15 total questions, 1 hour to complete

Take exam **Friday evening** or **Saturday morning**

1. CIE XYZ and xyY color spaces **TUE**
    a. Week 1
        i. Study multiple choice questions and have that information handy
            1. Just some good general information that will probably pop up again as it relates to human perception of light, as well as chromaticity diagrams. **Just have this pulled up in a tab during the exam.**
        ii. Converting from XYZ to xyY (question 1.5)
            1. The idea on how this is done is quite simple. x = X / X+Y+Z, while y = Y / X+Y+Z. The "Y" in xyY comes from the original Y value from the XYZ. SO, given 3 XYZ coordinates, this is how you convert to xyY

2. Gamma correction (among other things, know that gamma means raising a value to some exponent, and correction is raising a value to the reciprocal) **TUE**
    a. Week 1
        i. Understand question 1.6, the formula for Gamma correction and what the process really means
            1. How is this done? Well, it is easy for simple RGB colors. If it is sRGB, there is a different equation (in my notes), but otherwise you just take each value to the power of 1/gamma (gamma is provided).

3. Phong and Blinn-Phong reflection models **TUE**
    a. Week 2
        i. Go over multiple choice questions which relate to Phong and Blinn-Phong reflection models in general
            1. **Have this open**
        ii. Understand the lighting diagrams for Phong model.. Diffuse reflection vs specular reflection (big difference between the two)
            1. Key here is that diffuse reflection does not care at all about the angle of the viewer. Therefore, the diffuse reflection will always be maximized when the most light is hitting the point. When does the most light hit the point? That is when the normal vector (line coming out of the point) is in complete alignment with the reflection vector. In other words, if the light source is right above (completely vertical) to the point, the diffuse reflection is maximized.

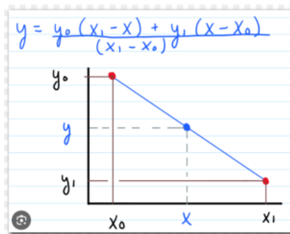
               On the other hand, specular reflections do depend on the viewer.

They seem to ignore the normal vector from what I can see. When the reflection vector, or the line that comes from the light source and reflects off a point, is most in line with the viewing vector, the specular reflection is maximized.

iii. Look at and understand the general concept for rasterization

1. Essentially, project a 3D scene into a 2D scene, and break that scene into triangles. For each triangle, you can color the pixels contained within that triangle

4. Linear and Bilinear interpolation **TUE**
   a. Week 3
      i. Understand the formula for linear interpolation, and how it is extended for bilinear interpolation
         1. Bilinear actually is easier it seems. The formula to interpolate between (x1,y1) and (x2,y2) is y = y1+ ((x-x1) * (y2-y1)) / (x2 – x1)



Note that this formula requires an x value to locate an interpolated y value at.

      ii. Do some variants of question 3.4 for bilinear interpolation, practice some instance of linear interpolation as well (even though you are doing linear interpolation in bilinear interpolation)
         1. Check the image from notes to clearly see how this is done

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5. Barycentric coordinates **WED**
   a. Week 3
      i. Question 3.3 - look at notes, but also have ChatGPT explain how I got this answer.. Understand the formula and do some variants
         1. Check notes:

Given a triangle with vertices $A = p_1, B = p_2, C = p_3$, and point $P = p_a$, the **barycentric coordinates** $(\lambda_1, \lambda_2, \lambda_3)$ are computed as:

$$\lambda_1 = \frac{((y_2 - y_3)(x - x_3) + (x_3 - x_2)(y - y_3))}{((y_2 - y_3)(x_1 - x_3) + (x_3 - x_2)(y_1 - y_3))}$$

$$\lambda_2 = \frac{((y_3 - y_1)(x - x_3) + (x_1 - x_3)(y - y_3))}{((y_2 - y_3)(x_1 - x_3) + (x_3 - x_2)(y_1 - y_3))}$$

$$\lambda_3 = 1 - \lambda_1 - \lambda_2$$

This assumes we are given 3 points – we can get the first two barycentric coordinates and then the 3rd using those first two. You also need a point, p. Just use this:

https://lawofcosinescalculator.com/barycentric-coordinates-calculator.html

and ignore the information about RGB at those points.

ii. Understand in general what the concept of Barycentric coordinates is
    1. "Describes the location of a point relative to the vertices of a triangle." Think of the Barycentric points as weights describing how much a point is related to the vertices of the triangle. The weights are the Barycentric coordinates, and they add up to 1.

