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Student Name:

Student ID:

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**Instructions: Read them carefully!**

*The exam begins at 5:10pm and ends at 8:00pm. You must turn your exam in when time is announced or risk not having it accepted.*

*Make sure you fill in your name and the above information, and that you sign below. Anonymous tests will not be graded.*

**Write legibly.** *If the person grading the test cannot read something, he/she will simply assume that you meant the illegible portion as a note to yourself and they will ignore it. If you lose points because part of your answer could not be read, you will not be given the opportunity to explain what it says.*

*You may use two pages of notes while taking the exam. You may not ask questions of other students, look at another student's exam, use a textbook, use a phone or calculator, or seek any other form of assistance. In summary: do not cheat. Persons caught cheating will be subject to disciplinary action.*

**Do not ask questions during the exam.** *Most questions are unnecessary and they disturb other students. Figuring out what the exam question is asking is part of the test. If you think you have to make some unusual assumption to answer a problem, note what that assumption is on the test.*

*The answers to most questions should be short. If you find yourself writing an excessively long response, you may want to think more carefully about the question.*

***I have read these instructions, I understand them, and I will follow them.***

Your Signature: \_\_\_\_\_

Total Points: \_\_\_\_\_ You Scored: \_\_\_\_\_

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1. Answer the following questions with True (T) or False (F)

1 point each

- \_\_\_\_\_ Progressive radiosity was developed at UC Berkeley and the name is a joke referring to local politics.
  - \_\_\_\_\_ The photon-mapping method cannot produce images with caustic reflections.
  - \_\_\_\_\_ Solid angle is the ratio of area to area of the unit sphere and it is measured in radians-squared.
  - \_\_\_\_\_ Light fields are large arrays of lights used with optical motion capture.
  - \_\_\_\_\_ In the absence of external effects, the angular velocity of a rotating sphere is preserved.
  - \_\_\_\_\_ Although they are interesting, particles systems have few practical uses.
  - \_\_\_\_\_ Euler integration is only stable for time steps of 0.01 seconds or less.
  - \_\_\_\_\_ It is not possible to reuse or combine recorded motion capture data.
  - \_\_\_\_\_ Feet sliding on the ground is a common problem for motion capture data, but it is very hard to notice so in practice people ignore the problem.
  - \_\_\_\_\_ In a kinematic skeleton, every body must have exactly one inboard and outboard joint.
  - \_\_\_\_\_ Given a kinematic skeleton, there will always be some finite number of solutions for a given IK problem.
  - \_\_\_\_\_ Moving least squares uses swept cubes, not squares, to define complex shapes.
  - \_\_\_\_\_ Using implicit functions for "morphing" shapes is convenient because it becomes easy to handle topological changes.
  - \_\_\_\_\_ Splines are modeled on thin strips of wood, metal, or plastic that were once commonly used by draftsmen.
  - \_\_\_\_\_ If a curve is  $G^1$  continuous then its parameterization must be  $C^1$ .
  - \_\_\_\_\_ Modern LCD displays have a dynamic range approximately equal that of the human eye.
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- \_\_\_\_\_ All linear transformations can be decomposed into a series of "primitive" transformations.
  - \_\_\_\_\_ The axis-angle representation of rotations, also called exponential maps, encode rotations as points inside a ball of  $4\pi$  radius.
  - \_\_\_\_\_ A rotation matrix always has determinant of +1.
  - \_\_\_\_\_ The near and far clipping planes serve no use other than a slight speed up from not drawing some objects.
  - \_\_\_\_\_ The sky is blue because water vapor scatters blue light.
  - \_\_\_\_\_ Any set of non-intersecting polygons can be sorted in front-to-back order.
  - \_\_\_\_\_ The cones in the human eye are each sensitive to a part of the visual spectrum that does not overlap with the region that the rods are sensitive to.
  - \_\_\_\_\_ Shining an ultraviolet light on scorpions induces a chemical response that causes them to glow green and become paralyzed, thus making them easy to find and safe to handle.
  - \_\_\_\_\_ Mach-banding effects will often occur when rendering adjacent regions of constant color that are slightly different.
  - \_\_\_\_\_ An image of a daytime scene can be made to look as if it were a nighttime scene by multiplying the blue channel values by 0.925.
  - \_\_\_\_\_ NURBS stands for Non-Uniform Rational B-Spline.
  - \_\_\_\_\_ The number of rays used to ray trace a scene will typically be exponential in the bounce depth.
  - \_\_\_\_\_ Computing motion blurred images of fast-moving objects is typically quite expensive.
  - \_\_\_\_\_ Ambient occlusion tends to smooth out the appearance of surface detail.
  - \_\_\_\_\_ Pasteurized coordinates facilitate representing perspective and translation using matrices.
  - \_\_\_\_\_ Overly large time-steps can cause a spring and mass simulation to go unstable.
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2. You are making a dress but need more fabric. You take a sample of your fabric to the store and find one that looks exactly the same color when held next to your sample. However when you get home you find that somehow the fabric you just bought no longer matches your sample. What is the most likely explanation for what has happened. *5 points*

