Midterm Exam

CS 184: Foundations of Computer Graphics
Fall 2014
Prof. James O'Brien

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

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 class account above****, 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: 241 + 10 You Scored: _____ + _____

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1. Please fill in each of the blanks with an appropriate answer. *2 points each blank, 84 Total*

True or False: The dynamic range of intensities that can be displayed with the projector in 306 Soda is smaller than that what can be perceived by the human eye. _____

True or False: Humans are good at judging the relative brightness of two squares on a screen when there is a black band separating them. _____

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

Fill in the three missing colors in order: Red, Orange, _____, Green, _____, Indigo, _____.

True or False: The light we see reflected off most objects consist of a single wavelength (or very narrow band of wavelengths) of light. _____

The sensitivity curves for the _____ and _____ cones have a the least amount of overlap.

The outer part of the retina contains very few _____.

The term AABB stand for _____.

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

_____ are distinct materials that appear to be the same color under some specific lighting.

_____ is the main phenomenon that makes the sky appear blue.

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

True of False: Spencer's law describes how refractive materials behave._____

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

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

True or False: Stochastic sampling tends to over-emphasize edges so that shading may appear discontinuous. _____

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

True or False: Rotation is a nonlinear transformation. _____

The determinant of an arbitrary rotation matrix is always _____.

True of False: Matrix multiplication is commutative. _____

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

Of the various methods discussed in class for representing rotations, the method of _____ is least appropriate for interpolation due to singularities which include gimbal lock.

True of False: Marching cubes is a method for building polygonal surfaces. _____

The implicit formula for a sphere is _____.

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

Under *perspective* projection a set of parallel lines will _____ unless the lines are parallel to the image plane.

Under *orthographic* projection spheres will generally appears as _____.

Which points in a linear perspective image are vanishing points for some set of parallel lines? _____

A key feature of Bresenham's line drawing algorithm is that is uses ***only*** _____ arithmetic.

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

True or False: A BSP tree can be used to quickly sort polygons in front-to-back order. _____

True or False: The peacock feathers results from wave interference. _____

True or False: Rotation about an arbitrary axis in 3D requires three separate transformation matrices. _____

True or False: Systems like OpenGL typically convert everything to triangles before rendering. _____

True or False: BSP Trees will always be balanced. _____

True or False: The marching cubes algorithm generated a quad mesh. _____

Finding the interaction of a ray with a sphere requires solving a _____ equation.

True or False: BSP Trees will always be balanced. _____

2. **If you have two *orthogonal unit* vectors, A and B, then we can write the dot and cross products as A . B and A x B, respectively. Simplify the following expressions:** *8 points*

   A . (B x A) =

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

   B x (A x B) =

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

3. **You have a sphere centered at [0,0,4] with radius 5, 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 compute the coordinates of the intersection point[s].** *Be neat and clear!* *15 points*

   Sphere equation:

   Ray equation:

   Intersection[s] at =

4. **Write out a 3x3 transformation matrix that will rotate -45 degrees about the Y axis.** *6 points*

5. **Circle the types of transformations that to be expressed in matrix form do NOT require homogenized coordinates.** *2 points*

