

Midterm Exam

CS 184: Foundations of Computer Graphics
Fall 2006
Prof. James O'Brien

page 1 of 12

Student Name:

Student ID:

Instructions: Read them carefully!

The exam begins at 2:40pm and ends at 4:00pm. You must turn your exam in when time is announced or risk not having it accepted.

Make sure you fill in your name and the above information, and that you sign below. Anonymous tests will not be graded.

Write legibly. *If the person grading the test cannot read something, he/she will simply assume that you meant the illegible portion as a note to yourself and they will ignore it. If you lose points because part of your answer could not be read, you will not be given the opportunity to explain what it says.*

You may use one page of notes while taking the exam. You may not ask questions of other students, look at another student's exam, use a textbook, use a phone or calculator, or seek any other form of assistance. In summary: do not cheat. Persons caught cheating will be subject to disciplinary action.

Do not ask questions during the exam. *Most questions are unnecessary and they disturb other students. Figuring out what the exam question is asking is part of the test. If you think you have to make some unusual assumption to answer a problem, note what that assumption is on the test.*

The answers to most questions should be short. If you find yourself writing an excessively long response, you may want to think more carefully about the question.

I have read these instructions, I understand them, and I will follow them.

Your Signature: _____

Total Points: 105 You Scored: _____

1. Answer the following questions with True (T) or False (F)

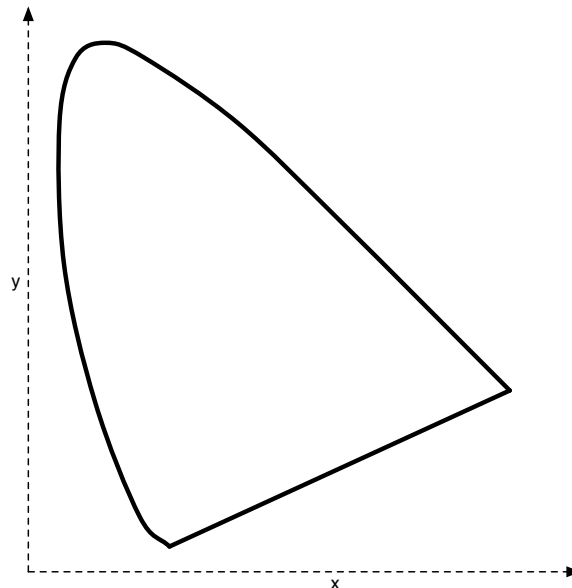
1 point each

- _____ Computer graphics has applications in the area of medicine.
 - _____ Vector-based images can only be displayed when printed on paper.
 - _____ The dynamic range of the human eye is quite small so computer generated images must be desaturated to avoid eye strain.
 - _____ All linear transformations in 3D can be expressed as a 4x4 matrix using pasteurized vectors.
 - _____ A linear transformation can be decomposed into a series of scales and rotations using the Suvart-Vittal decomposition.
 - _____ The "right-hand rule" defines the commonly used standard for how rotations should be done.
 - _____ A series of 2D rotations can be permuted and the final result will not change.
 - _____ A scale matrix always has determinant +1.
 - _____ Quaternions represent 3D rotations in a manner analogous to the way in which complex numbers represent 2D rotations.
 - _____ The images you see with your eyes have no more that four vanishing points.
 - _____ The term "Z-buffer" was trademarked by an American company, as a result other countries use the term "Zed-buffer" to refer to the same method.
 - _____ Any set of convex, non-intersecting polygons can be sorted in front-to-back order.
 - _____ The cones in the human eye are mainly located in the lens of the eye.
 - _____ The methods used in video games are not really related to computer graphics.
 - _____ Humans are very good at differentiating between a color and other colors they have seen previously.
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- _____ Good selection of near and far clipping plane distances is required when using a Z-buffer.
 - _____ Every color the human eye can see corresponds to one single frequency of light.
 - _____ The cones in the human eye come in three varieties "short," "medium," and "long."
 - _____ A good way to measure the perceptual difference between two colors is to subtract the RGB values and then square the result.
 - _____ The interaction of light with small particles can create the appearance of color through a process known as scattering.
 - _____ Iridescence is the mechanism by which many lights in modern office buildings work.
 - _____ Objects may appear different colors when one looks at light reflected from them and transmitted through them.
 - _____ The Phong model of specular reflections captures all known types of BRDFs.
 - _____ Specular surfaces are called "Lambertian."
 - _____ Direction vectors are represented in a homogenized fashion with a 0 for the "w" coordinate.
 - _____ Ray-tracers can be used to generate images with non-planar projections.
 - _____ Shadow rays are imaginary rays sent from the eye to an object.
 - _____ The term "distributed ray tracing" refers to rendering ray-traced images on computing clusters.
 - _____ In linear perspective projection images with a wide field of view, straight lines can appear as distorted curves.
 - _____ Orthographic projection is a special case of perspective projection.
 - _____ CSG models are built using a series of boolean operations on simple primitives.
 - _____ Displacement mapping leaves the silhouette of an object unchanged.
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2. You start to paint a wall but run out of paint half way through. You go to a store where you find another brand of paint that looks the same color the one you started with. Unfortunately when you get to your home you find the color does not match what you have on the wall. Concisely give a likely explanation for what has happened. (Assume the paint does not change color as it dries.) *5 points*