3. Imagine that you have a CMYK printer where the cyan and magenta inks have been swapped. When one attempts to print the following colors, what colors will actually appear on the paper? *5 points*

Red \_\_\_\_\_

Green \_\_\_\_\_

Blue \_\_\_\_\_

Cyan \_\_\_\_\_

Magenta \_\_\_\_\_

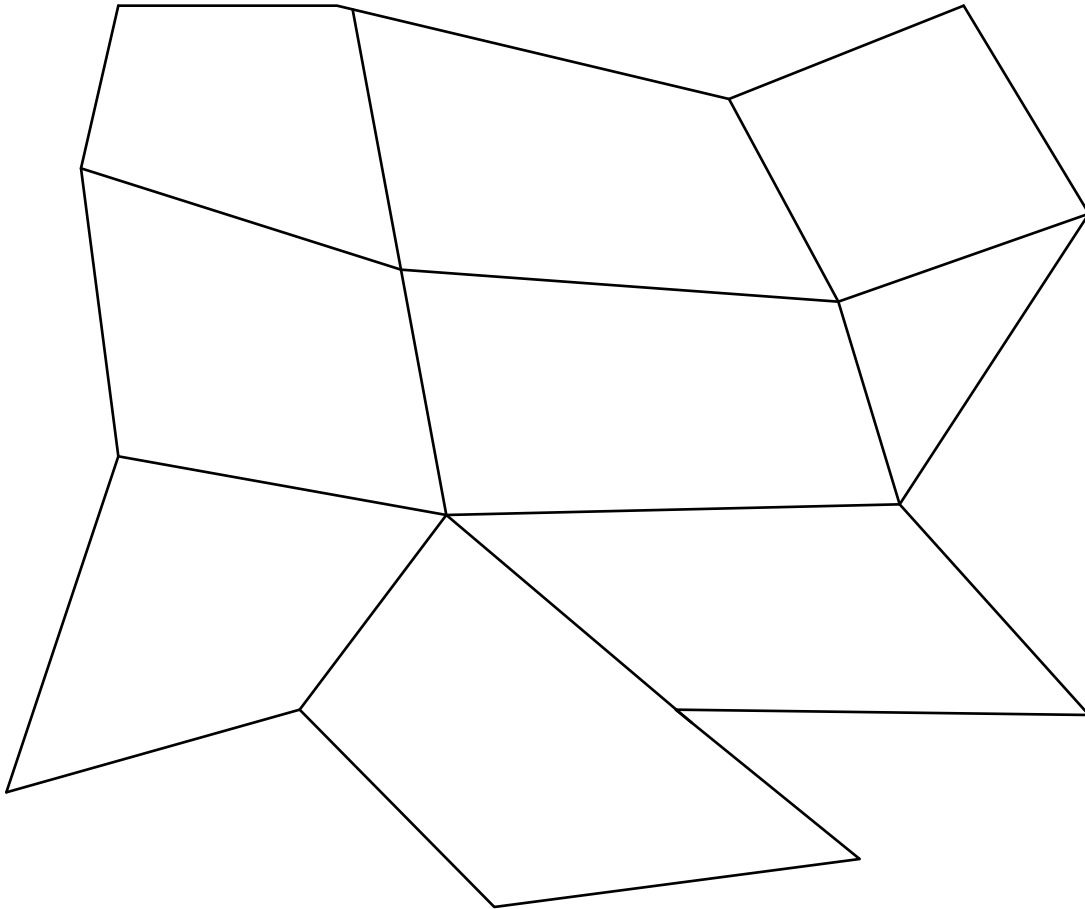
Yellow \_\_\_\_\_

Black \_\_\_\_\_

White \_\_\_\_\_

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4. Here is a piece of mesh. Draw the result of applying one iteration of Catmull-Clark subdivision. Then circle all vertices (both original and the new ones you added) that are extraordinary. *Note: I am only interested in the topology of your answer.* *7 points*



