CS 184: FOUNDATIONS OF COMPUTER GRAPHICS

FALL 2005

PROF. JAMES O'BRIEN

FINAL EXAM

Your Name: _____   Your Class Computer Account: cs184-_____

Room: _____   Your Student ID#: _____

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. 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.

Total Points: 116 You Scored: _____   Extra Credit Points: 10 You Scored: _____

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

Your Signature: _____

1. **Answer the following with true (T) or False(F)**   *1 point each*

_____ G^1 continuity does not always imply C^1.

_____   The Bezier basis functions are affine invariant.

_____   The Hermite basis functions have local support.

_____   Cubic spline surfaces can be ray-traced without first polygonizing them.

_____   Key frame animation becomes trivially easy when inverse kinematics are used.

_____   Animation of human characters rarely done using motion capture.

_____   Generating high-quality animations requires either Arwen sampling or Aragorn filtering to remove motion blur.

_____   Advanced methods for rendering arbitrary images in constant time exist, but we did not cover them in class.

_____   The fully implicit version of Euler's method (a.k.a. backwards Euler) is unconditionally stable.

_____   The singular values of a rotation matrix are the amounts of rotation abut the X,Y, and Z axes.

_____   The human eye is uniformly sensitive to all frequencies of visible light.

_____   Perspective transformations distort straight lines into circles.

_____   Radiosity methods are optimized for rendering scenes with diffuse surfaces.

_____   Final gathering can be used with both photon mapping and radiosity.

_____   Some motion capture systems use magnetic fields to determine the location and orientation of tracker objects.

_____   Cubic B-Splines can be exactly converted to quartic B-splines.

1. **Answer the following with true (T) or False(F)**   *1 point each*
   [Continued]

_____   When applying transformations to a 3D scene, the transformation applied to normal vectors should have any translation part doubled.

_____   Most useful cubic basis functions have both the interpolation and convex hull properties.

_____   The human eye has three types of light receptor.

_____   Pixel-based image representations have infinite resolution.

_____   A good scan-conversion algorithm has the property that when given a set of non-overlapping polygons, every pixel "belongs" to at most one single polygon.

_____   Non-zero winding number and parity testing will produce the same result for a polygon with non-self-intersecting boundary.

_____   A series of transformations which are all 3D rotations can be permuted and the result will not change.

_____   Bump-mapping will not change an object's silhouette.

_____   Tensor-product surfaces are built by letting the control points of a curve vary according to some other curves.

_____   Catmull-Clark subdivision only works on regular meshes.

_____   Cubic polynomial basis functions can be used to build interesting C^5 curves.

_____   Particle systems simulate objects such as waterfalls by modeling the interactions between individual molecules.

_____   Particles can be used to render smoke.

_____   Motion graphs are plots showing where joints are located in a figure.

_____   The result of applying subdivision to a cubic curve is two quadratic curves.

_____   Raytracing can be accelerated using BSP-Trees or K-D Trees.

2. **Imagine that you have an RGB monitor where the red and blue phospors have been swapped. When one attempts to display the following, what color will actually appear on the display?** *4 points*

Red   _____

Green   _____

Blue   _____
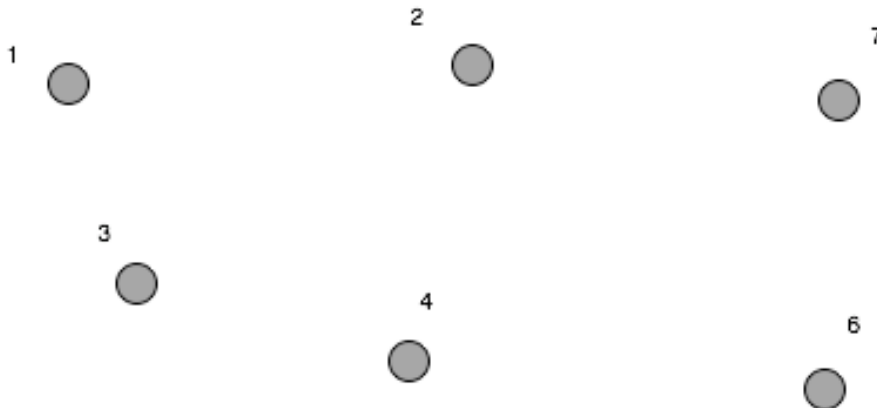
Yellow   _____

Cyan   _____

Magenta   _____

Black   _____

White   _____

3. **The diagram below shows control points for a curve made by joining two cubic Bezier segments. However control point #5 has been removed. Indicate location(s) where #5 may be placed to achieve C^1 continuity and where it may be placed to achieve G^1 continuity. *Clearly label your diagram.*** *5 points*

