CS 130
Practice Midterm

Winter 2018

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	
Multiple Choice		
9	4	
10	4	
11	4	
12	4	
13	4	
14	4	
15	4	
16	4	
Written		
21	8	
22	10	
23	10	
Total	76	

1 True/False

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

1. (T/F) The direction of a ray transmitted through a dielectric material can be computed using Snell's law.
2. (T/F) The initial ray cast in a ray tracing algorithm is the view ray, which goes from the eye in the direction of the pixel.
3. (T/F) Mipmapping involves generating and utilizing a hierarchy of textures to mitigate minification artifacts.
4. (T/F) The directional light source idealization is appropriate for a light that is very close to the scene.
5. (T/F) When using the Phong Reflectance Model, we calculate the red, green, and blue color channels independently.
6. (T/F) Modern day GPUs allow the user to supply custom vertex and pixel shaders.
7. (T/F) The OpenGL pipeline is primarily designed to implement global illumination.
8. (T/F) OpenGL supports z-buffering.

2 Multiple Choice

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

9. Which of the following statements regarding ray tracing are true?

   I. Using a regular pixel grid can alleviate aliasing artifacts.

   II. Depth of field can be implemented by perturbing the starting point of view rays.

   III. A bounding volume hierarchy can be used to accelerate ray tracing.

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

10. In ray tracing,

   (a) flat shading uses diffuse lighting to determine the color of an object.
   (b) point light sources lead to softer shadows than area light sources.
   (c) testing for ray-sphere intersection requires solving a quadratic equation.
   (d) reflected rays originate at an intersection point, and bounce in the negative direction of the incident ray.
   (e) rays may reflect up to a maximum of two times.

11. 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

12. 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

13. 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

14. 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

15. 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

16. Textures

(a) may be 2D images or 3D solid textures.

(b) can also be used to implement light maps, shadow maps, environment maps, and bump maps.

(c) can appear distored if perspective correct interpolation is not employed.

(d) all of the above

(e) none of the above

3 Written Response

17. 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 $t \in [0, 1]$.

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

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

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

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

(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 to 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 is no intersection.

19. Consider a ray with endpoint $\mathbf{e}$ and direction $\mathbf{d}$, given by the ray equation

$$\mathbf{p}(t) = \mathbf{e} + t\mathbf{d},$$

and a triangle with vertices $\mathbf{a}, \mathbf{b}, \mathbf{c}$.

(a) Find an implicit equation for the plane containing the triangle, of the form

$$f(\mathbf{p}) = \mathbf{N} \cdot (\mathbf{p} - \mathbf{q}) = 0$$

where $\mathbf{N}$ is a normal to the plane and $\mathbf{q}$ is a point in the plane. Specify $\mathbf{N}$ and $\mathbf{q}$ in terms of the triangle vertices.

(b) Find the intersection point of the ray with the plane, if any, or specify how to determine that there is no intersection point.

(c) How would you determine whether the ray intersects the original triangle or not? You do not need to give all the mathematical details, but simply outline in words a procedure.