5. Name a phenomenon that can be modeled easily using photon mapping but that cannot be modeled with a standard ray-tracing program. Give an example. *3 points*
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6. Below are two 4x4 homogenized transformation matrices. What does the first one do? How does the effect produced by the second one differ from that produced by the first? *3 points*

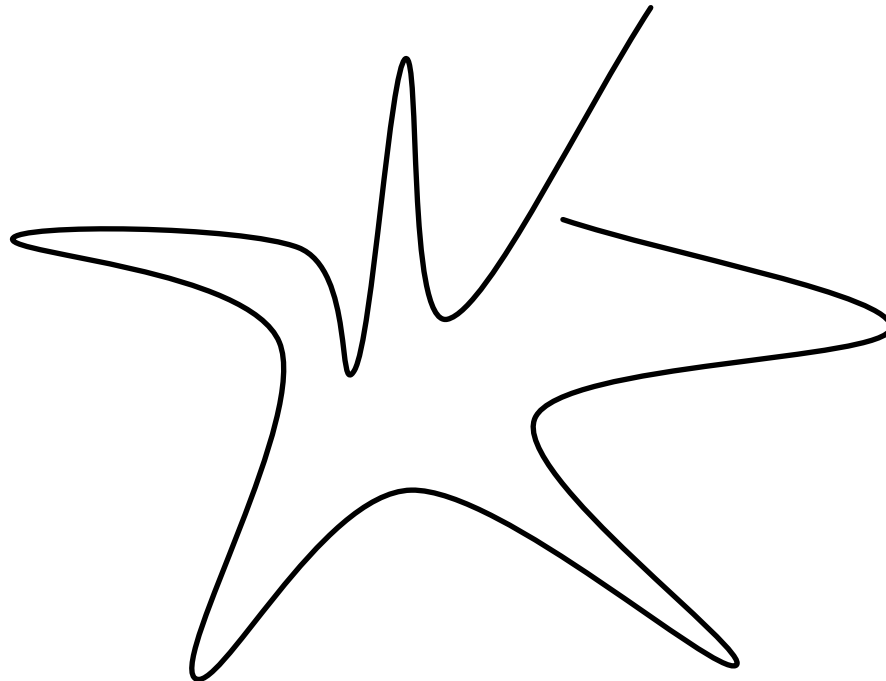
$$\begin{bmatrix} 6 & 0 & 0 & 0 \\ 0 & 6 & 0 & 0 \\ 0 & 0 & 6 & 0 \\ 0 & 0 & 0 & 2 \end{bmatrix} \qquad \begin{bmatrix} 3 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 6 \end{bmatrix}$$

