

CS 130
Exam I

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	
Multiple Choice		
11	4	
12	4	
13	4	
14	4	
15	4	
16	4	
17	4	
18	4	
19	4	
20	4	
Written		
21	15	
22	10	
23	15	
Total	100	

1 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) Rasterization may generate multiple fragments per pixel.
3. (T/F) Matrix multiplication is associative but not commutative.
4. (T/F) Perspective transformation is a linear transformation.
5. (T/F) Applying a perspective transformation in the graphics pipeline to a vertex involves dividing by its 'z' coordinate.
6. (T/F) Clipping geometry against the view volume can be done independently on each vertex, make the graphics pipeline extremely fast.
7. (T/F) The directional light source idealization is appropriate for a light that is very close to the scene.
8. (T/F) When using the Phong Reflectance Model, we calculate the red, green, and blue color channels independently.
9. (T/F) When using the Phong Reflectance Model with smooth shading for a triangulated surface, we will calculate the Phong Reflectance Model once per triangle.
10. (T/F) Modern day GPUs allow the user to supply custom vertex and pixel shaders.

2 Multiple Choice

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

11. Consider the use of homogeneous coordinates $(x, y, z, w)^T$ in the graphics pipeline.
 - I. $(x, y, z, w)^T$ can be used to represent either a 3D point or a 3D vector.
 - II. $w = 0$ for a 3D vector.
 - III. Nonzero values of w are used to effect translation and perspective transformation.
 - (a) I only
 - (b) I and II only
 - (c) II and III only
 - (d) I and III only
 - (e) I, II and III

12. Consider the OpenGL graphics pipeline. Which statements are true?

- I. Pipelining increases throughput and decreases latency.
- II. OpenGL sorts triangles to determine visibility.
- III. In modern OpenGL, the user may supply shaders which will execute on the GPU.

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

13. Which of the following are true?

- I. Backface culling refers to eliminating geometry with backfacing normals.
- II. The Painter's algorithm attempts to sort fragments and draw them back to front.
- III. Using z-buffering, shading calculations will be done for fragments that may never appear on screen.

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

14. Concerning flat, smooth, and Phong shading,

- I. in flat shading the shading calculation is done once per triangle, while in Phong shading the shading calculation is done once per fragment.
- II. flat shading does not require any normals.
- III. smooth shading requires interpolation of normals to vertices.

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

15. Match the type of transformation in the left column with the example transformation matrix in the right by drawing lines between the matching boxes.

translation

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

perspective

$$\begin{pmatrix} 5 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

nonuniform scale

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

identity

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

16. Perspective transformations

- I. are nonlinear transformations.
- II. preserve the z ordering of vertices between the near and far planes.
- III. can change the sign of the z coordinate for vertices behind the eye.

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

17. Consider the Midpoint algorithm given here:

```
(1)  y = y0
(2)  d = f(x0+1,y0+1/2)
(3)  for x = x0 to x1
(4)  do
(5)    draw(x,y)
(6)    if (d<0)
(7)    then
(8)      y = y+1
(9)      d = d+(y0-y1)+(x1-x0)
(10)   else
(11)     d = d+(y0-y1)
(12)   end
(13) end
```

Which statements are true?

- I. For a line with slope $m > 1$, we should change the outer loop in line (3) to be over y .
- II. Lines (9) and (11) update the decision variable d through an incremental evaluation of the line equation f .
- III. This algorithm fails if d is ever 0.

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

18. Which of the following statements about barycentric coordinates (α, β, γ) for triangles are true?

- I. If $s = \alpha + \beta + \gamma$, then $s < 1$ for points inside the triangle, $s > 1$ for points outside the triangle, and $s = 1$ for points on the triangle.
- II. At least one of α , β , and γ will be 0 for a point on the triangle.
- III. α , β , and γ can be used to interpolate vertex attributes across the face of the triangle.

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

19. Consider the 3D vectors, \mathbf{x} , \mathbf{y} , illustrated below, and dot product \cdot and cross product \times . Which statements are true?



- I. $\mathbf{x} \cdot \mathbf{y} > 0$.
 - II. $\mathbf{x} \times \mathbf{y} = 0$, because \mathbf{x} and \mathbf{y} lie in the same plane.
 - III. $\mathbf{x} \cdot \mathbf{x} = \mathbf{y} \cdot \mathbf{y}$.
- (a) I only
 - (b) II only
 - (c) I and II only
 - (d) I and III only
 - (e) None
20. Consider the following equation from the Lambertian reflectance model, where R_a , R_d , L_a , and L_d are the ambient and diffuse reflectance of the object, and the ambient and diffuse components of the light, respectively, \mathbf{l} is the light vector, and \mathbf{n} is the object normal vector.

$$I = R_a L_a + R_d L_d \max(0, \mathbf{l} \cdot \mathbf{n})$$

- I. Polygons facing away from the light will necessarily have $I = 0$.
 - II. This formula can capture specular highlights.
 - III. Generally \mathbf{n} will vary over the surface of the object but \mathbf{l} will be constant.
- (a) I only
 - (b) II only
 - (c) I and II only
 - (d) I and III only
 - (e) None

3 Written Response

21. Consider a line in the plane going through the points $(1, 2)$ and $(2, 4)$.
- (a) Write down the explicit equation for the line, with x the independent variable and $y = f(x)$ the dependent variable.
 - (b) Write down an implicit equation for the line. Identify a normal to the line.
 - (c) Write down a parametric equation for the line *segment* going through the two points, in terms of a single parameter $t \in [0, 1]$.

22. Come up with a series of matrices as well as an order of multiplication (you don't need to actually perform the multiplication) to transform the triangle $(0,0)$, $(1,0)$, $(0,3)$ to $(-1,0)$, $(-3,0)$, $(-1,-6)$. Sketch the triangle at every step of the transformation.

23. Consider a ray with endpoint \mathbf{a} and a normalized direction \mathbf{u} ,

$$\mathbf{p}(t) = \mathbf{a} + t\mathbf{u}, \quad t \geq 0, \quad (1)$$

and a sphere of radius r , centered at the origin. The implicit equation for the sphere is given as follows:

$$f(\mathbf{p}) = \mathbf{p} \cdot \mathbf{p} - r^2 = 0 \quad (2)$$

- (a) Describe geometrically the ways in which the ray can intersect/not intersect with the sphere. I.e., when is there exactly one intersection, when are there two intersections, and when are there no intersections?
- (b) Find an expression for t where the intersection occurs by plugging eq. (1) into eq. (2) and solving for t . How can this expression be used to distinguish the three cases described in part (a)?
Hint (Quadratic formula): Solutions to $ax^2 + bx + c = 0$ are $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
- (c) Write pseudocode for an algorithm for finding the intersection points or identifying that there is no intersection.

