CS 130
Final

Fall 2015

Name	
Student ID	
Signature	

You may not ask any questions during the test. If you believe that there is something wrong with a question, write down what you think the question is trying to ask and answer that.

Question	**Points**	**Score**
True/False		
1	2	
2	2	
3	2	
4	2	
5	2	
6	2	
7	2	
8	2	
9	2	
10	2	
11	2	
12	2	
13	2	
14	2	
15	2	
16	2	
17	2	
18	2	
19	2	
20	2	
Multiple Choice		
21	4	
22	4	
23	4	
24	4	
25	4	
26	4	
27	4	
28	4	
29	4	
30	4	
31	4	
32	4	
33	4	
34	4	
35	4	
Written		
36	10	
37	10	
38	10	
39	10	
40	10	
Total	150	

True/False

For each question, indicate whether the statement is true or false by circling T or F, respectively.

1. (T/[F]) Rasterization occurs before vertex transformation in the graphics pipeline.
2. (T/[F]) Clipping is performed after perspective division in the graphics pipeline.
3. ([T]/F) Given any matrices M_1, M_2, and M_3, $(M_1 M_2)M_3 = M_1(M_2 M_3)$.
4. (T/[F]) Given any matrices M_1, M_2, and M_3, $M_3 M_2 M_1 = M_1 M_2 M_3$.
5. (T/[F]) If monitor gamma is increased, the image will be brighter.
6. (T/[F]) Using an alpha channel allows you to represent more unique colors.
7. (T/[F]) The OpenGL pipeline is primarily designed to implement global illumination.
8. ([T]/F) OpenGL supports z-buffering.
9. ([T]/F) The perspective transformation is nonlinear in z.
10. ([T]/F) The viewport transformation maps from normalized device coordinates to screen space.
11. ([T]/F) This matrix is a rigid body transformation

$$\begin{pmatrix} \cos\theta & -\sin\theta & 0 & 2 \\ \sin\theta & \cos\theta & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

12. (T/[F]) This matrix reflects about the x-axis.

$$\begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

13. (T/[F]) We can translate the vector

$$\begin{pmatrix} 3 \\ 2 \\ 1 \\ 0 \end{pmatrix}$$

    by multiplying it by the matrix

$$\begin{pmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

14. ([T]/F) Diffuse shading gives us information about the geometry of the object.

15. ([T]/F) In the Phong reflection model, using ambient lighting alone makes the object appear flat.

16. ([T]/F) Lambertian shading is not affected by a change in the viewing direction.

17. ([T]/F) The Phong reflectance model requires more computation than the Lambertian reflectance model.

18. (T/[F]) Gouraud shading requires more computation than Phong shading.

19. (T/[F]) You can sample a 3D-solid texture using 2 texture coordinates.

20. ([T]/F) The OpenGL graphics pipeline allows for multiple textures to be bound to the same object.

Multiple Choice

For each question, circle exactly one of (a)-(e), unless otherwise stated.

21. The midpoint (or Bresenham) algorithm for rasterizing lines is optimized relative to the DDA algorithm in that it

    I. avoids round operations.

    II. is incremental.

    III. uses only integer arithmetic.

    (a) II only

    (b) I and II only

    (c) I and III only

    (d) II and III only

    (e) [I, II and III]

22. Which statements about the z-buffer approach to rendering are true?

    I. selects which fragment to draw based on its depth.

    II. orders triangles from back to front.

    III. orders triangles based on the average z-values of their vertices

    (a) [I only]

    (b) I and II only

    (c) I and III only

    (d) I, II and III

    (e) None

23. Consider a point with barycentric coordinates $(-1, 1, 1)$ relative to a given (non-degenerate) triangle. Which statement is true?

(a) The point is definitely inside the triangle.

(b) The point is definitely outside the triangle.

(c) The point is either inside or outside the triangle but there isn't enough information to tell.

(d) Those are not valid barycentric coordinates.

(e) The point lies on the edge of the triangle.