The first one will: \_\_\_\_\_

The second one will: \_\_\_\_\_

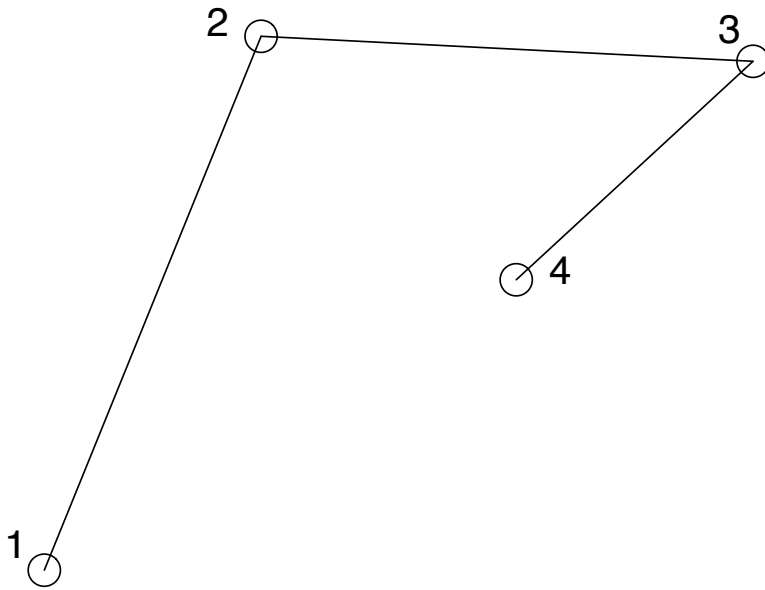
7. You have a parametric surface defined by some function,  $f(x)$ . Write out the form of an equation that you would use to compute the surface normal at some point. *4 points*

8. Draw the convex hull of the curve shown below. *2 points*



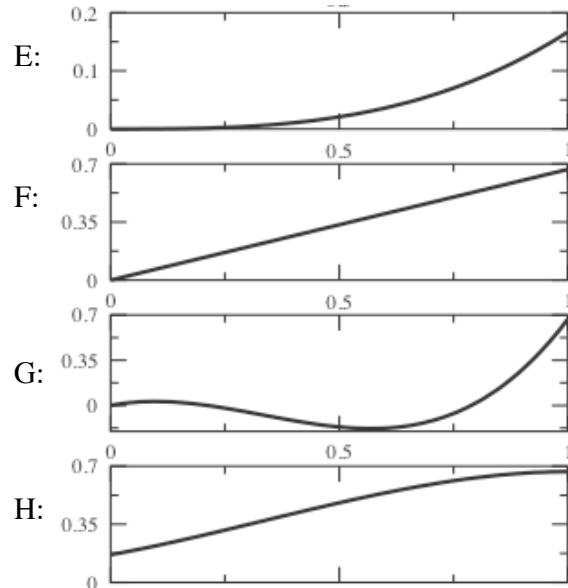
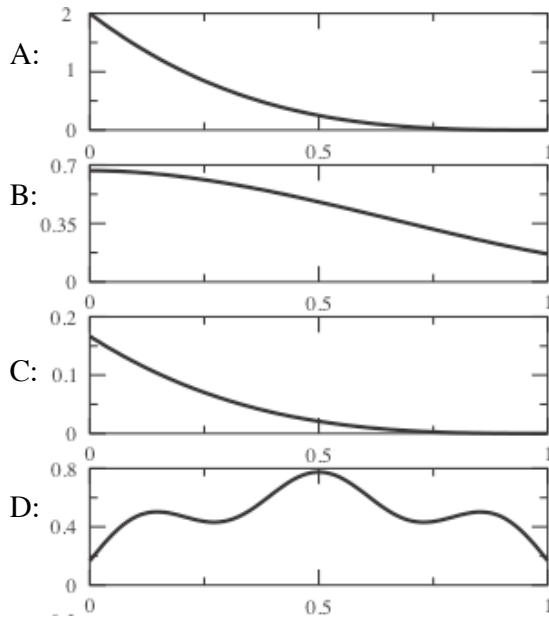
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9. The diagram below is the control polygon for a Bezier curve segment. Draw the control polygon for a second segment that connects to the first at vertex #4 with  $G^1$  continuity. Draw both segments of the resulting curve. *Make sure your drawing is geometrically reasonable and shows correct curve tangents for the the beginning, middle, and end of each segment.* 8 points



