Midterm Exam

CS 184: Foundations of Computer Graphics
Fall 2016
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: 204 + 10 You Scored: _____ + _____

---

1. Please fill in each of the blanks with an appropriate answer. *2 points each blank, 64 Total*

True or False: Modern computer displays can display a greater dynamic range than the human can view. _____

True or False: Mach banding is is an algorithm for displaying smooth image gradients in rendered images. _____

Fill in the three missing colors in order by wavelength: Red, orange, _____, green, _____, indigo, _____.

True or False: The light coming from most light sources consist of just a narrow range of wavelengths in the visible spectrum. _____

The sensitivity curve for the rods in the human eye peeks between the _____ and _____ cones.

The letters AABB in the term AABB Tree stand for :
_____.

True or False: If light could be negative then any color humans can see could be reproduced using any two distinctly colored light sources. _____

_____ is the main phenomenon that causes the rainbow-like color patterns observed when a thin layer of oil floats on the surface of still water.

Finding the intersection of a ray with a/an _____ requires solving a quadratic equation.

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

True of False: Caustics may be generated by either reflection or refraction of light. _____

A _____ can be thought of as the limit case for a perspective camera as the center of projection moves further away from objects in the scene.

True or False: Rotation is a linear transformation. _____

True or False: Bump mapping changes the shape of an object. _____

True of False: Image morphing techniques often use a warping method to align corresponding features in the images. _____

True of False: Pasteurized 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 _____ uses points in a 3-dimensional sphere embedded in a 4-dimensional space.

Most realtime rendering methods use a _____ for hidden surface removal.

True or False: Anti-aliasing methods can be used to accelerate ray intersection tests for complex scenes. _____

Visible light roughly corresponds to wavelengths between _____ and _____ nanometers.

True or False: Area light sources can be approximated using a handful of point-lights, but banding artifacts may be produced in penumbra regions _____.

Rotation matrices have determinant of _____.

The _____ breaks a matrix C into C = (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: Systems like OpenGL typically convert everything to spheres before rendering. _____

The "S" in HSV color space stands for _____.

True or False: The term *black-body radiation* refers to electromagnetic energy outside the visible spectrum. _____.

True or False: Lambertian materials lack strong specular highlights.. _____

2. **You have two pieces of perfectly opaque plastic. They look the same color when held side-by-side in your dorm room. When you take them outside into the sunlight, they look to be different colors. Provide the most plausible explanation.** *6 points*

3. **You have a sphere centered at [2,3,4] with radius 5, and a ray from [0,0,0] in the direction [1, 1, 1]. 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!* *9 points*

Sphere equation:

Ray equation:

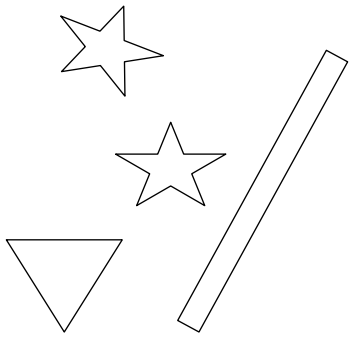
Intersection[s] at =

4. Write out a 3x3 transformation matrix that will perform a +90 rotation degrees about the axis [1, 0, 0]. *3 points*

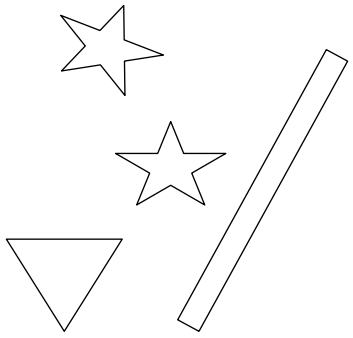
5. Place an $\times$ through the matrices that could <u>not</u> be valid camera matrices. *3 points*

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

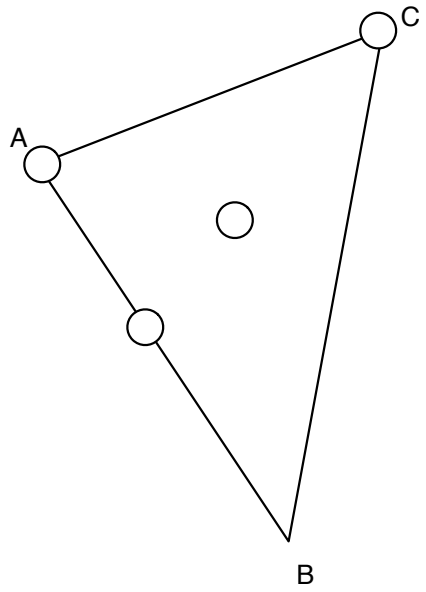
6. Draw the single *<u>convex hull</u>* that encloses all four shapes shown:** *6 point*



