

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	
<b>Total</b>	<b>150</b>	

## 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  $M_3$ ,  $(M_1M_2)M_3 = M_1(M_2M_3)$ .
4. (T/F) Given any matrices  $M_1, M_2$ , and  $M_3$ ,  $M_3M_2M_1 = M_1M_2M_3$ .
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.

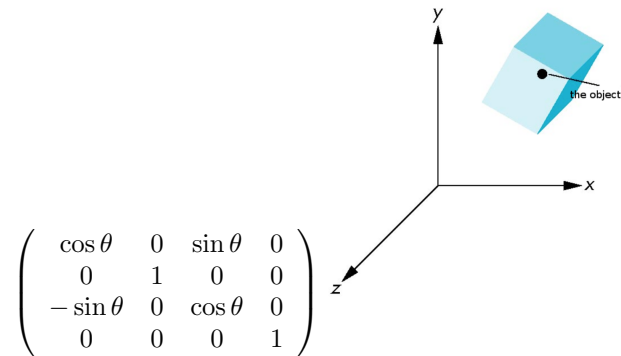
17. (T/F) The Phong reflectance model requires more computation than the Lambertian reflectance model.
18. (T/F) Gouraud shading requires more computation than Phong shading.
19. (T/F) You can sample a 3D-solid texture using 2 texture coordinates.
20. (T/F) The OpenGL graphics pipeline allows for multiple 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?
- The point is definitely inside the triangle.
  - The point is definitely outside the triangle.
  - The point is either inside or outside the triangle but there isn't enough information to tell.
  - Those are not valid barycentric coordinates.
  - The point lies on the edge of the triangle.
24. Which of the following statements about rotations are true?
- The vector component of the quaternion encodes the rotation axis.
  - Gimbal locks remove a degree of freedom of rotation.
  - Interpolation using Euler angles does not always yield geodesic (shortest) paths.
- I only
  - II only
  - I and III only
  - II and III only
  - I, II and III
25. Which of the following statements about rotations are true?
- Any rotation in 3D space can be described using an angle and an axis.
  - The inverse of a rotation matrix  $R$  is  $R^T$ .
  - This rotation matrix will rotate the object pictured about its center.



- II only
- I and II only
- I and III only
- II and III only
- 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 two 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

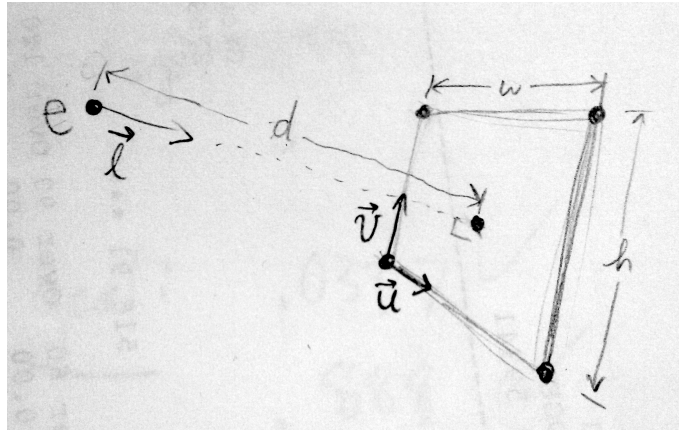
- (a) Give an implicit equation for a 2D circle of radius  $R$  centered at  $(x_0, y_0)$ .
- (b) Give a parametric equation for the same circle as in part (a), i.e. complete the following equations:

$$x(t) = ?$$

$$y(t) = ?$$

- (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  $\mathbf{e}$  and is looking in direction  $\mathbf{l}$  at an image of width  $w$  and height  $h$ , oriented perpendicular to  $\mathbf{l}$ . If image is  $d$  units along  $\mathbf{l}$ , and the width and height unit vectors are  $\mathbf{u}$  and  $\mathbf{v}$ , 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  $256 \times 256$  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.