4. **Give two examples of specific phenomena that cannot be computed with a local illumination method. For each, name an algorithm that could compute the phenomena.** *4 points*

5. **When computing the Boolean intersection of two arbitrarily oriented squares (in 2D), what is the minimum and maximum number of sides that the resulting shape can have? Draw an example of the minimum and maximum shapes.** *3 points*

6. **Concisely state how you should interpolate between two 3D transformation matrices.** *4 points*

7. **When rendering a scene with a ray-tracing method, what part of the solution must be recomputed when the viewer moves?** *2 points*

8. **In the context of doing inverse kinematics problems, when is the Jacobian singular? Draw an example using a two-link arm whose links are connected by a rotation joint and whose root link is attached to ground with a rotation joint.** *Make sure your diagram is clear. Use an X to indicate the goal point.* *4 points*
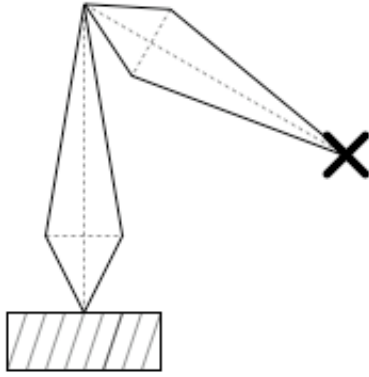
Example figure

9. **Concisely describe what "foot skate" is and why it is a problem.** *2 points*

10. **On the spring diagram below, draw the springs that should be added for the structure to resist shear.** *3 points*
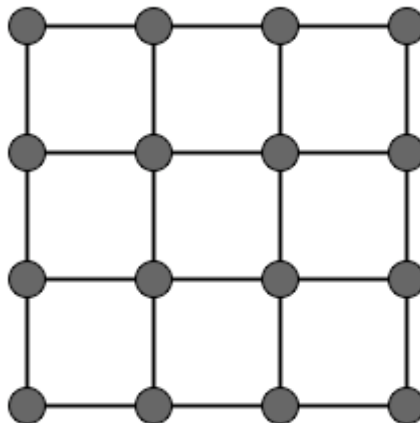
11. **What limits the size of the capture region that can be used with a magnetic motion capture system?** *3 points*

12. **Would the differences between Phong interpolation (interpolating normals) and Gouraud interpolation (interpolating colors) be more noticeable on a very fine of very coarse mesh? Why?** *4 points*

13. **Bob makes a movie and compresses it. Later, he decides to make a change. He decompresses the movie, edits it, and re-compresses it with the exact same codec using the exact same parameters as he used the first time. The re-encoded movie looks terrible. Explain why.** *3 points*

14. **Circle the plot showing the Hermite basis functions.** *Hint: The other is Bezier.* *2 points*
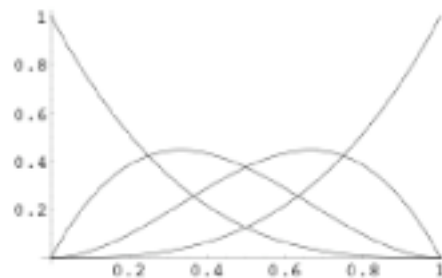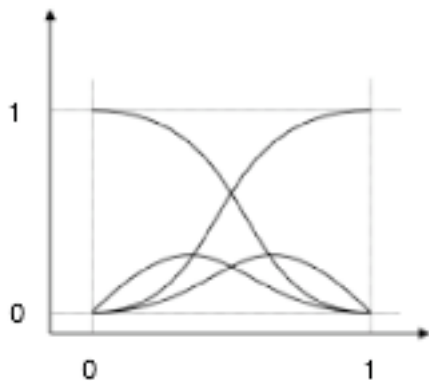
15. **These are the control points of a Bezier curve. Draw a convex hull for the curve. Show how DeCasteljau's method can be used to evaluate the curve at t=0.25 (assuming the segment is parameterized 0..1). Label the figure clearly. Make sure the curve is geometrically correct.** *5 points*