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



8. This diagram shows a triangle with vertices labeled a, b, and c. Five 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. *10 points*



- [1,0,0]
- [0,0,1]
- [1/3,1/3,1/3]
- [1/2,1/2,0]
- [-1,1.5,1.5]

9. Write down plausible RGB values for the following materials: *16 points*

Glossy Metallic Blue
Kd =
Ks =

Glossy Plastic Yellow
Kd =
Ks =

Flat Yellow
Kd =
Ks =

Glossy Plastic Black
Kd =
Ks =

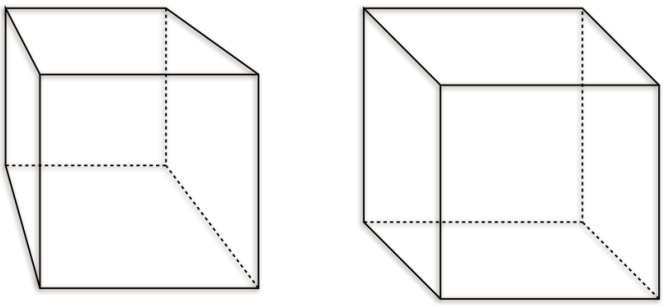
10. Given a rotation encoded as a axis-angle (a.k.a. exponential map), in general how is the rotation changed when the representation is doubled? *4 points*

11. If shading a point at the origin with normal [1,0,0] and Kd=[0.25, 0.00 ,0.20], where the light is located at [4,3,0] with intensity [10, 10, 0] and the eye located at [27,91,17], compute the RGB value of the diffuse lighting term. *12 points*

12. Circle the 3D homogenized matrix that effectively does nothing. *4 points*

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

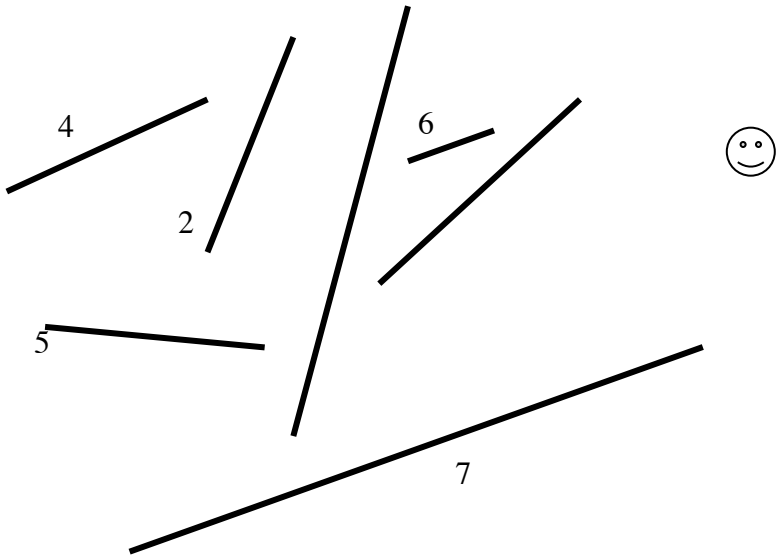
13. One of the diagrams below shows a cube under orthographic projection, the other under perspective projection. Label which is which. *4 points*



14. In what direction will the +Z axis point after a -90 degree rotation about the +Y axis? *2 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.*** ***<u>The negative-side children should be on the left of your tree and the positive-side on the right.</u>***

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.) 12 *points*



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

16. 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, red, and blue 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 _____