24. Which of the following statements about rotations are true?

I. The vector component of the quaternion encodes the rotation axis.

II. Gimbal locks remove a degree of freedom of rotation.

III. Interpolation using Euler angles does not always yield geodesic (shortest) paths.

(a) I only

(b) II only

(c) I and III only

(d) II and III only

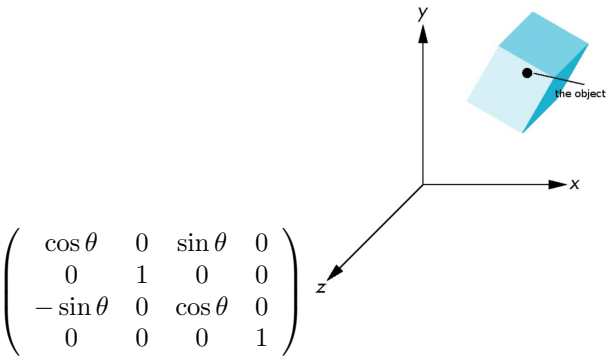
(e) I, II and III

25. Which of the following statements about rotations are true?

I. Any rotation in 3D space can be described using an angle and an axis.

II. The inverse of a rotation matrix R is R^T.

III. This rotation matrix will rotate the object pictured about its center.



$$\begin{pmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

(a) II only

(b) I and II only

(c) I and III only

(d) II and III only

(e) I, II and III

26. Which of the following statements about texture mapping are true?

    I. Bump mapping perturbs vertices.

    II. Bump mapping can be used to give the object a bumpy appearance in both the interior polygons and its silhouette.

    III. Shadow mapping can be used to add shadows in a z-buffer based rendering approach.

    (a) I only
    (b) II only
    (c) [III only]
    (d) I and II only
    (e) II and III only

27. Which of the following statements about texture mapping are true?

    I. Texture coordinates inside a triangle are interpolated from the texture coordinate of its vertices.

    II. Mipmapping with n levels requires n times the amount of memory

    III. Point sampling a texture can introduce aliasing artifacts.

    (a) I only
    (b) I and II only
    (c) [I and III only]
    (d) II and III only
    (e) I, II and III

28. Using the Phong reflectance model, the strength of the specular highlight is determined by the angle between

    (a) the view vector and the normal vector.
    (b) the light vector and the normal vector.
    (c) the light vector and the reflected vector.
    (d) [the reflected vector and the view vector.]
    (e) none of the above.

29. Minification occurs when

    (a) [multiple texels cover a single pixel.]
    (b) a single texel covers multiple pixels.
    (c) the area of the texture being mapped is less than half the area of the surface it is being mapped to.
    (d) texture image resolution is not high enough.
    (e) a small picture is applied to a large object.

30. In the Phong reflectance model, if only _____lighting is used, a flat surface illuminated with a directional light source will have a uniform color intensity across the surface.

    (a) diffuse
    (b) specular
    (c) [ambient]

31. Compared to flat shading, _____improves the appearance of the objects silhouette.

    (a) Gouraud shading
    (b) Phong shading
    (c) [none of the above]

32. Texture filtering

    (a) [can reduce aliasing artifacts in texture mapping.]
    (b) is used to reduce the lighting calculations done on a fragment.
    (c) is cheaper than point sampling.
    (d) adds detail to a texture.
    (e) none of the above.

33. How many degrees of freedom does a rigid body have in <u>two</u> dimensions?

    (a) 1
    (b) 2
    (c) [3]
    (d) 4
    (e) 6

34. What is true the two vectors depicted below?

    (a) Their cross product is zero because they in the same plane.
    (b) Their dot product is zero.
    (c) [Their dot product is positive.]
    (d) Their dot product is negative.
    (e) The dot product between them is undefined.