16. **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. Also note: you don't need to split the dotted edges.* *5 points*
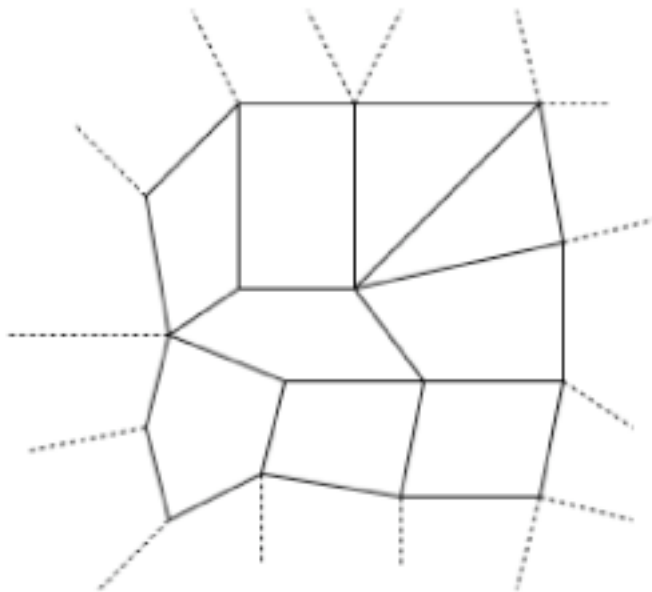
17. **I wish to ray-trace a scene containing a complex space station. The image will be 1000x1000, each pixel with be supper sampled on a 10x10 jittered grid. I have two point light sources in the scene (two distant suns). Each bounce will use 10 rays to sample diffuse reflections. I will include shadows. What is the minimum number of rays I will have to trace? Explain why.** *3 points*

18. **Do you think it would be possible to come up with a non-iterative inverse kinematics algorithm? Justify your answer.** *3 points*

19. **I define a 2D curve with $c(u) = \sum_i p_i b(u)$. I then plot the p_i as points in the plane and claim that the portion of my curve defined by $u \in [0 \cdots 1]$ will always be inside the bounding box of the points no mater what values I have chosen for the p_i. How could you verify that this claim was true/untrue.** *3 points*

20. **Explain the relation between The Rendering Equation and the ray-tracing algorithm.** *4 points*

21. **I ray-trace a scene containing a colorless glass slab a green table all inside a closed blue room. Every inch of the room is well lit by white light. I then notice that some of the pixel values in the resulting image are black. Do you think my code must have a bug in it? If so, why? If not, tell me what do you think is responsible for the black pixels.** *4 points*

22. **Below are two 4x4 homogenized transformation matrices. How does the effect produced by the first one differ from that produced by the second?** *4 points*
   *(Note: Long rambling answers will not score as well as short concise ones!)*

$$\begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 4 \\ 0 & 0 & 1 & 6 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad \begin{bmatrix} 2 & 0 & 0 & 2 \\ 0 & 2 & 0 & 4 \\ 0 & 0 & 2 & 6 \\ 0 & 0 & 0 & 2 \end{bmatrix}$$

23. **In the diagram below of a light source, a clear glass ball, and a diffuse surface, draw lines illustrating the path traveled by light to form a refraction caustic on the surface.** *4 points*
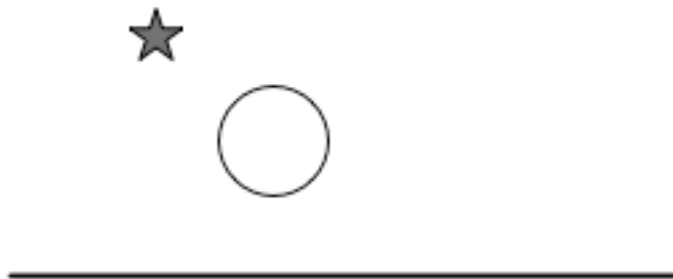
24. **There are 8 functions plotted below. Neatly cross out the ones that are not part of the cubic B-spline basis set. Number the remaining functions to show the order that they go together to form the B-spline "hump" function.** *6 points*