3. The following diagram shows the the x-y plane of the CIE color space. Mark and label one plausible location each for red, green, and blue basis colors. Indicate the color gamut for the color basis you have shown. *5 points*



4. You have a 3x3 matrix. You generate 100 random vectors and multiply each one by your matrix. You notice that while the vectors are all changed by the multiplication, the magnitude of each vector is not changed by doing this multiplication. What can you infer about your matrix from this information? *6 points*
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5. Given a rotation encoded as a quaternion, how is the rotation changed when the quaternion representation is negated? *2 points*

6. In the diagram below, indicate the point on the line that will appear brightest to the observer if the line acts like a diffuse reflector. *3 points*

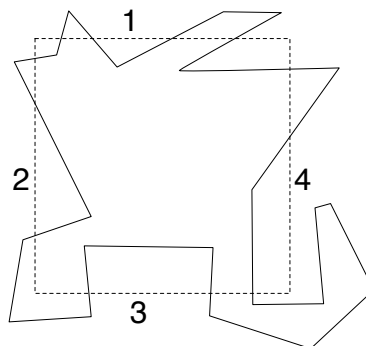
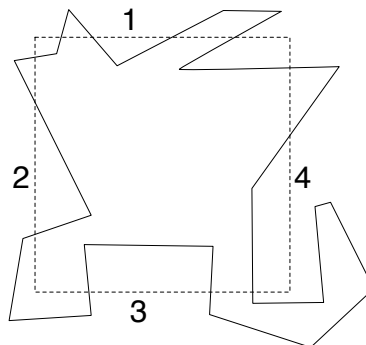
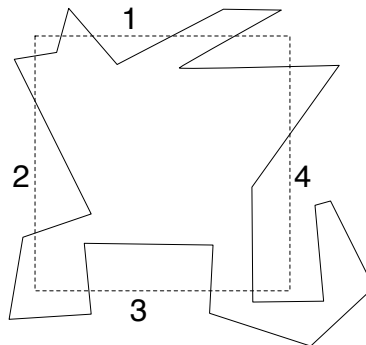
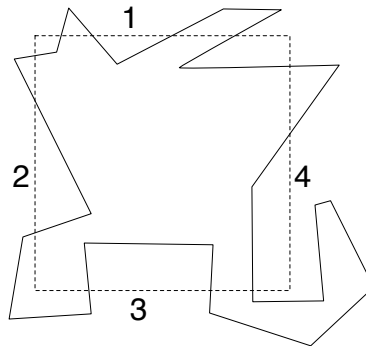


7. In the diagram below, indicate the point on the line that will appear brightest to the observer if the line acts like a specular reflector. *3 points*

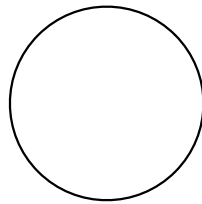


8. Name a physical phenomena that can cause the appearance of color on a surface to change dramatically as the location of the observer is changed. *3 points*
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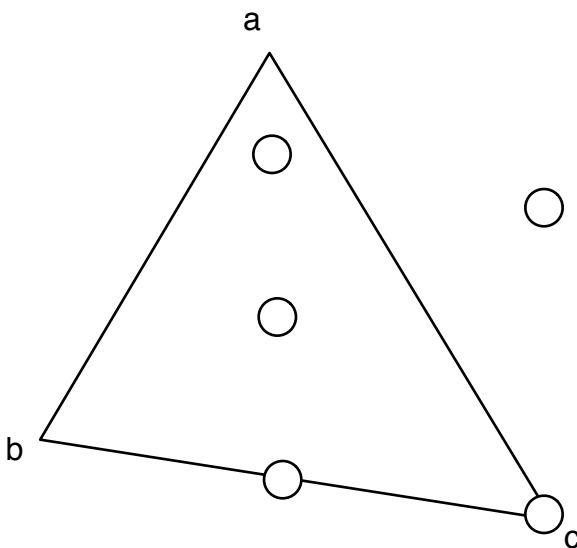
9. A polygon is to be clipped against the convex boundary shown as a dashed line. The algorithm used is the one discussed in class, and the numbers indicate the order in which the sides are considered. On each of the four diagrams show the successive result of clipping the polygon against each face. In other words, draw the result of clipping against side #1 in the first diagram, in the second diagram show the result of clipping the result from the first diagram against side #2, and so on so that the last diagram shows the final result. *6 points*



