Midterm Exam

CS 184: Foundations of Computer Graphics
Spring 2013
Prof. James O'Brien

Student Name:_____ **Class Account Username:**_____

Instructions: ***Read them carefully!***

The exam begins at 10:40pm and ends at 12:00noon. 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, s/he 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.*

***Be clear and concise**. 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. Long rambling answers generally get fewer points that short ones do because there are more opportunities to mark something wrong.*

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.*

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

Your Signature: _____

Date: _____

Student ID: _____

Total Points: XXX + XX You Scored: _____ + _____

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1. Please fill in each of the blanks with an appropriate answer. *2 points each blank, 90 Total*

True or False: The dynamic range of intensities that can be displayed on a typical monitor is smaller than that of the human eye. _____

True or False: Humans are not good at judging the relative brightness of two objects that are distant from each other. _____

Visible light falls roughly in the range of _____ nanometers at the **RED** end of the spectrum to _____ nanometers at the **BLUE** end.

Fill in the missing color: Red, Orange, Yellow, _____, Blue, Indigo, Violet.

_____ colors consist of a single wavelength (or very narrow band of wavelengths) of light.

The three types of cones in the human are correctly referred to as the _____, _____, and _____ cones.

The response curve of the rod in the human eye peaks between the _____ and _____ cones.

True or False: Any color humans can see can be reproduced using any ***four*** distinctly colored light sources. _____

Two materials which appear the same color under a particular lighting condition but have different reflectance spectra are called _____.

_____ is the main phenomenon that makes hot coals glow red.

_____ is the phenomenon that makes milk appear white.

_____ is the phenomenon that makes rainbow colors appear in oil slicks and peacock feathers.

The _____ describes how much light coming in from one incoming direction goes out in another outgoing direction.

True of False: Lambert's law describes how diffuse materials behave._____

True of False: The exponent in the Phong shading model controls how approximately "gray" a material appears. _____

A _____ can be thought of as a point light located "at infinity".

True or False: Mach banding tends to over emphasize edges so that shading may appear discontinuous when displayed on a computer monitor. _____

True or False: Flat shading is named after the French computer graphics researcher Pierre Flat. _____

True or False: Rotation is a nonlinear transformation. _____

The determinant of a rotation matrix is always _____.

True of False: Matrix multiplication is commutative. _____

True of False: Homogenized coordinates are needed to allow rotation to be expressed as matrix multiplication. _____

Of the methods discussed in class for representing rotations, only _____ and _____ are free of singularities.

Rotation matrices in 3D generally have one real eigenvalue. This eigenvalue is _____ and the corresponding eigenvector is the _____.

In ray tracing, a ray from a point on an object's surface to the location of a light source is called a _____ ray.

A simple way of _____ is to send many rays randomly distributed through a given pixel and average the result.

The implicit formula for a sphere is _____.

True or False: BSP Trees can be used to accelerate ray intersection tests for complex scenes. _____

Under linear perspective projection straight lines will always appears as _____.

Under linear perspective projection spheres will generally appears as _____.

An orthographic image contains how many finite vanishing points? _____

An linear perspective image contains how many vanishing points? _____

Bresenham's line drawing algorithm uses _____ arithmetic.

A _____ stores depth values and is used for hidden-surface removal when rendering a scene

In general, a triangle that is split by a plane will produce _____ (number of) triangular pieces.

True of False: The parameterization of a given curve is unique._____

True of False: When representing curves with cubic polynomials it is generally a bad idea to omit the quadratic term. _____

True of False: Any curve represented using the cubic B-Spline basis could also be represented using the Bezier basis. _____

The _____ breaks a matrix A into A = U S V where U and V are orthonormal and S is diagonal.

2. **If you have two *unit* vectors, A and B, then we can write the dot and cross products as A . B and A x B, respectivly. Simplify the following expressions:** *5 points*

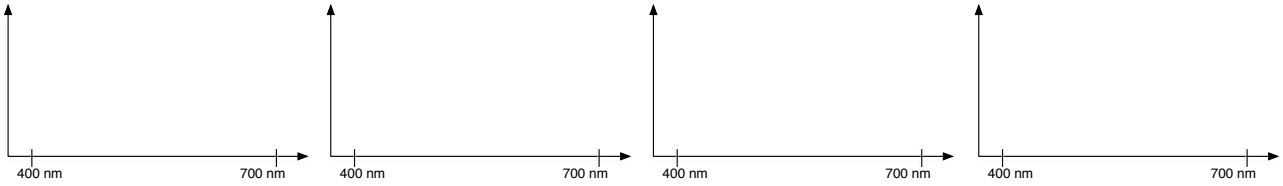
   A . (A x (A x (A x B)) =

   A x (A x (A x (A x B)) =

   A x (A x (A x (A x (A x B))) =

3. **You have two pieces of opaque ***GREEN*** plastic, pieces "A" and "B." When viewed under light source "X" they look identical in color, but when viewed under sunlight (light source "Y") they look different. Draw a set of curves showing the spectral reflectance for A and B and spectral emissions for X and Y that could provide a reasonable explanation for this situation.** *10 points*

   Note: Makes sures the curves you draw show plausible distributions. In other words, if you tried to draw a curve for "green" by making a hump centered at 700 nm, it would be wrong.



