Student ID ______________________________

Fall 2015
CAP 5705 Computer Graphics
Exam I

Instructions:

1. Write your name and UF ID on each answer sheet.
2. The exam is exactly 50 minutes long.
3. **Answer all 3 questions.**
4. Write your answers in the space provided. Additional answer sheets are available if necessary. Clearly indicate which questions you are answering on the answer sheets.
5. Use a pen as your answers will be copied and copies must be legible.
6. Raise your hand if you have a question. **Do not get out of your seat for any reason** unless you have permission.
7. At the end of the 50 minutes, the proctor will announce that the exam is over. At that time, **stop writing**, turn back to the front page, make sure all of your answer sheets are labeled and included in your exam. Wait for the proctor to come and pick up your exam. Do not leave until everyone has turned in their exam.
8. You must stop working immediately when you are asked. Otherwise, your exam will not be accepted.
9. You may not leave the exam room until the end of the exam unless it is a medical emergency or you need to use the restroom.
10. Proctors will not answer technical questions. Please do the best you can with the information provided on the question sheet.
11. You are permitted one $8\frac{1}{2} \times 11$ sheet of paper with notes on both sides.
12. 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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Shading and Lighting (25 pts)

Shading models simulate the complex interaction of light with materials.

1. For each light interaction, draw a simple diagram that shows what happens when a ray of light hits a surface. Show the relationship between incoming and outgoing light directions (where applicable).
   (a) Mirror reflectance
   (b) Sub-surface scattering
   (c) Absorption
   (d) Diffraction
   (e) Refraction
2. Gouraud shading is an early form of flat shading. Explain how Gouraud shading is implemented.
3. Name and associate each lighting equation **1-3** with the rendering effect **a-c** that it produces best.

$$L_o = L_i(k_d(L \cdot N) + k_s(R \cdot V)^n) \tag{1}$$

$$R(\theta) = R_0 + (1 - R_0)(1 - \cos\theta)^5 \tag{2}$$

$$I = \alpha\,(\hat{n} \cdot l) \tag{3}$$

   (a) A matte object without specular highlights.
   (b) A rendering of a lake showing the light reflection and refraction as it travels from air to the water surface.
   (c) View dependent specular highlights on the surface of a bowl.

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Triangle Meshes (35 pts)

Efficient mesh data structures are crucial to the performance of many graphics programs.

1. An online program, *RemoteMeshEdit*, transmits high resolution meshes (composed of thousands of triangles) across a network to a remote user who edits them via a web-based interface before saving them back to the original server. Triangle tessellation is adaptively decreased to allow interactive viewing. Server disk space and network bandwidth is limited.

   (a) Describe a data structure that will manage mesh information efficiently for this application. How is the mesh data stored and accessed? Why is your choice better than other mesh data structures for this scenario?

2. Many mesh applications only work on meshes with specific topology restrictions.

   (a) When loading some meshes, *RemoteMeshEdit* crashes, or is thrown into an infinite loop. What restriction should be placed on mesh topology to prevent this?

   (b) A few of the mesh triangles look black while others are the correct color. What mesh property should be restricted in this case?

3. Mesh data structures store more than vertex positions and connectivity information.

   (a) Give examples of other triangle attributes and explain where they are stored.

   (b) What mathematical process is used to apply these attributes smoothly across the surface of the triangle?

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Graphics Pipeline (40 pts)

1. The graphics pipeline is the sequence of operations required to convert 3-D object points to pixels in a 2-D image.
   (a) Sketch a diagram of the graphics pipeline.
   (b) During which stage in the pipeline would you apply the *mid-point* algorithm to remove aliasing artifacts?
2. Transformation matrices convert vertices from one coordinate system to another.
   (a) How are homogeneous coordinates used in perspective projection?
   (b) The perspective transformation matrix can be written as:

$$\begin{bmatrix} n & 0 & 0 & 0 \\ 0 & n & 0 & 0 \\ 0 & 0 & n+f & -fn \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

where n and f are the near and far planes of a perspective camera. Use matrices to describe the perspective transformation chain that converts the 3-D object point:

$$\begin{bmatrix} x_o \\ y_o \\ z_o \end{bmatrix}$$

to 2-D screen coordinates:

$$\begin{bmatrix} x_s \\ y_s \\ z_s \end{bmatrix}$$