Final Exam

CS 184: Foundations of Computer Graphics
Fall 2008
Prof. James O'Brien

Student Name: **Class Account Username:**

Instructions: ***Read them carefully!***

The exam begins at 5:10pm and ends at 7:00pm. 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.*

***Be clear and concise**. 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. Long rambling answers generally get fewer points that short ones do because there are more opportunities to mark something wrong.*

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.*

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

Your Signature: _____

Date: _____

Student ID: _____

Total Points: 106 + 5 *You Scored:* _____ + *Extra* _____

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1. Please fill in each of the blanks with an appropriate answer. *2 points each blank, 80 Total*

The Euler integration scheme tends to cause simulations to "blow up." The implicit version of this scheme, known as _____, is much more stable but has a tendency to damp motions artificially.

Implicit integration schemes make use of the accelerations at the _____ of each simulation timestep.

_____ algorithms we discussed in class involve numerical root finding for a set of nonlinear equations and are often used for posing animated characters.

_____ colors consist of light at a single wavelengh.

_____ motion capture systems make use of multiple cameras to determine the location of retroreflective markers.

_____ motion capture systems use trackers that return orientation and position information.

The pseudo inverse of a matrix can be computed using the _____ algorithm.

Standard kinematic algorithms assume that articulated structures will have the topology of a _____.

The _____ vectors of an parametric surface generally can be used to compute the surface normal.

When representing _____ in 3D using homogenized coordinates, the fourth coordinate (i.e. "w") will be zero.

Animations lacking motion blur may suffer from _____.

The radiosity method operates from the assumption that all surfaces in a scene act like _____ reflectors.

In a radiosity method, the process of computing the _____ is often the time bottleneck.

When rendering using a photon-mapping algorithm, the last step called _____, often takes the most time.

_____ approximates global illumination by making diffuse shading proportional to the un-occluded area over a surface.

Radiance is measured in units of _____.

Radiance is _____ along straight lines in free space.

_____ surfaces are a generalization of uniform, cubic, tensor-product b-splines.

A b-spline curve always _____ the convex hull of its control points.

In Catmull-Clark subdivision, vertices with valence other than four are referred to as _____.

The _____ in the human eye are used in low-light situations.

Under linear perspective projection, straight lines always appear as _____.

Violet spectral colors appear at the _____ end of the visible spectrum.

The _____ is a function that describes how well a material reflects incoming light from one direction out in another direction.

The _____ of an orthonormal matrix is equal to its inverse.

The _____ parameterization of 3D rotations is plagued by the fearful phenomena known as gimbal lock.

_____ encode 3D rotations as point in 4D space.

Waiting until the last day to start working on your raytracer assignment is a _____ idea.

_____ law can be used to compute the angle that transmitted ray will make with the normal of a transparent material's surface.

The "P" in BSP-Tree stands for _____.

_____ is a special case of perspective projection where the viewer is infinitely far away.

In the context of a scan-line renderer, Z-buffers are used for _____ .

A bump map is used to change the _____ vectors when shading an object.

The normal vector at a point on a parametric surface is given by the _____ of two vectors tangent to the surface at that point.

When two curve segments join at a point and both curves approach that point with the same tangent vector, the joining is said to be _____ continuous.

When two curve segments join at a point and both curves approach that point with the same derivative, the joining is said to be _____ continuous.

NURBS are b-splines that use _____ for control points.

In Catmull-Clark subdivision, the number of quads grows by a factor of _____ for each level of subdivision.

_____ are the dimensionless units used to measure solid angles.

When the view point used to generate a radiosity solution changes, updating the solution for the new viewpoint takes _____ time.

2. Imagine that you have a RGB monitor where the wires have been swapped so that the red, green, and blue outputs from the computer have been respectively attached to the green, red, and blue inputs on the monitor. When one attempts to display the following colors, what colors will actually appear on the screen? *8 points*

