to construct the 4 x 4 homogenous transformation matrix that can produce the translation.
52. Given a description of a desired uniform or non-uniform scale operation, construct the 4 x 4 homogenous transformation matrix that can produce the desired scaled coordinate system.
53. Given a description of a desired uniform or non-uniform scale operation, write a statement that uses a GLM function to construct the 4 x 4 homogenous transformation matrix that can produce the translation.
54. Given a description of a position, orientation, and size, write a code fragment that will generate the composite (modeling) transformation that will place the object in that desired position and orientation with the desired size.

55. ~~List, in order, the transformations that must be carried out to produce object coordinates, world coordinates, eye coordinates, clip coordinates, normalized device coordinates, and window coordinates.~~
56. ~~Given matrices that describe modeling, viewing, projection, and viewport transformations, order them correctly for use in transforming a vertex from Object to Window coordinates.~~
57. ~~Given a modeling transformation, write an expression of statement that would correctly transform a normal vector to World coordinates.~~

Memorize

Memorize how to perform the basic vector operations for addition, subtraction, and scalar multiplication.

Memorize the following:

Mapping from one interval to another:

$$x' = (x - fromLow)\frac{toHigh - toLow}{fromHigh - fromLow} + toLow$$

Length of vector:

$$\|\mathbf{a}\| = \sqrt{x_x^2 + y_x^2 + z_x^2}$$

Vector Normalization:

$$\hat{\mathbf{a}} = \frac{1}{\|\mathbf{a}\|}\mathbf{a} = \frac{\mathbf{a}}{\|\mathbf{a}\|}$$

Dot Product:

$$\mathbf{a} \bullet \mathbf{b} = x_a x_b + y_a y_b + z_a z_b$$
$$\mathbf{a} \bullet \mathbf{b} = \|\mathbf{a}\|\|\mathbf{b}\|\cos\alpha$$

Implicit Equation of a Plane:

$$(\mathbf{p} - \mathbf{a}) \bullet \mathbf{n} = 0$$

Vectors used in Lighting Calculations:

If **e**+*t***d** is the traced ray, **n** is the surface normal, **i** is the point of intersection, and **p** is the position of the light source then:

$$view\,vector = \mathbf{v} = \frac{-\mathbf{d}}{\|\mathbf{d}\|} = \frac{\mathbf{e} - \mathbf{i}}{\|\mathbf{e} - \mathbf{i}\|}$$

$$light\ vector = \mathbf{l} = \frac{\mathbf{p} - \mathbf{i}}{\|\mathbf{p} - \mathbf{i}\|}$$

$$reflection\ vector = \mathbf{r} = \frac{\mathbf{l} - 2(\mathbf{l} \bullet \mathbf{n})\mathbf{n}}{\|\mathbf{l} - 2(\mathbf{l} \bullet \mathbf{n})\mathbf{n}\|}$$

Matrices:

Implicit Equation of a Sphere:

$$\|\mathbf{p} - \mathbf{c}\|^2 - r^2$$

Parametric Representation of a Line:

$$\mathbf{p}(t) = \mathbf{p_0} + t(\mathbf{p_1} - \mathbf{p_0})$$
$$\mathbf{p}(t) = \mathbf{p_0} + t\frac{(\mathbf{p_1} - \mathbf{p_0})}{\|(\mathbf{p_1} - \mathbf{p_0})\|}$$

Alpha Blending:

$$color_{fragment} = (1 - \alpha)color_{destination} + (\alpha)color_{source}$$

Aspect Ratio:

$$\text{aspect ratio} = \frac{width}{height}$$

Ambient Reflection:

$$\mathbf{color_{ambient\,light}}\ \mathbf{color_{surface}}$$

Diffuse Reflection:

$$\max(0, \mathbf{n} \bullet \mathbf{l})\,\mathbf{diffuse\ color_{light}}\ \mathbf{diffuse\ color_{surface}}$$

Specular Reflection:

$$\max(0, \mathbf{n} \bullet \mathbf{h})^{shininess}\,\mathbf{specular\,color_{light}}\ \mathbf{specular\,color_{surface}}$$
$$\max(0, \mathbf{r} \bullet \mathbf{v})^{shininess}\,\mathbf{specular\,color_{light}}\ \mathbf{specular\,color_{surface}}$$

Attenuation:

$$attenuation\ \ factor = \frac{1}{k_c + k_l d + k_q d^2}$$

$$\mathbf{IM} = \mathbf{MI} = \mathbf{M}$$

$$\mathbf{M}^{-1}\mathbf{M} = \mathbf{MM}^{-1} = \mathbf{I}$$

<u>Transformations</u>

$$^{\mathbf{window}}\mathbf{v} = \begin{bmatrix} viewport \\ matrix \end{bmatrix} \Leftarrow \underbrace{perspective\ division \Leftarrow \begin{bmatrix} Projection \\ matrix \end{bmatrix}}_{\substack{Projection \\ tranformation}} \begin{bmatrix} view \\ matrix \end{bmatrix} \begin{bmatrix} modeling \\ matrix \end{bmatrix} \ ^{\mathbf{object}}\mathbf{v}$$