A:

B:

C:

D:

E:

F:

G:

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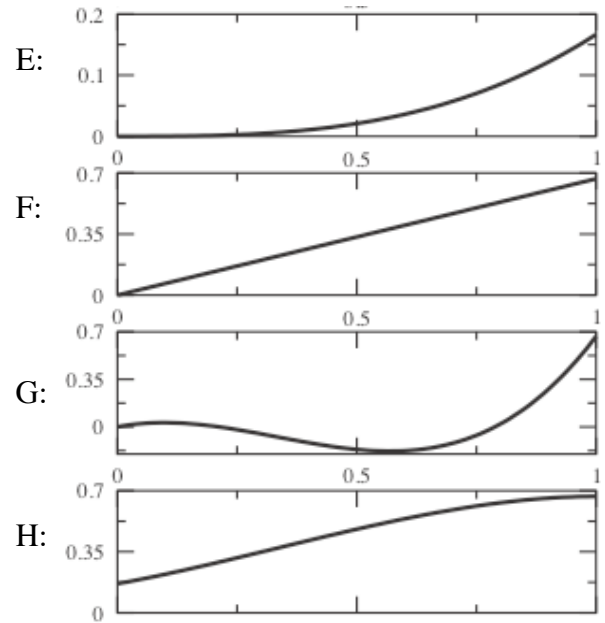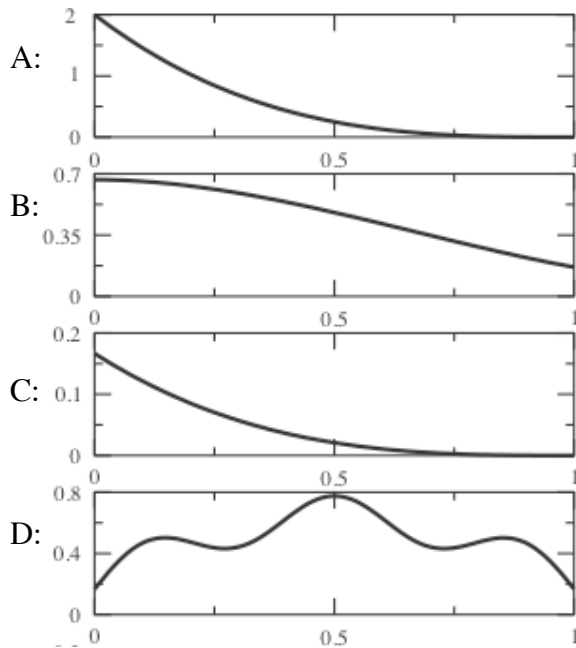
For those that are NOT B-spline basis functions write a single short sentence that explains why they could not be. Your reason should be simple. Note: "It isn't what I have in my notes," "it won't fit," "it doesn't solve the equations," or other generic answers will not be accepted. *4 points*

Letter   **Reason**

_____   _____

_____   _____

_____   _____

_____   _____

You have been asked to create an animation showing a group of sentient rats raiding a refrigerator. Discuss how you might make such an animation. Mention what algorithms we discussed in this class could be potentially useful and how you might use them. *Please note that I have a short attention span and I'd rather go skiing that grade exams. So short clear answers are better than long rambling ones!*   *10 extra points max*

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This portion of the test should only be completed <u>after</u> you have finished the rest of the exam. If you wish, you may remove this sheet and later submit it anonymously by sliding it under Prof. O'Brien's office door.

Did you enjoy this class?

Do you have any suggestions for future offerings of the course?

Do you have any comments specifically about Prof. O'Brien?

Do you have any comments specifically about either the TA or the grader?