CSE167, Introduction to Computer Graphics
Midterm, Tuesday May 15
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Please include all steps of your derivations in your answers to show your understanding of the problem. Try not to write more than the recommended amount of text. If your answer is a mix of correct and substantially wrong arguments we will consider deducting points for incorrect statements. There are thirteen questions for a total score of 100 points.

Your name:

1. Compute the dot-product of vectors \( \mathbf{a} = (1, 2, -3) \) and \( \mathbf{b} = (4, 1, 2) \). What is the angle between \( \mathbf{a} \) and \( \mathbf{b} \)? (6 points)

2. Given two vectors \( \mathbf{a} \) and \( \mathbf{b} \) and their cross product \( \mathbf{c} = \mathbf{a} \times \mathbf{b} \). What is the cross product \( \mathbf{b} \times \mathbf{a} \) and \( \mathbf{c} \times \mathbf{b} \)? (6 points)
3. Show that the vectors \((2, 6, 5), (-3, 5, 1),\) and \((12, 8, 13)\) are linearly dependent. \((8 \text{ points})\)

4. Given a rotation and a translation matrix \(R\) and \(T\),

\[
R = \begin{bmatrix}
r_{11} & r_{12} & r_{13} & 0 \\
r_{21} & r_{22} & r_{23} & 0 \\
r_{31} & r_{32} & r_{33} & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}, \quad T = \begin{bmatrix}
1 & 0 & 0 & t_{14} \\
0 & 1 & 0 & t_{24} \\
0 & 0 & 1 & t_{34} \\
0 & 0 & 0 & 1
\end{bmatrix},
\]

write down the matrix \(RT^{-1}\), i.e., write down its sixteen elements. \((8 \text{ points})\)

5. What is the geometric interpretation of a homogeneous point with a homogeneous coordinate that is zero, i.e., a point of the form

\[
p = \begin{bmatrix}
x \\
y \\
z \\
0
\end{bmatrix}. \quad (4 \text{ points})
6. Explain the term *metamer* (1-2 sentences). (7 points)

7. Describe the main property of perceptually uniform color spaces (1-2 sentences). (7 points)

8. Why does linear interpolation of texture coordinates in screen space lead to artifacts? Explain using a sketch and one or two explanatory sentences. (8 points)
9. Write down the four stages of the rendering pipeline and explain their main functionality in one sentence each. (12 points)

10. Given a directional light source with direction $\mathbf{d} = (1, 1, 0)/\sqrt{2}$ and strength $c_l = (0.5, 0.5, 0)$. Compute diffuse reflection on a surface with the following properties: The surface normal is $\mathbf{n} = (1, 0, 1)/\sqrt{2}$, and the material has a diffuse reflectance coefficient $k_d = (1, 0, 0)$. (8 points)
11. How many texel values have to be read to perform nearest neighbor texture filtering, bilinear texture filtering, and trilinear mipmapping? (6 points)

12. What is the advantage of trilinear mipmapping over bilinear filtering (2-3 sentences)? (8 points)
13. Give pseudocode for hierarchical view frustum culling with bounding spheres. (12 points)