6. Structured grid representations of domains **WED**
    a. Week 4
        i. "Meshes and Elements" video
            1. Have this video open – you have watched it so you should be able to jump to points in the video if your notes are not enough.
        ii. Check notes, understand the math and formula behind both question 4.1 and question 4.3
            1. For rectilinear grids, you just need to sum the number of columns of vertices, number of rows of vertices, number of sheets of vertices, and 3 additional numbers. These 3 additional numbers are the actual values of the number of columns, rows, and sheets respectively.
            2. Curvilinear grids are almost the exact same, but you just multiply the values together. You would do # rows * # columns * # sheets * dimension (3 if we are in 3d) + 3 numbers (the number of rows, columns, sheets).

7. Half-edge data structure **WED**
    a. Week 4
        i. I have a feeling that the question will be similar to question 4.2 - just have an understanding of the data structure in comparison to the other ones discussed. Just like how it is in the question, understand the time complexity of reaching other edges of points in this structure
            1. Good

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8. Colormap construction **THURS**

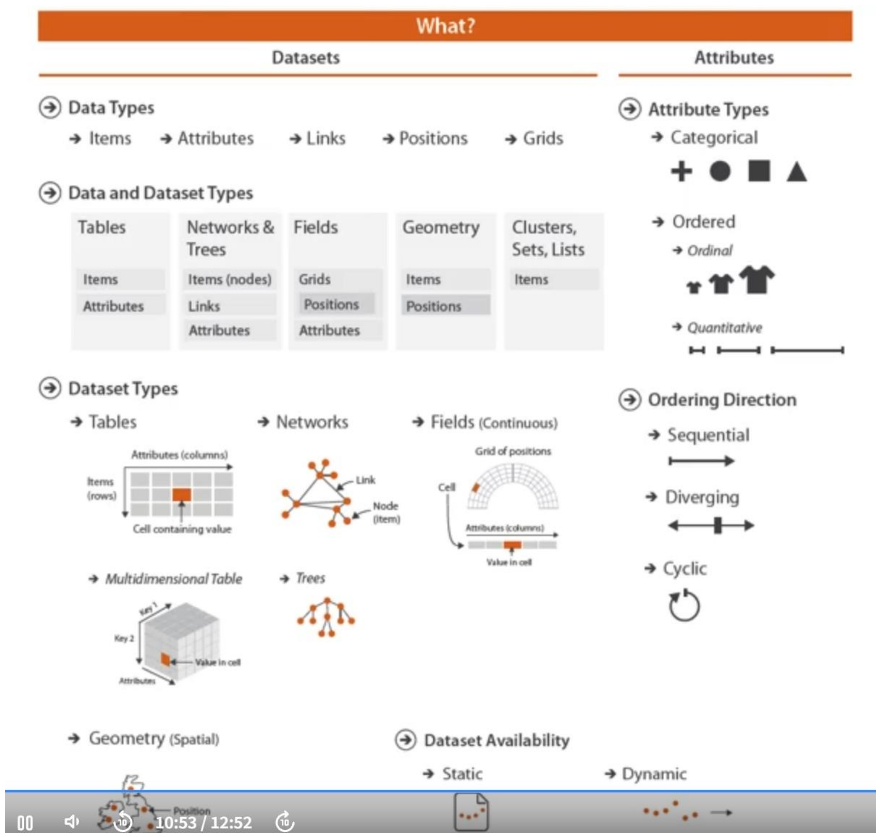
a. “Colormaps” - 24 minute long video to skim, and look at notes again
   i. What to take from this video? Color maps can be generated in two ways: table based, or more commonly using a transfer function

      Need a perceptually linearized grayscale map? Raise values to a power of gamma.. as people are more sensitive to changes in dark regions than light regions (nonlinear perception of light)

      we use an equation to map a scalar to a color.

