CMSC 435 Midterm Exam (Fall 2016)

Instructions: Clearly write your name on this sheet. Answer each problem in the space provided. If you need extra space, clearly write your name and the problem number on an extra sheet of paper, write on extra sheet in the answer space on the exam paper, and turn in the extra sheet with your exam.

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 any existing resource to complete the exam, including your notes, the textbook, and online materials. However, your exam must represent your own work. You may not discuss the exam with anyone, either in person or virtually through bulletin boards or discussion sites. You may not ask questions of other students, look at another students exam. In summary: do not cheat. Persons caught cheating will be subject to disciplinary action.

Each question is marked with a number of points. There are 135 points total.

If something isn’t clear, you will have an opportunity to ask questions during class on monday and wednesday.

Exams are due by the end of class on Monday October 31.

Good luck

Name: __________________________________________

GL Login: __________________________________________
1. (1 pt) A_____________ describes a length and a direction.

2. (1 pt) True/False: Vector addition is commutative. ____________

3. (1 pt) The dot product can be used to find the ________________ of one vector onto another.

4. (1 pt) $a \times b$ is _______________ to both $a$ and $b$.

5. (1 pt) In a parallel projection, if the image plane is not perpendicular to the view direction, the projection is called ________________.

6. (2 pts) _______________ and _______________ shading are view independent.

7. (3 pts) The three components of the phong shading model are _______________ , _______________ , and _______________.

8. (1 pt) A useful property of light is ________________ —the effect caused by more than one light source is simply the sum of the effects of the light sources individually.

9. (1 pt) _______________ displays show images as rectangular arrays of pixels.

10. (1 pt) _______________ _______________ refers to an optimization that avoids drawing polygons that do not face the camera.

11. (2 pts) RenderMan performs vertex shading after _______________ polygons into small quadrilaterals called _______________.

12. (1 pt) Image textures exacerbate _______________ issues.

13. (1 pt) A cubemap consists of _______________ square textures.

14. (1 pt) It is common to store texture coordinates on the _______________ of a triangle mesh.

15. (1 pt) A _______________ is a sequence of textures that all contain the same image but at lower and lower resolution.

16. (1 pt) A texture that modifies normals by specifying a heightfield over the surface is called a _______________ map.

17. (1 pt) A texture that modifies vertex positions is called a _______________ map.

18. (1 pt) A shadow map stores the _______________ buffer of an image rendered from the light source.

19. (1 pt) _______________ maps add detail to incident illumination.
20. (1 pt) When finding a good parameterization of a surface is difficult, textures can be used.

21. (1 pt) When computing a refraction direction, occurs when the discriminant is negative.

22. (1 pt) The reflectivity of a dielectric surface varies with the incident angle according to the equations.

23. (1 pt) For homogeneous impurities a light-carrying ray’s intensity will be attenuated according to Law.

24. (1 pt) A sampling strategy that randomly perturbs a regular grid is called sampling.

25. (1 pt) When an area light source is only partially visible from a point on a surface, the surface is in the .

26. (1 pt) refers to collecting light over a non-zero size lens.

27. (1 pt) When rays are distributed in time the effect of is achieved.

28. (1 pt) Quadric surfaces are given by polynomials.

29. (1 pt) Given a point on a plane, and a normal to the plane, we know that a point lies on the plane if .

30. (1 pt) In perspective straight lines in world space become straight lines in the image.

31. (1 pt) Orthographic projection is a special case of perspective projection where the focal length is set to .

32. (1 pt) Axis-aligned scales are represented with matrices.

33. (1 pt) Rotations are represented with matrices.

34. (1 pt) If , then is .

35. (3 pts) The singular value decomposition guarantees that all transformation matrices can be decomposed into a followed by a , followed by a .

36. (1 pt) True/False: Inkjet printers print binary images—pigment is either deposited or not at each grid position, with no intermediate amounts possible.

37. (1 pt) In an RGB additive color model red + green = .
38. (1 pt) In an orthographic projection parallel lines meet at ____________.

39. (1 pt) In a perspective projection parallel lines meet at ____________.

40. (2 pts) Diffuse shading is based on ____________ law and can be computed as \( L = \) ____________.