Red _____

Green _____

Blue _____

Cyan _____

Magenta _____

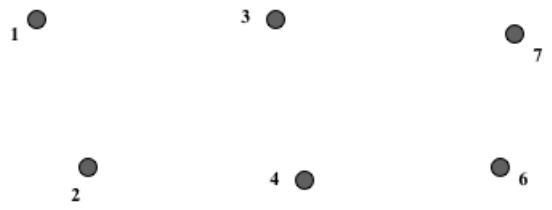
Yellow _____

Black _____

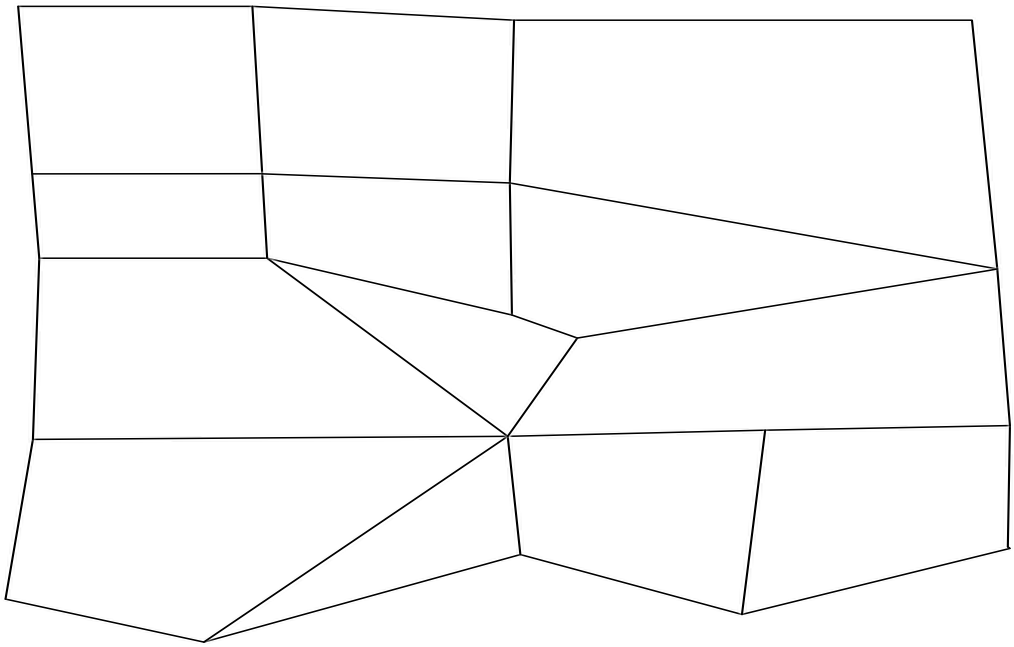
White _____

3. If a surface is defined implicitly by the function $f(\mathbf{x}) = 0$, write out the equation you would use to compute the surface's normal at some point. (Assume that negative values are inside the surface.) *2 points*

4. 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 G^1 continuity and where it may be placed to achieve C^1 continuity. Clearly label your diagram. *6 points*



5. 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*



6. Name a phenomenon that can be modeled easily using photon-mapping but that cannot be modeled with a basic ray-tracing algorithm. Give an example. *3 points*

7. Briefly state why interpolating transformation matrices by linearly interpolating the matrix components is a bad idea. *4 points*

8. **When animating fluids such as water or air using a simulation method such as the "stable fluids" method discussed in class, why is it seldom necessary to an an explicit viscosity term?** *5 points*

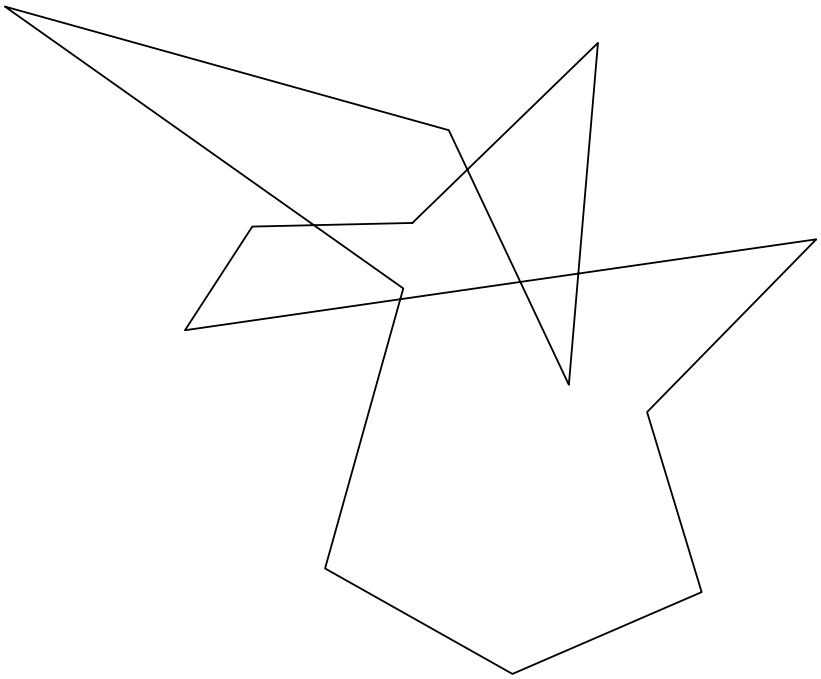
9. **Below are two 4x4 homogenized transformation matrices. What does the first one do? How does the effect produced by the second one differ from that produced by the first?** *4 points*

$$\begin{bmatrix} 4 & 0 & 0 & 4 \\ 0 & 4 & 0 & 0 \\ 0 & 0 & 4 & 0 \\ 0 & 0 & 0 & 4 \end{bmatrix} \qquad \begin{bmatrix} -4 & 0 & 0 & 4 \\ 0 & -4 & 0 & 0 \\ 0 & 0 & -4 & 0 \\ 0 & 0 & 0 & -4 \end{bmatrix}$$