10. The diagram below shows a light source, a glass sphere, and a diffuse surface. Draw lines illustrating the formation of a refraction caustic. *Your diagram must be geometrically plausible.* 5 point



11. This diagram shows a triangle with vertices labeled a, b, and c. Several locations have been indicated with circles. The list of numbers to the right contains triples of numbers representing the barycentric coordinates of these circles. Draw a line connecting each triple with the correct circle. 5 points



0, 0, 1

0.75, 0.75, -0.5

0.333, 0.333, 0.333

0, 0.5, 0.5

0.8, 0.1, 0.1



12. The following line segments will be inserted into a BSP Tree in the order indicated. As discussed in class, the segments themselves will be used to define the split planes. The numbers are on the positive side of each line.

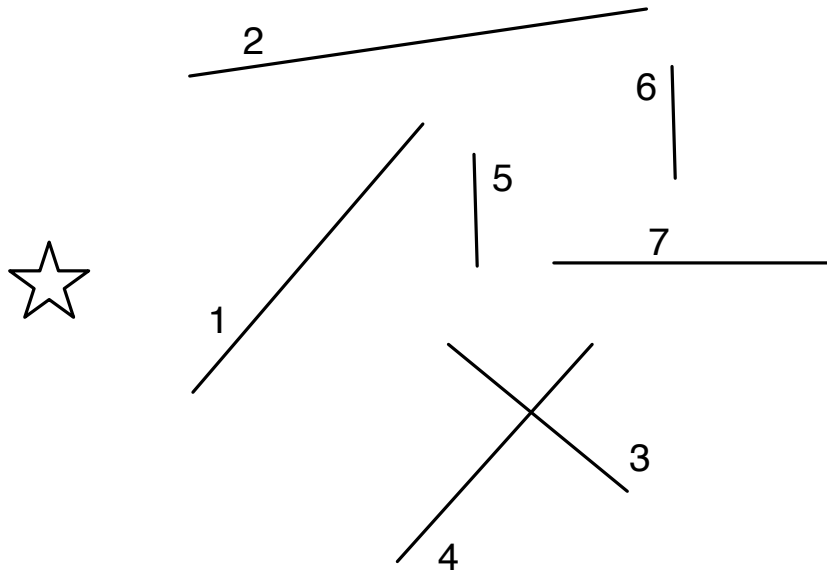
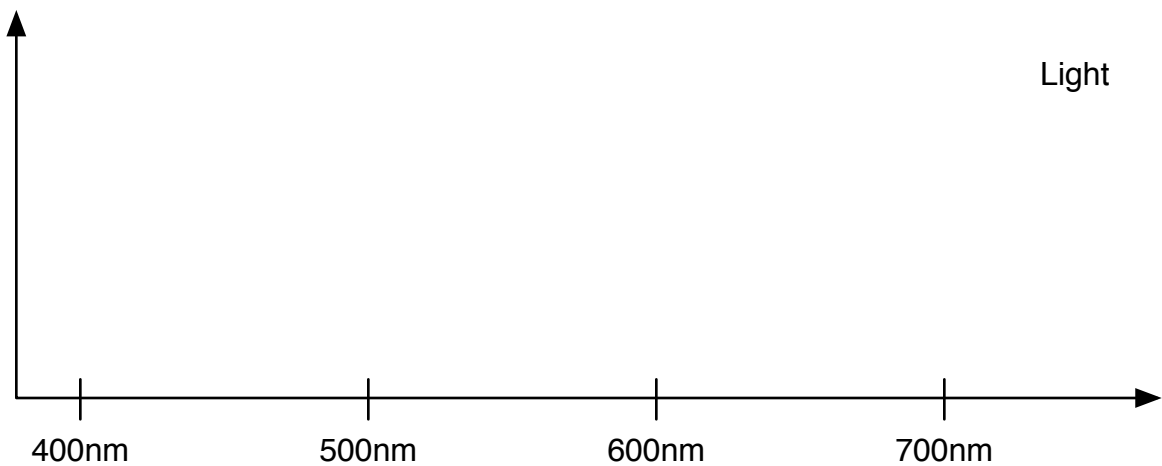
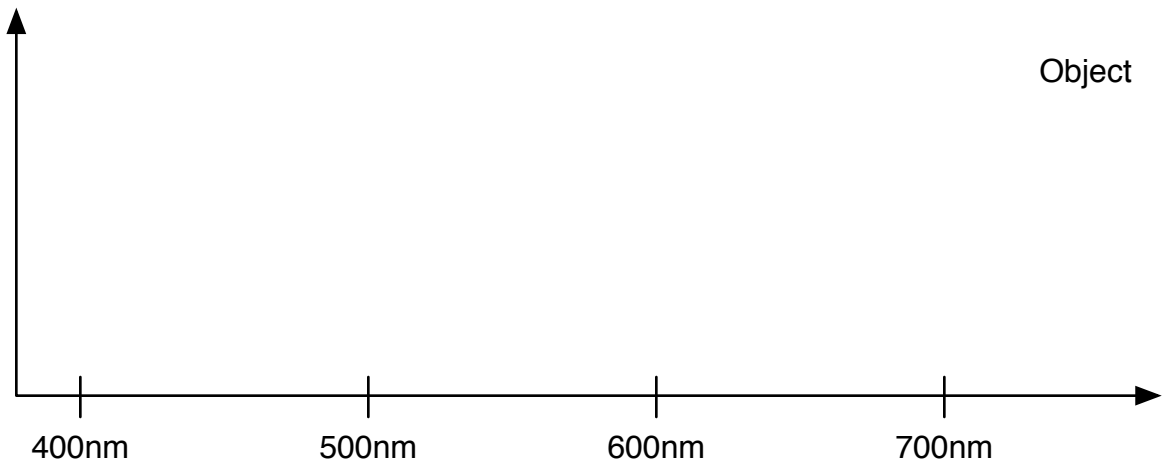