41. (1 pt) When tracing shadow rays we search for intersections in the interval \( t \in [\epsilon, l] \) where \( \epsilon \) is the ____________ and \( l \) is the distance to the light.

42. (1 pt) If a matrix \( A \) satisfies the property ____________ , then \( A \) includes a reflection.

43. (1 pt) When intersecting a ray with a sphere if the discriminant is negative, the ray ____________ intersect the sphere.

44. (1 pt) The output of rasterization is ____________.

45. (1 pt) On modern GPUs, the ____________ algorithm is the most commonly used hidden surface removal algorithm.

46. (1 pt) Per-vertex shading, which passes color to the rasterizer, is known as ____________ shading.

47. (1 pt) Given a vector, \( e \), from the camera to an edge and, \( n_0 \) and \( n_1 \), the normals to the incident triangles, the edge is a silhouette if ____________.

48. (1 pt) True/False: Texturing a surface requires parameterizing the surface with texture coordinates. ____________

49. (1 pt) ____________ law relates incoming and exiting angles of light rays that pass through a dielectric surface.

50. (1 pt) In an implicit representation of the surface the normal can be computed by taking the ____________ of the function.
51. (6 pts) What is clipping? Why do we do it? When (in the graphics pipeline) do we do it?

52. (2 pts) Give a parametric equation of a circle centered at (3, 5) with radius 2.

53. (2 pts) Give an implicit equation of a circle centered at (3, 5) with radius 2.
Assume you have a triangle with vertices \( A, B, C \), where the vertices are given in counterclockwise order.

54. (2 pts) Give an equation for the unit-magnitude normal for the triangle.

55. (2 pts) Give an equation for the area of the triangle.

56. (2 pts) Give a parametric equation for a (3D) ray with origin \( e \) and direction \( d \).

57. (5 pts) Setup, but do not solve, the linear system that results when intersecting a ray with the triangle. Circle the unknowns in this equation.
58. (5 pts) Setup, but do not solve, the equation for intersecting a ray with a sphere centered at \( c \) with radius \( r \). Circle the unknowns in this equation.

59. (7 pts) Given a camera center, \( c \), a gaze direction, \( d \), and an up vector, \( b \), construct an orthonormal coordinate system. Give the origin of the system and equations for the \( u \), \( v \), and \( w \) directions. \( w \) should be in the negative gaze direction, and \( v \) should be as close to \( b \) as possible.

60. (2 pts) Give the \( 4 \times 4 \) homogeneous matrix that converts from world coordinates to the camera coordinates constructed in the previous question.
Consider the following perspective transformation matrix:

\[
\begin{pmatrix}
    n & 0 & 0 & 0 \\
    0 & n & 0 & 0 \\
    0 & 0 & n+f & -fn \\
    0 & 0 & 1 & 0 \\
\end{pmatrix}
\]

61. (2 pts) Where does the perspective transformation map the point \((x, y, z, 1)\)?

62. (2 pts) What happens to points on the near clipping plane?

63. (2 pts) What points are mapped to infinity?
64. (3 pts) Perspective transformations result in closer objects appearing larger, giving good depth cues. If a square is 1 unit wide at 5 units away how wide will it appear at 2 units away?

65. (5 pts) Draw a figure that gives the intuition for the equation of a reflection ray \((r = d - 2(d \cdot n)n)\).

66. (3 pts) Give an implicit equation for the line passing through points \((x_0, y_0)\) and \((x_1, y_1)\).

67. (8 pts) Give four desirable properties for texture coordinate functions.
68. (5 pts) Describe how to interpolate texture coordinates while accounting for perspective distortions.

69. (3 pts) How does one achieve soft shadows in a ray tracing program?

70. (10 pts) Where does the matrix $M$ described on page 153 of the textbook map the point $(-4, 1.33333, 0)$ if the camera's origin is $(10.86, 7.2, 5.4)$, looking at $(0, 0, 0)$, with an up as close to $(0, 0, 1)$ as possible, the field of view is 55 degrees, the near clipping plane is set to $z = -1$ and the far clipping plane is set to $z = -1000$. What if $M_{\text{OpenGL}}$ is substituted for $M_{\text{per}}$?