Midterm Exam

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 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.*

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: 170 + 10 You Scored: _____ + _____

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1. **Please fill in each of the blanks with an appropriate answer.**   *2 points each blank, 66 Total*

The human eye contains receptor cells, called _____, that function relatively well under low-light conditions.

The human eye contains an another type of receptor cell, called _____, that come in three varieties and allow color vision.

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

The term _____ refers to energy emitted by hot objects.

The sky appears blue due to _____ of light.

The mechanism responsible for the color in a peacock feather is _____.

Scorpions _____ under ultraviolet light.

The _____ term in the Phong shading model approximates global illumination.

Increasing the _____ in the Phong shading model causes specular reflections to appear smaller and tighter.

The _____ is a function that describes how light is reflected form a surface.

The soft, smooth appearance of healthy skin is caused by _____ of light.

The diffuse term in Phong shading is proportional to the cosine between _____ and the surface normal.

The specular term in Phong shading is proportional to the cosine between _____ and the surface normal.

The _____ term in the Phong shading model is not view independent.

A _____ light is the limit behavior of a point light located infinitely far away.

In the real world, illumination from a point source falls off proportional to _____.

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In _____ shading, the vertex color values are interpolated.

In _____ shading, the vertex normals are interpolated.

Any 3x3 transformation matrix can be decomposed into a product of _____ and scaling.

The _____ of a rotation matrix is always +1.

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

The use of _____ coordinates allows translation to be expressed as matrix-vector multiplication.

If a matrix is used to transform the points on an object, the _____ of the matrix should be used to transform the surface normals.

_____ encode rotations in 3D as points on the unit hyper sphere in R4.

When using Euler angles, _____ occurs when the first and third axes align on top of each other.

In a raytracer, _____ are generated by tracing rays from surface points to the lights.

Depth-of-field effects result when the opening of a pin-hole camera is replaced with a _____.

_____ recursively partition space in a binary fashion.

In linear perspective, the surface of projection is a _____.

Bresenham's line drawing algorithm uses only _____ arithmetic.

The _____ receptors are mainly concentrated in the fovea (center of the retina).

Area light sources create _____ shadows.

Writing a raytracer is like _____.

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

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

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

3. You have two pieces of opaque **_BLUE_** 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 sure 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.

400 nm 700 nm	400 nm 700 nm	400 nm 700 nm	400 nm 700 nm
A	**B**	**X**	**Y**
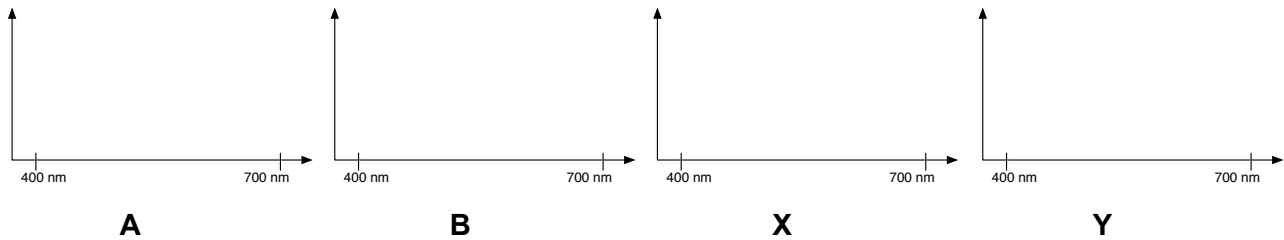
4. A perspective camera has its center of projection at $[7,-3,+5]$, and it's image plane is defined by $z = +2$. What set of lines vanish at the same point in the image plane as does the line $x(t) = [3,-1,1] + t\,[2,1,0]$?   *5 points*
    Be precise and concise.

    What lines do not vanish to any finite point in the image?   *3 points*
    Be precise and concise.