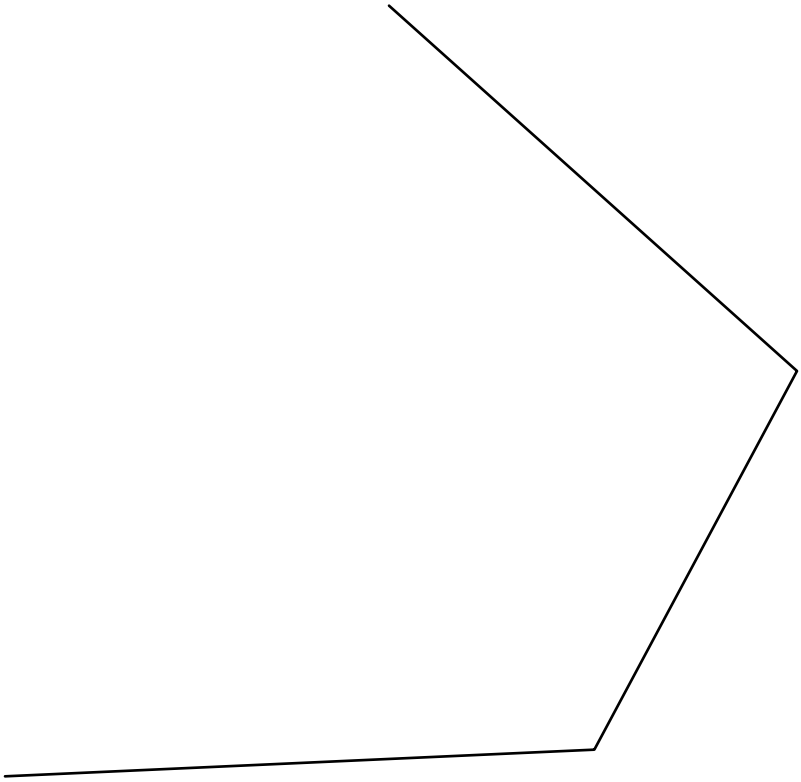
The first one will: _____

The second one will: _____

10. **Draw the convex hull of the shape shown below.** *2 points*

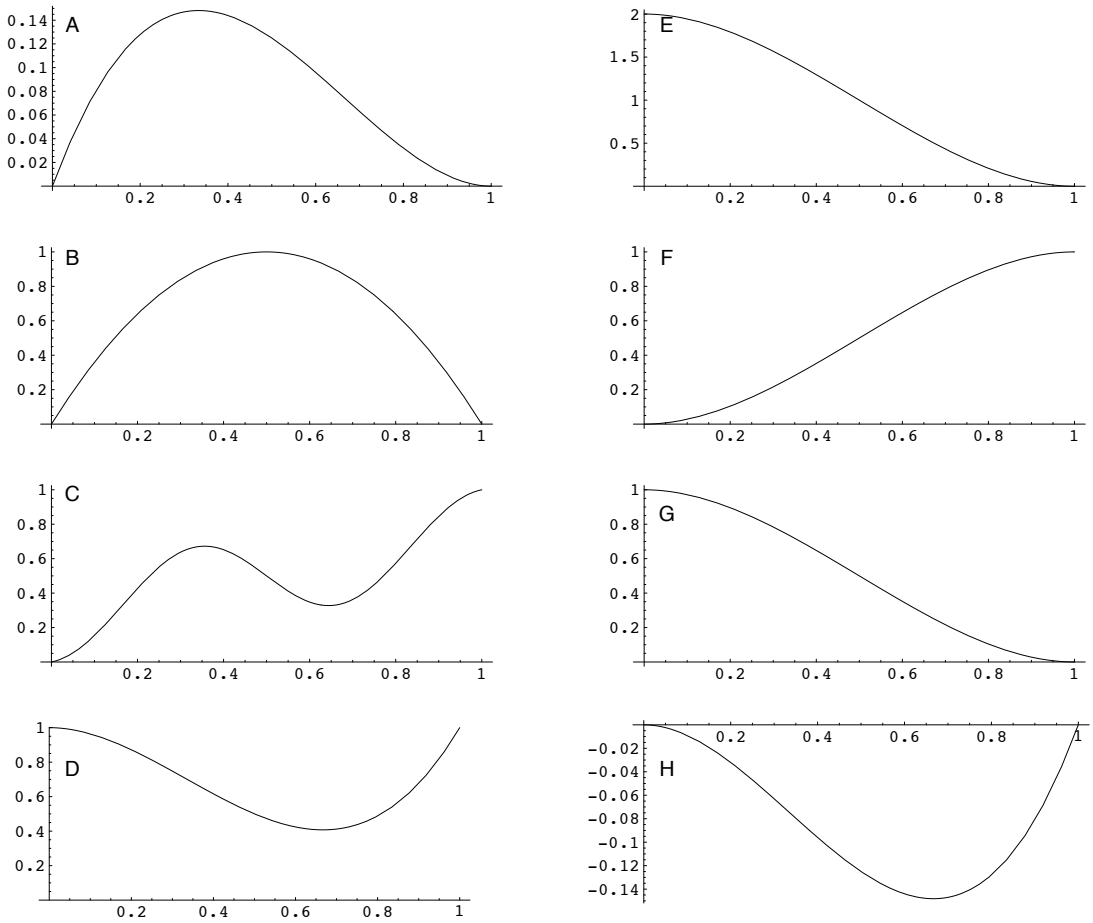


11. The diagram below is the control polygon for a Bezier curve segment. Draw the curve and show how de Casteljau's algorithm can be used to subdivide the curve into two halves. *Make sure your drawing is geometrically reasonable and shows correct curve tangents for the the beginning, middle, and end of each segment.* *5 points*



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

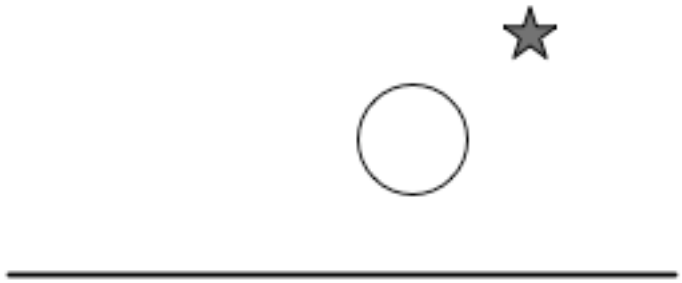
13. There are 8 functions plotted below. Neatly cross out the ones that are not part of the cubic Hermite basis set. Next to the remaining plots write what feature of the curve that basis controls. *6 points*



For those that are NOT Hermite 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
