Student ID _____

Fall 2017
CAP 5705 Computer Graphics
Exam I

Instructions:

1. Write your name and UF ID on the cover of the blue exam booklet provided. Write your UF ID on each page of your exam in the space provided.
2. The exam is exactly 50 minutes long.
3. **Answer all 3 questions.**
4. Write your answers in the blue exam booklet provided. Additional booklets are available if necessary. Clearly indicate which questions you are answering on the answer sheets in the exam booklet.
5. Raise your hand if you have a question. **Do not get out of your seat for any reason** unless you have permission.
6. At the end of the 50 minutes, the proctor will announce that the exam is over. At that time, **stop writing**, otherwise, your exam will not be accepted. Turn back to the front page, make sure all of your answer sheets are labeled and included in your exam.
7. You are permitted one $8\frac{1}{2} \times 11$ sheet of paper with notes on both sides.
8. Calculators are permitted but they are not necessary to complete the exam. No other wireless devices or devices with image-based memory are permitted.

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1. **Triangle Meshes (12 pts)**

   UF hired a local graphics company to create a geometric model of Griffin Stadium. The application will transmit a high resolution mesh of *The Swamp* (as the stadium is popularly known) composed of millions of triangles from a server to remote clients across the globe to promote the University's athletic program. Due to budget constraints, texture mapping will not be incorporated.

   (a) The primary concerns for UF are memory storage, lag time loading data into RAM and limited bandwidth.

      i. Describe a mesh data structure that will manage mesh information given these constraints. Explain how the mesh data is stored and accessed?

      ii. List two other mesh data structures and explain why your choice is better than these options for this scenario?

   (b) When the marketing team decides to use the model for interactive walkthroughs, users complain that there is significant buffering and lag time (even though the model has no textures).

      i. What feature could be added to permit faster streaming and more interactive walkthroughs? How does it work?

      ii. Would you implement this feature on the client or server?

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2. **Shading and Lighting (35 pts)**

The ray tracing algorithm is used to create photorealistic images.

(a) Ray tracers often incorporate barycentric coordinates.

i. Define the term *barycentric coordinates*?

ii. Draw a diagram to further illustrate your definition.

iii. How are barycentric coordinates used for image synthesis in ray tracing?

iv. List three advantages of using a barycentric coordinate representation.

(b) Shading is the final stage of the ray tracing process. Name AND associate each lighting equation **1-3** with the rendering effect **i-iv** that it produces best.

$$I = \alpha\,(N \cdot L) \tag{1}$$

$$L_o = L_i(k_d(L \cdot N) + k_s(R \cdot V)^n) \tag{2}$$

$$R(\theta) = R_0 + (1 - R_0)(1 - \cos\theta)^5 \tag{3}$$

i. A piece of dull white chalk.

ii. View dependent specular highlights on a red billiard ball.

iii. A dielectric like a transparent glass pane with a slight green hue.

iv. A ball with a matt surface and no specular highlights.

(c) Explain each term in equation 2.

(d) A ray tracer produced the bugs and artifacts listed below after shading with equation 2. For each case, (1) explain the cause of the artifact or bug, (2) modify equation 2 to correct the problem and (3) explain why the modification works. *Note:* You may add and/or remove terms. Define any terms you add.

i. Solid black shadows make the image appear less realistic.

ii. Brightly lit, non-shadowed object regions appear black.

iii. Shadows have sharp edges rather than smooth, soft ones.

iv. For configurations like Figure 1, equation 2 fails, producing invalid results.

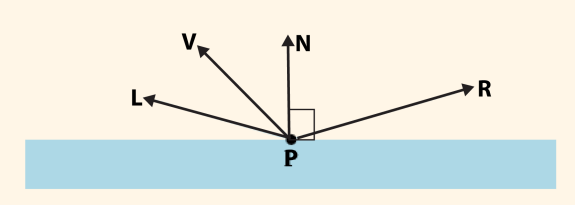

Figure 1: Scene: Rendering point **p** on a surface.

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3. **Texture Mapping (16 pts)**

Texture mapping functions map 3-D surface points to 2-D image coordinates. The computed coordinates are used for texture lookup. Matrix transformations then project 3-D points with associated texture information to 2-D screen space.

(a) In order to produce believable results, texture mapping functions must satisfy four properties.

i. List the four properties.

ii. Examine the image in Figure 2 of a checker board pattern textured onto a mesh model of a bunny. The same texture mapping function ϕ is used in both results but with varying parameters. State whether ϕ satisfies each property listed. Explain your answer using examples from Figure 2.

Figure 2: Texture mapping a checkerboard pattern onto a mesh model.

(b) The traditional texture mapping process may be difficult to implement for 3-D detailed shapes.

i. Name a simplified method that approximates a textured model for a complex detailed 3-D object.

ii. Describe the process. Include the category of texture mapping function, state what is being projected and include all coordinate spaces.