5. Draw a tight axis-aligned bounding box around each of these shapes: *5 points*
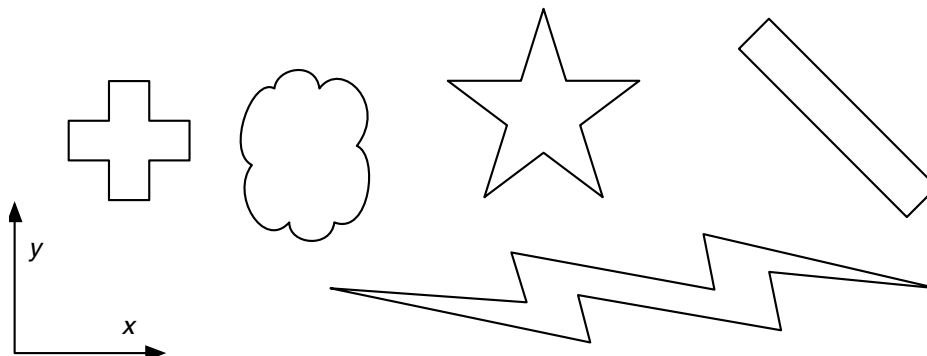
6. **This diagram shows a triangle with vertices labeled a, b, and c. Several locations have been indicated with circles. The list of numbers to the right contains triples of numbers representing the barycentric coordinates of these circles. Draw a line connecting each triple with the correct circle. Cross out the triple that does not match any circle.** *6 points*
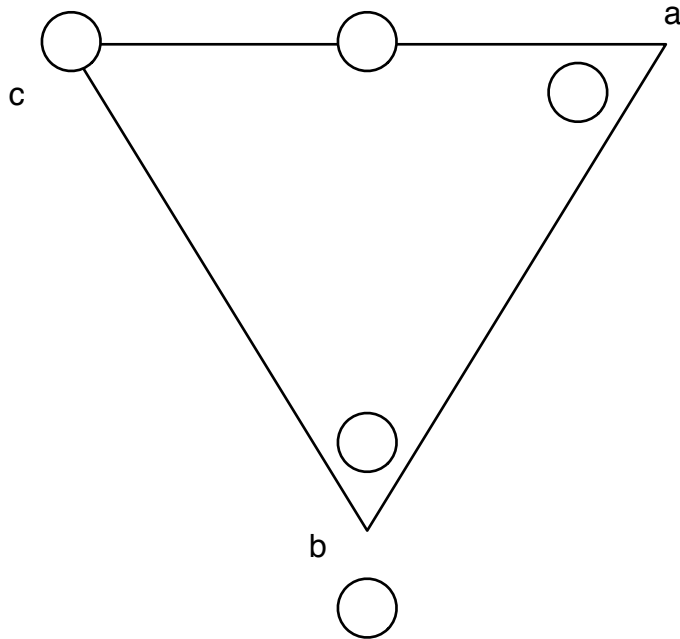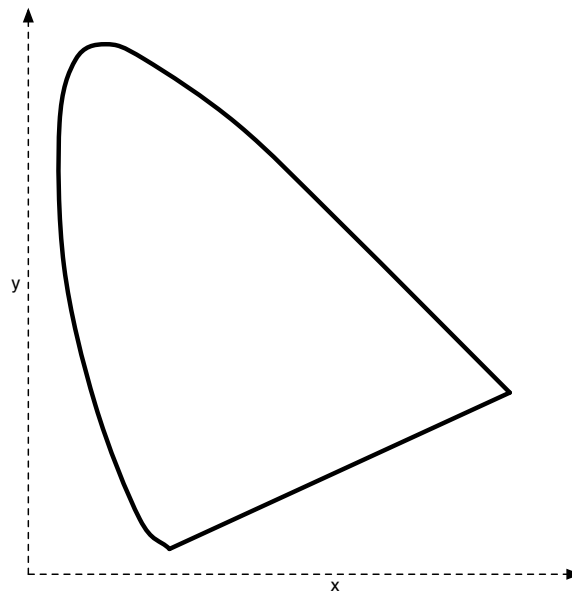

[0.5, 0.0, 0.5]

[0.0, 0.0, 1.0]

[0.8, 0.1, 0.1]