   Translation

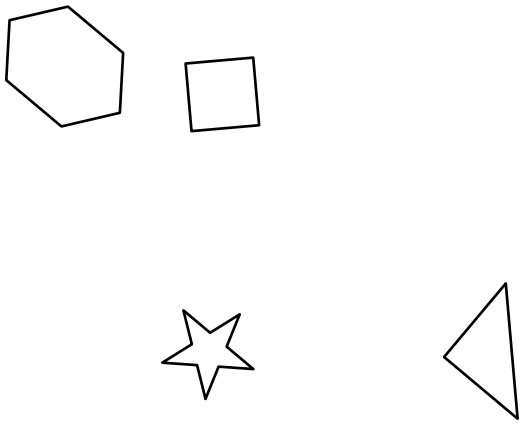
   Rotation

   Shear

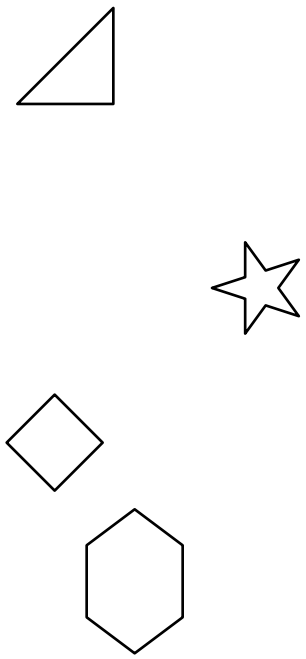
   Scale

   Perspective

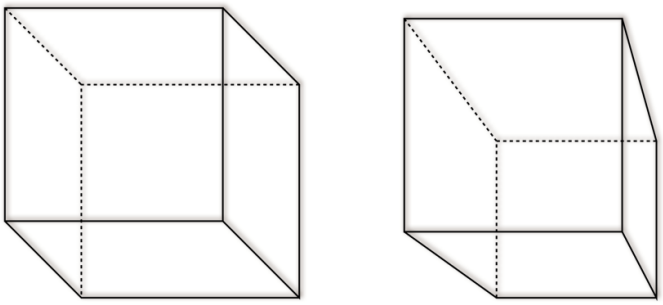
6. Draw the single *convex hull* that encloses all four shapes shown: *6 points*



7. Draw the single *axis-aligned bounding box* that encloses all four shapes shown: *6 points*



8. One of the diagrams below shows a cube under orthographic projection, the other under perspective projection. Label which is which. *2 points*



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

[10 , 20 , 0]

10. Given a rotation encoded as a quaternion, in general how is the rotation changed when the *only the real part is negated*? *3 points*

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

Glossy Metallic Red
Kd =
Ks =

Glossy Plastic Yellow
Kd =
Ks =

Flat Blue
Kd =
Ks =

12. If shading a point at the origin with normal [0,0,1] and Kd=[0.1 ,0.2 ,0.3], where the light is located at [0,4,3] with intensity 5 (white), and the eye located at [27,91,17], compute the RGB value of the diffuse lighting term. *10 points*

13. Circle the 3D homogenized matrix that would *do nothing*. *4 points*

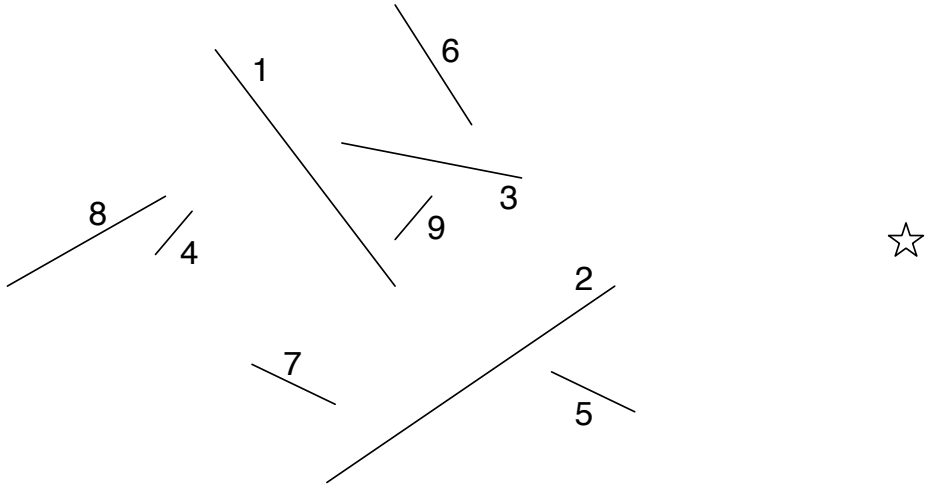
$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 2 \end{bmatrix} \quad \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 2 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1/2 \end{bmatrix}$$

14. When solving for the intersection of a ray with a plane, as discussed in class, write out the conditions on beta, gamma, and t that would indicate that there is an intersection. *12 points*

What condition should you test for that would indicate that there is no solution for beta, gamma, or t? *4 points*

15. 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. The negative-side children should be on the left of your tree and the positive-side on the right.*

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.) 13 *points*



List the *back-to-front* traversal order that would result for the location indicated by the viewer icon (the star). *9 points*

16. 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*. *4 points*

17. 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 blue, red, and green inputs on the monitor. When one attempts to display the following colors, what colors will actually appear on the screen? *8 points*