A **B** **X** **Y**

4. **You have a sphere centers at the origin with unit radius, and a ray from [10,0,0] in the direction [-1,0,0]. Write the implicit equation for the sphere, the parametric equation for the ray, and set a quadratic equation solving for the t-value of the intersection points.** Be neat and clear! *20 points*

5. Circle the types of transformations that to be expressed in matrix form require homogenized coordinates. *10 points*

Translation

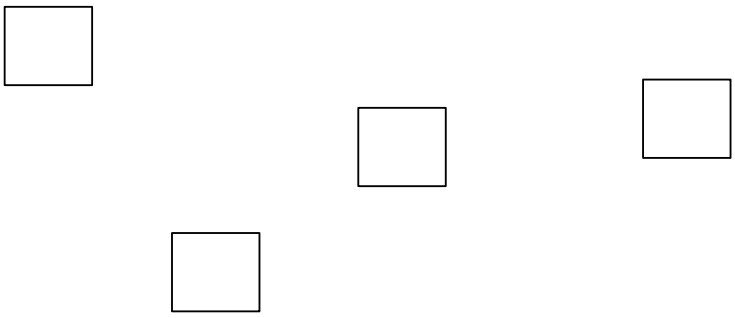
Rotation

Shear

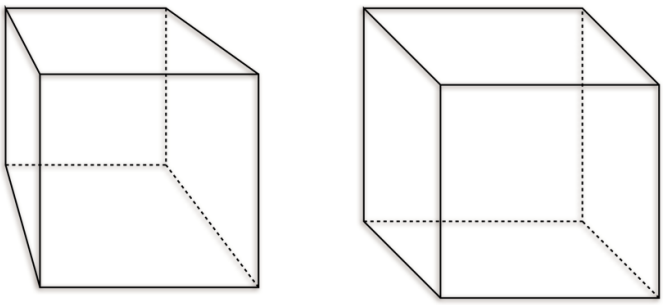
Scale

Perspective

6. Draw the *convex hull* that encloses four boxes shown: *6 points*



7. One of the diagrams below shows a cube under orthographic projection, the other under perspective projection. Label which is which. *3 points*



8. Given a rotation encoded as an exponential map with the vector shown, write out a vector that express the inverse rotation. (units are radians) *3 points*

[1 , 0.7 , 0]

9. Given a rotation encoded as a quaternion, in general how is the rotation changed when the representation is *negated*? *3 points*

10. Write down plausible RGB values for the following materials: *6 points*

Glossy Metallic Yellow
Kd =
Ks =

Glossy Plastic Red
Kd =
Ks =

Flat Green
Kd =
Ks =

11. In the diagram below, indicate the point on the line that will appear brightest to the observer if the line acts like a purely specular reflector. *2 points*

12. If shading a point at the origin with normal [0,0,1] and Kd=[0.2,0.25,0.5], where the light is located at [0,0,10] with intensity 20 (white), and the eye located at [17,9,7], compute the RGB value of the diffuse lighting term. *10 points*

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

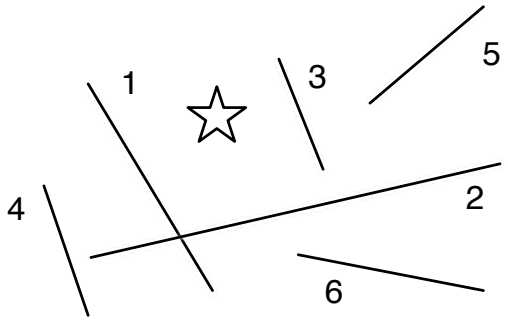
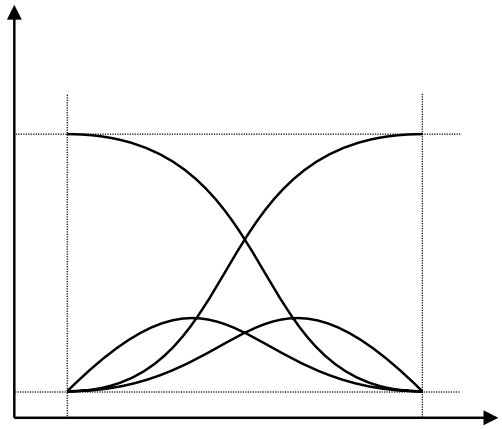