[0.1, 0.8, 0.1]

[-0.1, 1.2, -0.1]

[0.1, -0.2, 0.1]

7. **The following diagram shows the the x-y plane of the CIE color space. Mark and label the approximate locations of spectral red, spectral blue, spectral green, spectral yellow, pink, and white.** *12 points*

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8. Given a rotation encoded as a length-3 vector (*e.g.* axis-angle, a.k.a. exponential map), in general how is the rotation changed when the representation is *doubled*?   *3 points*

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

10. One of the diagrams below shows a cube under orthographic projection, the other under perspective projection. Label which is which.   *2 points*
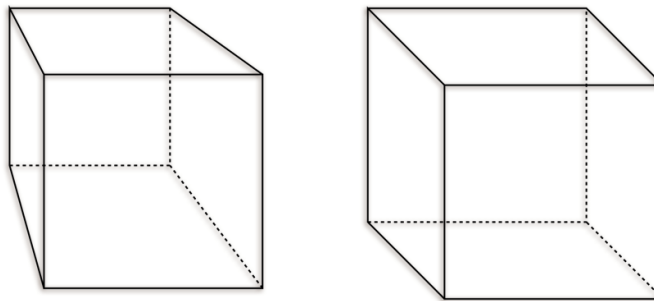
11. Write down plausible RGB values for the following materials: *4 points*

   Glossy Black
   Kd =
   Ks =

   Flat Blue
   Kd =
   Ks =

12. True or false, an orthographic rendering of a sphere will always be perfectly round?   *2 points*

13. True or false, two lines that meet at a right angle in 3D will always appear to meet at a right angle when orthographically projected into 2D ?   *2 points*

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14. **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.**
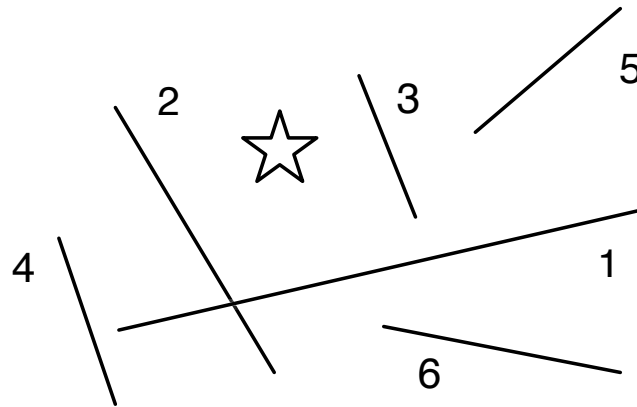

Diagram the resulting tree below. If needed, show where line segments need to be split by marking on the above figure. Also, indicate the names of the split parts by writing labels on the figure above. (For example, if there were a segment 9 and it was to be split, you would draw a mark showing where it would be split and label the resulting pieces 9a and 9b.) *15 points*

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

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15. In what direction will the +Y axis point after a -90 degree rotation about the +Z axis? *2 points*

16. Which matrix scales by -1 about the X axis? (Circle your answer.)   *2 points*

$$
\begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & & & \\ 0 & & \bigstar & \end{bmatrix}
\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ & & & \\ & & & 1 \end{bmatrix}
$$

**17. True or false, rotation ab   s three separate transfor-
mations matrices.?**   *2 points*

18. 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*

19. Write out the 3x3 matrix for a rotation about the Y axis. Now write out a 3x3 matrix for a rotation about the Y axis that would result if we did rotations *clockwise* instead of *counterclockwise*.   *5 pts*