Cyan _____

Magenta _____

Yellow _____

Red _____

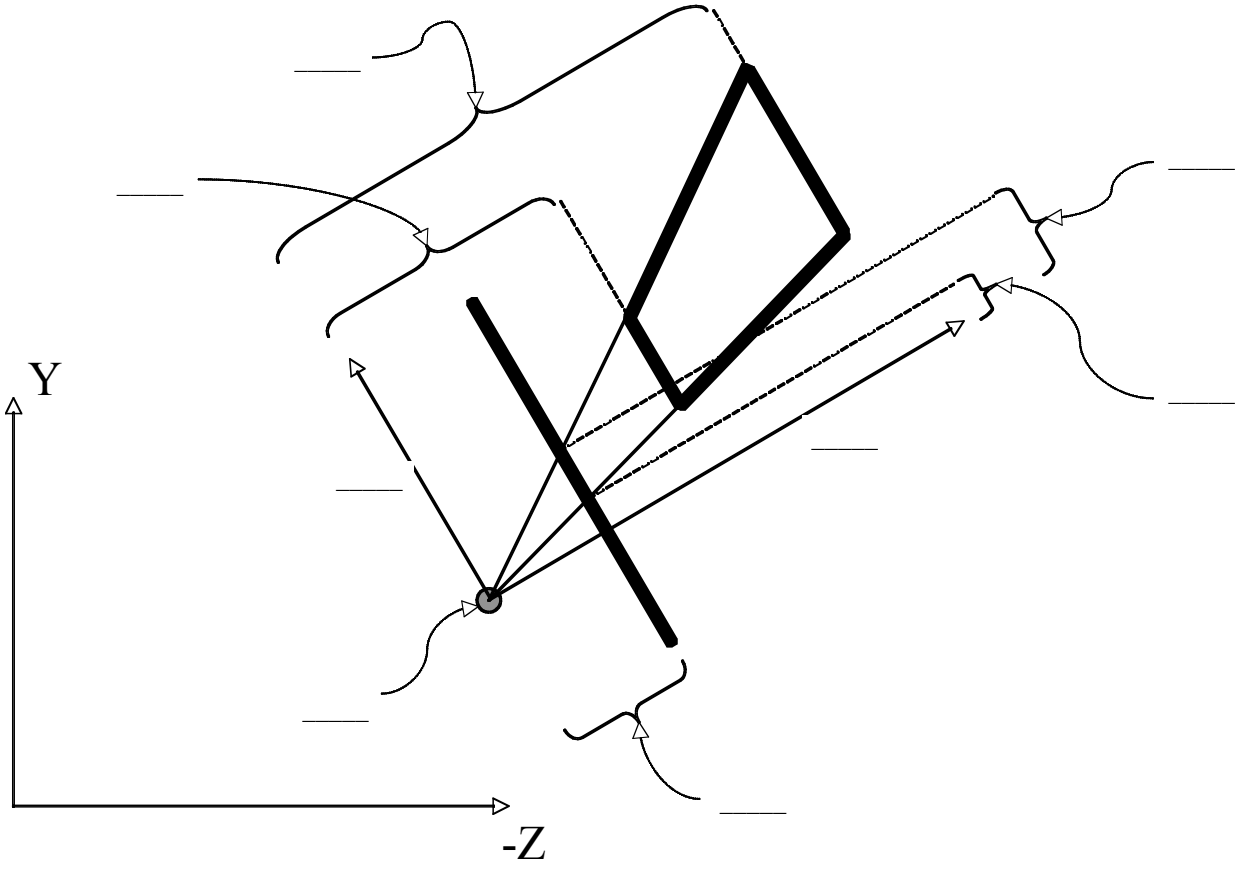
Green _____

Blue _____

Black _____

White _____

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. *16 points*



A	Center of projection	I	Bottom clipping plane distance
B	Scale factor	J	Focal distance
C	Distance to image plane	K	Right clipping plane distance
D	Projection singularity distance	L	View up vector
E	Top clipping plane distance	M	View plane normal
F	Magnetic zero	N	Far clipping plane distance
G	Near clipping plane distance	O	Aperture
H	Look-at direction	P	Origin

19. Write out a series of 4x4 matrices that would scale an object by 2x along the axis [1,1,0] with the point [0,3,4] staying fixed in space. *20 points*

Note that unclear or sloppy answers will not receive any credit.

EXTRA CREDIT **+10** *points*

Given:

A ellipse defined by

$$\left(\frac{x-c_x}{r_x}\right)^2+\left(\frac{y-c_y}{r_y}\right)^2+\left(\frac{z-c_z}{r_z}\right)^2-1=0$$

and a ray defined by

$$\mathrm{ray}(t)=[p_x,p_y,p_z]+t\,[d_x,d_y,d_z]$$

Write out the quadratic equation that should be solved to find the intersection.

Your answer must be neat and clear. No points will be awarded for imprecise answers. Do not attempt this question until you have completed the rest of the exam!