Diagram the resulting tree below. If needed, show where line segments need to be split by marking on the above figure. Also, indicate the names of the split parts by writing labels on the figure above. (For example, if there were a segment 11 and it was to be split, you would draw a mark showing where it would be split and label the resulting pieces 11a and 11b.) *20 points*

List the *back-to-front* traversal order that would result for the location indicated by the viewer icon (the star). *6 points*

14. Write out the 3x3 matrix for a rotation about the X axis. Now write out a 3x3 matrix for a rotation about the X axis that would result if we did rotations *clockwise* instead of *counter-clockwise*. *6 pts*

15. Draw a line clearly connecting each of these curves from the Cubic Hermite Basis with the feature it controls. *12 pts*



$x(0)$

$x(1)$

$x'(0)$

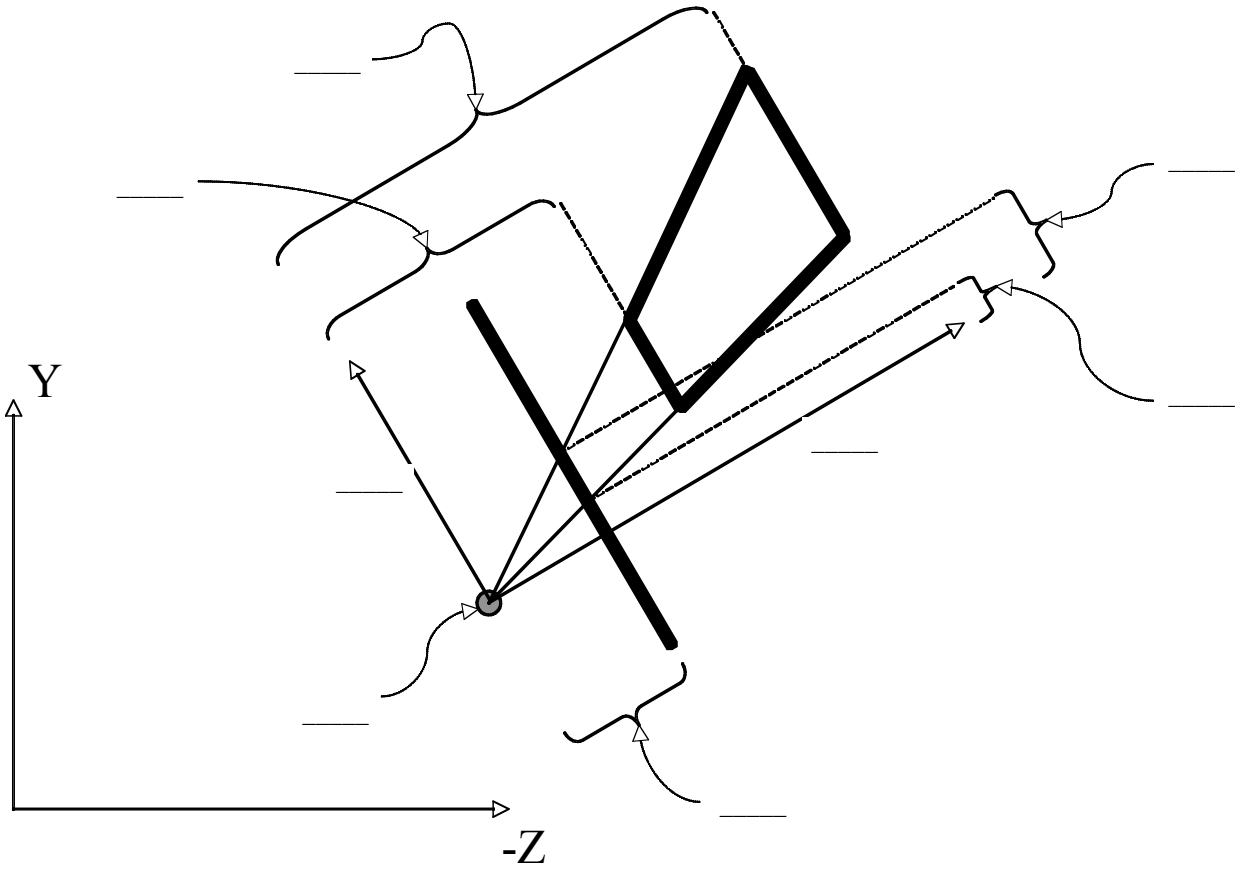
$x'(1)$

16. Place an $\times$ through the matrices that could not be valid perspective matrices. Explain your decision. *5 points*

$$\begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 7.9 \\ 0 & 0 & 9 & 8 \end{bmatrix} \quad \begin{bmatrix} 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 2 \end{bmatrix}$$