      There are definitely better alternatives to the rainbow color map.. see notes for them

9. Munzner's data taxonomy **THURS**
   a. Week 3
      i. Watch the 12 minute lecture video again
         1. Look at all the terms I put in the notes.. semantics, data types, etc.. **have this video open**, I could see a question asking if a certain element of a visualization is a specific definition from this taxonomy



10. DEM and TIN representations and converting from one to the other **FRI**
    a. Week 4
        i. Review the questions from the week 4 quiz - these are questions 4.4 and 4.5
            1. A triangular irregular network is a way of representing surfaces (terrains) using non-overlapping triangles that are fit together. It **IS** a polygonal mesh because triangles are polygons. It **IS** a surface mesh because TINs are designed to represent surfaces. It **IS** an unstructured mesh because a TIN is based on irregularly spaced points.

               Not curvilinear because TINs use straight line edges (in triangles)

               Not volume mesh because TIN represents surface, not interior volume

               not a rectilinear mesh because TIN is based on triangles, not rectangular grids

               Not a uniform mesh, because the triangles can be different shapes and sizes

               Not raster data, as TIN is vector based (raster uses regular grids of pixels/ cells)
            2. A digital elevation model (DEM) is a representation of the earth's surface elevation – typically in GIS or terrain modeling. Most are grid-based, where each cell represents the elevation at that location. A DEM **IS** a surface mesh – it represents terrain elevation, which is a 2.5D surface. It **IS** raster data, as it stores regular grids of elevation values. This is the definition of raster data. Each pixel or cell in the grid holds an elevation value. Also, it **IS** a uniform mesh, grid spacing is uniform in the DEM where each cell is the same size.

               It is not a polygonal mesh as DEMs use grids of points, not polygons

               It is not curvilinear – points are aligned to coordinate axes and not warping or curving grids

               It is not an unstructured mesh, as DEMs are stored in structured, regular grids.

While a DEM may appear rectilinear, the term rectilinear mesh refers to structured grids with variable spacing, which is not typical of DEMs (they are uniform)

Not a volume mesh: it represents surfaces, not volumes

ii. How can you convert from one to another?
    1. Just look at notes or the GPT explanation

11. Marching squares and cubes **FRI**
    a. Week 4 and Week 5
        i. Check code from programming assignment and review notes for general process
        ii. Also, understand question 5.4 - why is this the case?
            1. Two topologically opposite corners are inside, the rest are outside.. this causes ambiguity
        iii. Understand question 5.7 too - talk to ChatGPT about this

12. Dual marching squares **FRI**
    a. Week 5
        i. Look at notes and lectures again - how is this different from normal marching squares? Why is it needed?
        ii. Questions 5.2 and 5.3: understand the answers - discuss with ChatGPT if needed
            1. 5.2, see 6:09 image in the lecture on dual marching cubes..

               It seems to just be the # of separate intersections surfaces in the cube = the number of isosurfaces generated in MC
            2. 5.3, actually not that hard. Given the isovalue, you find the two corners that the point will be dealing with. For 79, that falls between the corner who's function value is 62, and the one which is 90.

               We find where the line will cross between those two points by doing simple linear interpolation. We then can find another line segement where the function values are making a range our iso value falls into (32 to 90 this time) to find the other segment our line will cross.

               Then, again interpolate between those values. Now we have two points on two lines.. we find the midpoint between them (average them out) and that is our answer.
13. Scattered data interpolation using RBFs **FRI**

a. Week 3
   i. “Scattered data interpolation” - 18 minute lecture video
   ii. Re-understand how I got the correct answer for question 3.2

14. Gradient vectors and fields **FRI**
    a. Week 5
       i. This is all the contouring stuff - find the video that outlines this all in week 5 and re-watch it
       ii. Understand question 5.5
          1. Simple: just point the vector in the direction we observe the fastest rate of change (based on color)