10. Given a 3x3 matrix that encodes a 3D transformation, how does singular value decomposition separate the matrix into scale and rotation components? 4 points

11. There are 8 functions plotted below. Neatly cross out the ones that are not part of the cubic B-spline basis set. Number the remaining functions to show the order that they go together to form the B-spline “hump” function. 6 points



For those that are NOT B-spline basis functions write a single short sentence that explains why they could not be. Your reason should be simple. Note: “It isn’t what I have in my notes,” “it won’t fit,” “it doesn’t solve the equations,” or other generic answers will not be accepted. 4 points

Letter	Reason
_____	_____
_____	_____
_____	_____
_____	_____



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12. You are working on the shader for computer animated character that is supposed to look as realistic as possible. Unfortunately, the results look more like a figure made out of painted plaster than a real human. What is likely the problem with your skin shader? *4 points*

13. When rendering a scene with a radiosity method, what part of the solution must be recomputed when the viewer moves? *3 points*

14. The two images below show two 12 point versions of the letter "A" that have been significantly enlarged. Concisely explain the most likely difference between the two fonts used in the images. *2 points*



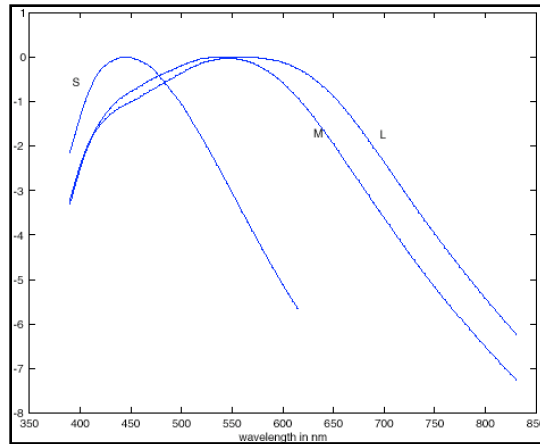
15. Briefly describe how one computes ambient occlusion values for an object. *Be clear and concise as long rambling answers will lose points.* *4 points*

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16. The following equation describes how the radiosity at patch  $P_i$  is a function of the radiosity of other patches. Circle the part(s) that are responsible for taking into account the apparent area of the other patches when viewed from  $P_i$ . 5 points

$$H_i = E_i + \rho_i \sum_j H_j \int_{S_j} \delta_{ij} \frac{\cos(\theta_i) \cos(\theta_j)}{2\pi \|\mathbf{c}_i - \mathbf{x}\|^2} d\mathbf{x}$$

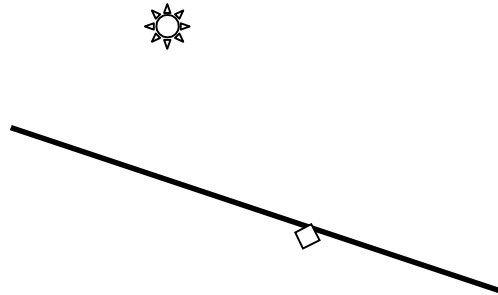
17. The following are the response curves for the cones in the human eye. Which type of cone is most sensitive to blue light? 1 point



18. Give two examples of phenomena that require a global illumination model for them to be rendered properly. 4 points

19. A friend of yours tells you that they have a method for computing an analytical inverse to any kinematics equation. Give two succinct reasons why this claim is very unlikely to be true. (Claiming you have no smart friends is not a valid answer.) 5 points

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20. Consider the diagram below. A location has been marked on the surface. Indicate a viewer position such that a viewer looking at the surface from that position would see a specular highlight on the surface at the marked location. *3 points*



21. Given a rotation matrix, how would you determine its axis of rotation? *3 points*