17. Let f(x,y) be a scalar function on the plane. Write out the expression for the downward pointing gradient. *6 points*

18. On the figure below write the appropriate letter in each of the blanks to label the diagram properly. Some of the letters are just there to confuse you. *8 points*

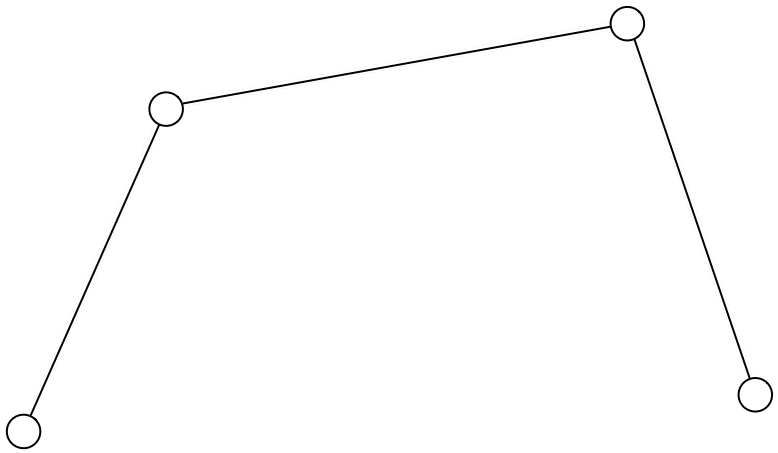


A	View up vector	I	Bottom clipping plane distance
B	Top clipping plane distance	J	View horizon
C	End of all the things	K	Left clipping plane distance
D	Origin	L	Singular vector
E	Right portal	M	Far clipping plane distance
F	View plane normal	N	Right clipping plane distance
G	Near clipping plane distance	O	Axis of rotation
H	Distance to image plane	P	Center of projection

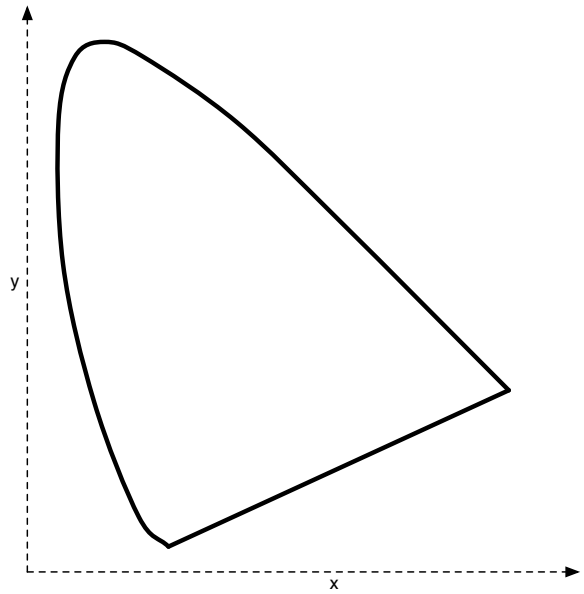
19. Write out the transformation steps discussed in class for a perspective camera. It may help to refer to the previous question. *12 pts*

20. Draw an example of 3 polygons that do not intersect, but that cannot be sorted in front-to-back order from the viewer's perspective. *3 points*

21. The diagram below is the control polygon for a Bezier curve segment. Draw the curve and show how de Casteljau's algorithm can be used to subdivide the curve into two halves. *Make sure your drawing is geometrically reasonable and shows correct curve tangents for the the beginning, middle, and end of each segment.* *10 points*



22. 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*



23. Imagine that you have a RGB monitor where the wires have been swapped so that the red, green, and blue outputs from the computer have been respectively attached to the green, blue, and red inputs on the monitor. When one attempts to display the following colors, what colors will actually appear on the screen? *8 points*

Red _____

Green _____

Blue _____

Cyan _____

Magenta _____

Yellow _____

Black _____

White _____

EXTRA CREDIT **+*6 points***

Given:

The equations for two lines

$$\mathbf{a}(t) = \mathbf{b} + t\mathbf{c}$$

$$\mathbf{d}(s) = \mathbf{e} + s\mathbf{f}$$

Write out an equation for finding the values of s and t corresponding to where the lines come closest to intersecting. (Put your final answer in the box.)

When does your method fail to produce a unique solution?

Your answer must be neat and clear, written out in the box. No points will be awarded for imprecise answers. You must get all parts right to earn any credit. (i.e. all or nothing) Do not attempt this question until you have completed the rest of the exam!