Diagram the resulting tree below. If needed, show where line segments need to be split by marking on the above figure. Also, indicate the names of the split parts by writing labels on the figure above. (For example, if there were a segment 9 and it was to be split, you would draw a mark showing where it would be split and label the resulting pieces 9a and 9b.) 6 points

List the *back-to-front* traversal order that would result for the location indicated by the star shaped icon. 3 points

13. You have an object that appears to be yellow when viewed in sunlight. You take the object into a dark room and turn on a yellow light. The object now appears to be black. In the space below plot a spectral distribution for the reflectance of the object and the emittance of the light that could explain this situation. *6 points*



14. What physical phenomena is key to producing the realistic appearance of skin, but is not captured in the BRDF model of light-object interaction? *2 points*

15. Give a concise definition of what a “light field” is. *4 points*

16. Indicate which of the following uses which method for shading. Draw a line connecting the image with the appropriate label. *3 points*



Flat shading



Interpolating color values



Interpolating normal values

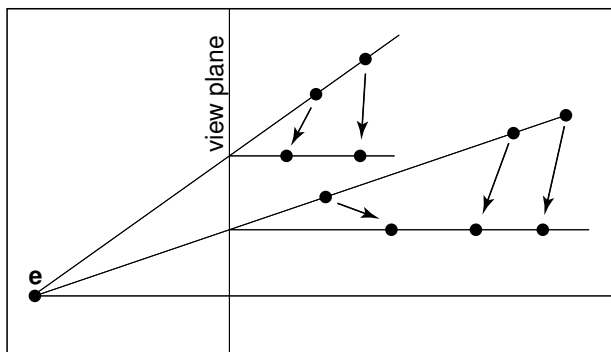
17. Circle the types of transformations that to be expressed in matrix form require homogenized coordinates. 5 points

- Translation
- Scale
- Rotation
- Shear
- Perspective

18. Assume that I want to ray trace an image, and I decide that each time a ray strikes a surface I will send out K number of rays to sample the light coming in to that surface. How will my rendering time grow as I increase recursion depth? 2 points

19. Write out the quadratic equation. If you are trying to intersect a ray with a sphere, what part of this equation is relevant to determining if your ray has hit the sphere? Explain how it is relevant. 3 points

20. What is wrong with this picture? 2 points



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21. Below are two 4x4 homogenized transformation matrices. Which one will do a uniform scale making object 2x larger? What does the other do? *2 points*

$$\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 4 \end{bmatrix}$$

$$\begin{bmatrix} 6 & 0 & 0 & 0 \\ 0 & 6 & 0 & 0 \\ 0 & 0 & 6 & 0 \\ 0 & 0 & 0 & 3 \end{bmatrix}$$

22. The two diagrams below are supposed to show a perspective square with evenly spaced gridlines. Cross out the one that shows incorrect perspective and explain what the problem is. *4 points*

