You must answer ALL 5 questions.

For full credit, an answer must be both correct and well-presented (clear and concise).

If you feel a question is ambiguous, state any assumptions that you need to make. Hint: more often than not, this is a sign that you either do not understand the question, or are missing some important insight or piece of knowledge.

Several of the questions are ``essay'' questions. For these essay questions, there are many correct answers. It is more important that you provide a good argument for the answers you give than that you give the ``most correct possible'' answer.

## Question 1:

MipMaps, combined with tri-linear interpolation, have become the de-facto standard for texture map filtering. By making some simplifying assumptions to the actual filtering problem, they can provide for very efficient performance. Not including pre-computation time to create the MipMaps, each filtered texture access requires a constant number of map accesses.

 However, these simplifications cause limitations on the filters that are realized by the method. Phrased differently, MipMapping restricts some of the filtering options that other methods might use to create different performance.

1. Describe some of the simplifications and limitations that are introduced in order to do mipmap + tri-linear interpolation (as opposed to better approximations of the ideal filtering). For each one, explain why this limitation is required to achieve the constant-time performance, and describe a situation where this simplification and/or limitation leads to a visible artifact (it is best to describe this in terms of a picture and what the viewer would see, compared to a more “ideal” method that didn’t have the limitation).

Note: it is better to have 2-3 good limitations, than a larger number of not-so-good ones.

1. MipMaps + trilinear interpolation could be used for implementing the image filtering for other image resampling operations than texture mapping. In fact, they are a pretty effective tool for doing image warping, but probably overkill for more basic image resampling. Why would MipMaps + trilinear interpolation be overkill for:

B.1 Image Resizing (scaling an image, potentially a different amount in each direction)

B.2 Image Rotation

 Hint: Why do these special cases allow more ideal resampling to be efficient?

## Question 2:

The so called “Rainbow Color Map” (RCM) is often used to encode a scalar quantity as a color for data visualization.

(Note: while RCM was not part of the qual reading list, the ideas of visual encodings were, as well as perception, particularly of color. While you could answer this question by remembering some of the literature about RCM, you should be able to answer this question based on your understanding of visual encodings and perception)

The rainbow color map encodes a continuous value as hue. Sometimes this is done in a truly spectral manner (so that the value is mapped to the spectral frequency of the color), although usually the value is mapped around the color wheel. For example, the lowest value is mapped to blue, the highest value is mapped to red, and values in between are interpolated around the color wheel.

There are many reasons why the RCM is a bad idea for use as a visual encoding of a continuous variable. Describe some of them.

Note: if you choose “it doesn’t work well for color blind people” as one of the reasons (and it is a good reason), you must explain how the RCM would be seen by someone with the common form(s) of color blindness.

## Question 3:

In this question, we consider “batch mode” rendering – that is, the buffer is cleared, the triangles are drawn, and then the buffer is displayed. No one ever sees the intermediate results. This is what usually happens when you do double-buffered graphics.

A graphics system uses a Z-buffer for visibility testing, but it randomizes the order that triangles are drawn on each frame.

Describe two or three situations where this random-order system would provide different behavior than a system that guarantees that triangles are drawn in order. For each, describe an example where you would see the difference visually (and explain what you would be different).

## Question 4:

In the first and second edition of the Shirley textbook, there is a chapter on Image-Based Rendering (IBR). The third edition (on which this exam is based) omits the chapter. The old chapter basically described the topics that were in the qual reading lists: Quicktime VR/Panoramic viewing and Lightfield/Lumigraph. In some ways, the fact that the chapter went away is a statement about the relevance of these two approaches: while they were really important conceptually, and had a major influence on subsequent techniques, they never really caught on.

Consider the two basic styles of Image-Based Rendering on the qual reader: panoramic viewing (i.e. QuicktimeVR) and Lightfields/Lumigraphs.

Fifteen years later, we now have ubiquitous 3D graphics hardware that supports texture mapping. (This was not so common back in the mid 90s when those papers were written!). This is the predominant way we create 3D experiences nowadays.

For each of the 2 styles of IBR (panoramas, lightfield/lumigraph), compare it to the “modern 3D” approach. What limitations and problems does the IBR approach have? What advantages might it have?

## Question 5:

Many shading models are intentionally non-realistic (as opposed to models that are just simplified for practical reasons, or poor approximations to reality despite trying).

Suppose that someone was able to figure out how to do completely realistic shading in a fast and practical way.

Give examples of current “intentionally non-realistic” (or stylized) shading models that might still be used, and give arguments for why they would be useful in a world where we had the choice of realistic shading models.