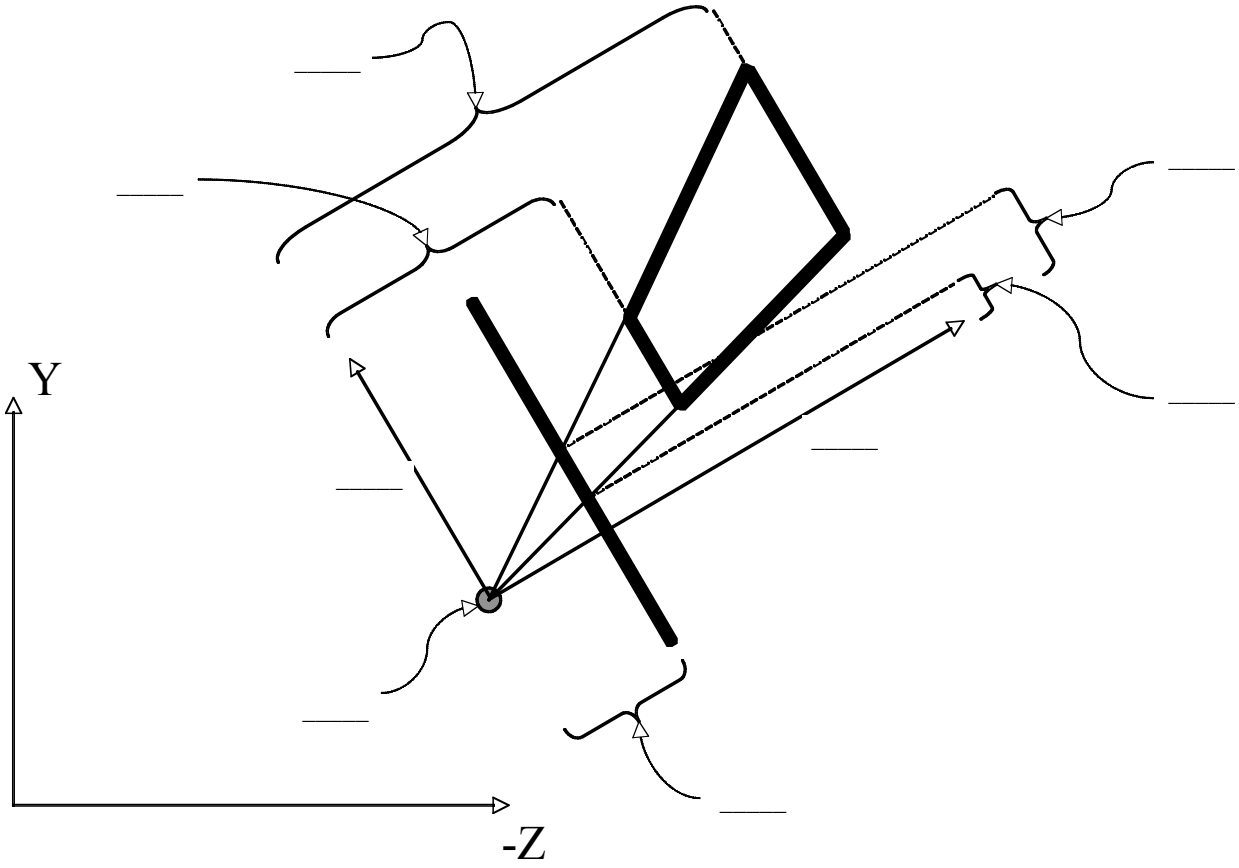
Blue _____

Black _____

White _____

17. Write out a series of 4x4 matrices that would scale an object by 2x along the X axis and by 3x along the Y and Z axes, with the point [0,3,4] staying fixed in space. *10 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. *16 points*



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

EXTRA CREDIT **+10** *points*

Given a plane and a sphere:

Plane: $\hat{\mathbf{n}} \cdot \mathbf{x} + f = 0$

Sphere: $||\mathbf{c} - \mathbf{x}|| - r = 0$

Write out a simple mathematical expression that will give the point on the sphere which is furthest away from the plane. (You may *not* include conditional statements.)

When is this point not unique?

When the point is not unique, what will your expression produce?

Your answers must be neat and clear. No points will be awarded for imprecise answers. Your answers should be in the form a simple mathematical expressions that you have drawn a box around. Do not attempt this question until you have completed the rest of the exam! There will be no partial credit for this question. Use the below space and back of the page to work out your answers, and do not clutter up the above space with anything other than your final answers.