35. What is the correct order of operations of the OpenGL graphics pipeline?

    (a) projection transformation, modelview transformation, divide by w, viewport transform
    (b) modelview transformation, divide by w, projection transformation, viewport transform
    (c) modelview transformation, viewport transform, divide by w, projection transformation
    (d) [modelview transformation, projection transformation, divide by w, viewport transform]

Written Response

36. Homogeneous Transformations

    (a) Write a matrix to transform a point by first rotating it $\frac{\pi}{2}$ radians about the y-axis, and then translating it by $(1, 3, 0)$.

    (b) Write down a vector pointing in direction $(1, 1, 1)$ in homogeneous coordinates and apply the transformation matrix from part (a) to it.

    (c) Explain the difference between how the transformation matrix would transform the point and how it transformed the vector.

37. Implicit and Parametric Equations

(a) Give an implicit equation for a 2D circle of radius R centered at (x_0, y_0).

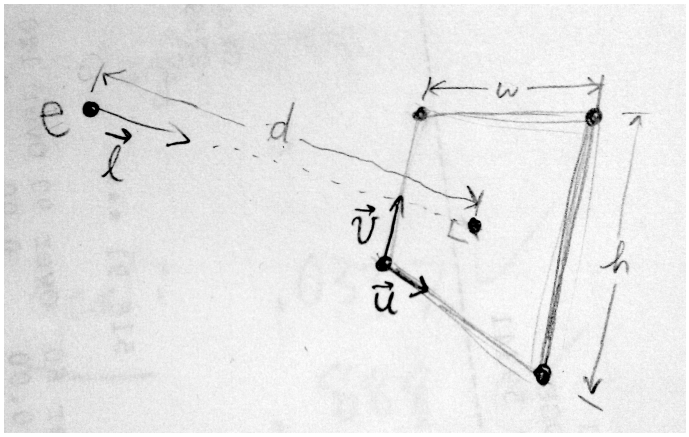
(b) Give a parametric equation for the same circle as in part (a), i.e. complete the following equations:

$$x(t) = ?$$
$$y(t) = ?$$

(c) Given two points A and B, write down an equation for the line segment between them parameterized by $t \in [0, 1]$ (It should linearly interpolate between A and B such that $f(0) = A$ and $f(1) = B$).

(d) Give an implicit equation of a square centered at the origin with side length $2S$. Hint: your equation can be piecewise.

38. Camera Transformations. A camera has position **e** and is looking in direction **l** at an image of width w and height h, oriented perpendicular to **l**. If image is d units along **l**, and the width and height unit vectors are **u** and **v**, respectively, what are the world space coordinates of the four corners of the image?



39. Consider a reflectance model equation

$$I = C_1 \max(0, \mathbf{L} \cdot \mathbf{N}) + C_2 \max(0, \mathbf{R} \cdot \mathbf{V})^s$$

where $\mathbf{N}$, is the surface normal, $\mathbf{L}$ is the normalized light vector (the vector pointing from the point being illuminated to the light source), $\mathbf{V}$, is the normalized view vector (the vector pointing from the point being illuminated to the camera), and $\mathbf{R}$, is the normalized reflection of $\mathbf{L}$ across $\mathbf{N}$. C_1, and C_2 are constant scalars.

(a) If the value C_1 was set to 1.0 and the value C_2 was set to 0.0, what kind of materials could be represented by those parameters and why?

(b) If the value C_1 was set to 0.1, the value C_2 was set to 1.0, and s was set to 10.0, what kind of materials could be represented by those parameters and why?

(c) How does s affect the illumination of the object? What would increasing its value do? What would decreasing its value do? For what materials would you model using a high s value and for what materials would you want a low s value?

(d) Suppose the equation was changed to $I = C_1|\mathbf{L} \cdot \mathbf{N}| + C_2|\mathbf{R} \cdot \mathbf{V}|^s$. What effect would that have on the illumination of the object?

40. Textures.

(a) Given a texture of 256×256 texels, explain how you might generate a mipmap for the texture.

(b) For each image below, indicate whether (1) mipmapping was used, and (2) bilinear filtering was used.