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20. 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*
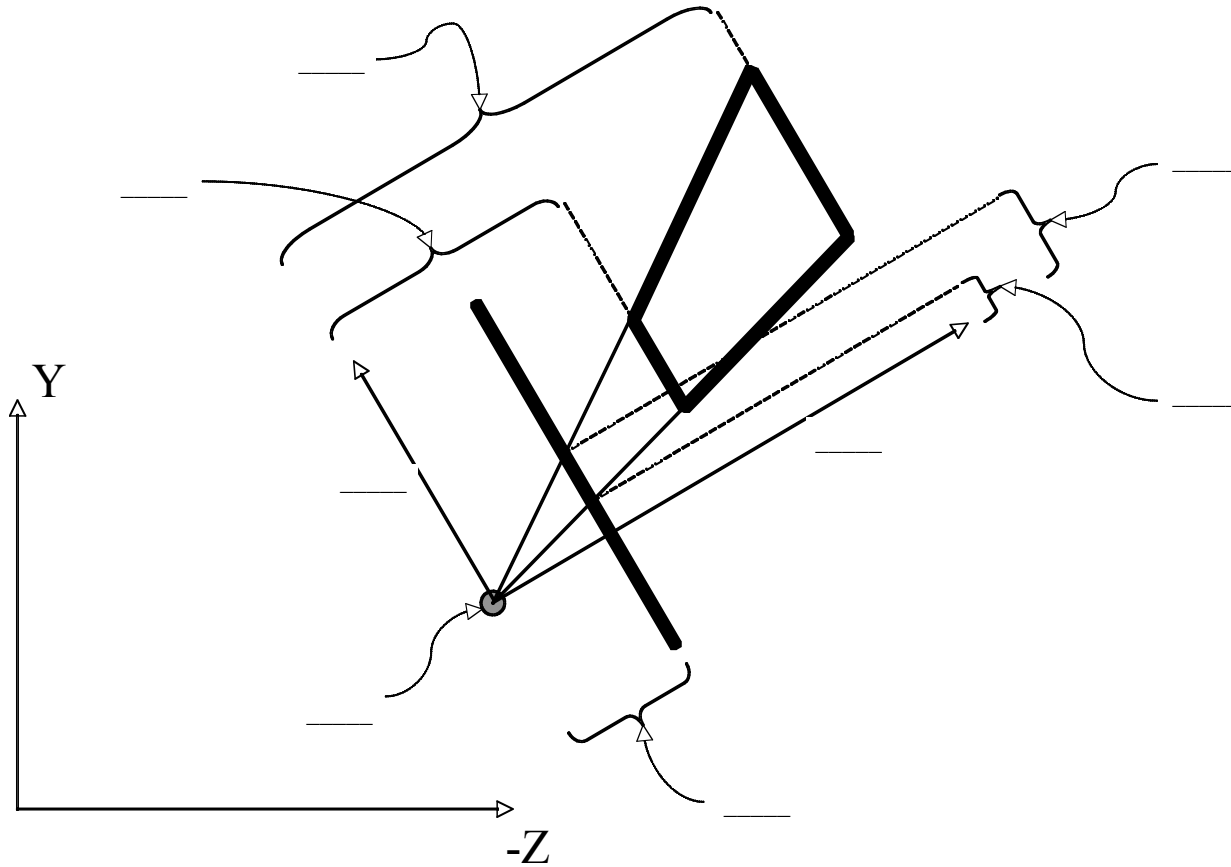
A	Center of Projection	I	Zero point
B	Small blind	J	Bottom clipping plane distance
C	Top clipping plane distance	K	Big blind
D	View up vector	L	Star power
E	View plane normal	M	Far clipping plane distance
F	Main tank	N	Right clipping plane distance
G	Near clipping plane distance	O	Left clipping plane distance
H	Distance to image plane	P	Distance to a higher plane

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EXTRA CREDIT   **+10 points**

Given two spheres in R3 described by the implicit equations:

Sphere 1: $||x - c_1||^2 - r_1^2 = 0$

Sphere 2: $||x - c_2||^2 - r_2^2 = 0$

the intersection of the two spheres (if it exists) will be a circle.

Write out equations for computing the center of the circle, _c_, the radius of the circle, _r_, and the equation for the plane containing the circle. Note what conditions must apply for there to be a solution.

Your answer must be neat and clear. No points will be awarded for imprecise answers that do not fit in the boxes. You must get all four 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!

_c_ =

_r_ =

Plane equation:

Fails when: