Student Name: ______________________  Class Account Username: ____________

Instructions: Read them carefully!

The exam begins at 3:10pm 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: 159 + 10  You Scored: ________________ + ________________
1. Please fill in each of the blanks with an appropriate answer.  

2 points each blank, 62 Total

True or False: The dynamic range of intensities that can be displayed on your laptop monitor is larger than that what you’d find in most real-world scenes. 

True or False: Humans are good at judging the relative brightness of two squares on a screen when the borders of the colors are touching.

Fill in the three missing colors in order: Red, , , , Yellow, Green, , , violet.

True or False: The light we see reflected off most objects consist of a continuos combination of many wavelengths of light.

The sensitivity curves for the and cones have the most amount of overlap with the sensitivity curves for the rods.

The letters BSP in the term BSP Tree stand for:

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

 is the main phenomenon that makes the sky appear blue.

 is the main phenomenon that makes rainbow patterns in peacock feathers.

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

True of False: The exponent in the Flat shading model controls how rounded a material appears.

A can be thought of as a light located “at infinity”.
True or False: Translation is a nonlinear transformation. 

The real eigenvalue of an arbitrary rotation matrix is always _______________.

True of False: Matrix multiplication is associative. __________________

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 solid ball.

The implicit formula for a sphere with radius 5 is ____________________________.

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

Under perspective projection a set of parallel lines will converge to a vanishing point unless the lines are _____________________________ to the image plane.

Under perspective projection spheres will generally appear as ____________________.

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

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

True or False: An AABB tree can be used to quickly sort polygons in front-to-back order. ____________

True or False: Systems like OpenGL typically convert everything to quadrilaterals before rendering. _______________
True or False: BSP Trees will always be unbalanced. ________________

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

True or False: AABB Trees will always be balanced. ________________

2. If you have three orthogonal unit vectors, A, B and C, then we can write the dot and cross products as $A \cdot B$ and $A \times B$, respectively. Simplify the following expressions: 8 points

$$ (B \times A) \cdot (B \times A) = $$

$$ (B \times A) + (A \times B) = $$

$$ C \times (A \times B) = $$

$$ C \times B \times (B \times (B \times A)) = $$

3. You have a sphere centered at $[0,3,4]$ with radius 5, and a ray from $[0,0,0]$ in the direction $[0, 0.75, 1]$. 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 360 rotation degrees about the axis $[3, 4, 2]$. 2 points
5. Draw the single *convex hull* that encloses all four shapes shown:  

6. Draw the single *axis-aligned bounding box* that encloses all four shapes shown: 
7. Given a rotation encoded as a quaternion, in general how is the rotation changed when the both the real and imaginary parts are negated?  

8. Write down plausible RGB values for the following materials:  
   Glossy Metallic Magenta  
   \( K_d = \)  
   \( K_s = \)  
   Glossy Plastic Cyan  
   \( K_d = \)  
   \( K_s = \)  
   Flat Yellow  
   \( K_d = \)  
   \( K_s = \)  

9. If shading a point at the origin with normal [0,0,1] and \( K_d=[0.1 ,0.2 , 0.2] \), where the light is located at [3,0,4] with intensity [10,10,20] and the eye located at [27,91,17], compute the RGB value of the diffuse lighting term.  

10. Circle the 3D homogenized matrix that would \textit{scale by 1/2}.  

\[
\begin{align*}
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 \\
\end{bmatrix} & \quad \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 \\
\end{bmatrix} & \quad \begin{bmatrix}
2 & 0 & 0 & 0 \\
0 & 2 & 0 & 0 \\
0 & 0 & 2 & 0 \\
0 & 0 & 0 & 2 \\
\end{bmatrix} & \quad \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1/2 \\
\end{bmatrix}
\end{align*}
\]
11. 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.) 9 points

List the *back-to-front* traversal order that would result for the location indicated by the viewer icon (the star). 9 points
12. 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?

- Cyan ____________________
- Magenta ____________________
- Yellow ____________________
- Red ____________________
- Green ____________________
- Blue ____________________
- Black ____________________
- White ____________________

8 points

13. Write out a series of 4x4 matrices that would scale an object by 4x with the point [0,3,4] staying fixed in space.

6 points

Note that unclear or sloppy answers will not receive any credit.
14. 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  
B Scale factor  
C View up vector  
D Projection singularity distance  
E Top clipping plane distance  
F View direction  
G Near clipping plane distance  
H Look-at direction  
I Center of focus  
J Focal distance  
K Right clipping plane distance  
L View plane normal  
M Bottom clipping plane distance  
N Far clipping plane distance  
O Aperture  
P Center of projection
Given:
A 3D shape defined implicitly by
\[(x - c_x)^2 + (y - c_y)^2 - r^2 = 0\]
and a ray defined by
\[
\text{ray}(t) = [p_x, p_y, p_z] + t [d_x, d_y, d_z]
\]
What is the shape?

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