_____	_____
_____	_____
_____	_____
_____	_____

14. 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. *3 points*



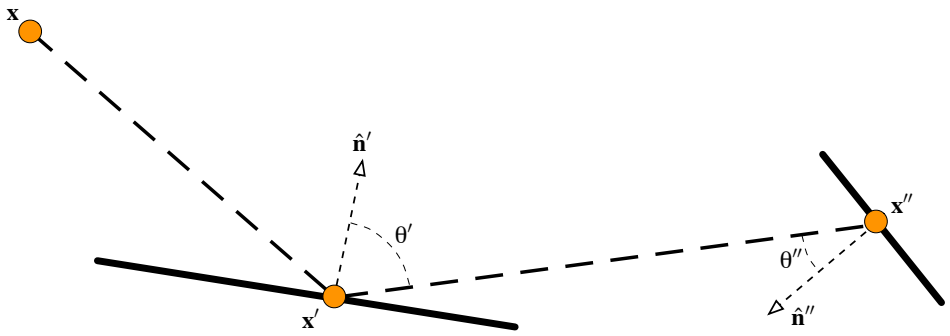
15. When computing the boolean *intersection* of two arbitrarily oriented triangles (in 2D), what is the minimum and maximum number of sides that a resulting polygon could have? Draw an example of the minimum and maximum shapes. *3 points*

16. Write out a implicit equation for a sphere. *4 points*

17. Write out an parametric equation for a line in 3D. *3 points*

18. Consider the following equation and diagram:

$$L_s(\mathbf{x},\mathbf{x}') = \delta(\mathbf{x},\mathbf{x}')\left[E(\mathbf{x},\mathbf{x}') + \int_S \rho_{x'}(\mathbf{x},\mathbf{x}'')L_s(\mathbf{x}',\mathbf{x}'')\frac{\cos(\theta')\cos(\theta'')}{||\mathbf{x}'-\mathbf{x}''||^2}d\mathbf{x}''\right]$$



Explain what effects each of the following is responsible for. *10 points*

$\delta(\mathbf{x},\mathbf{x}')$ _____

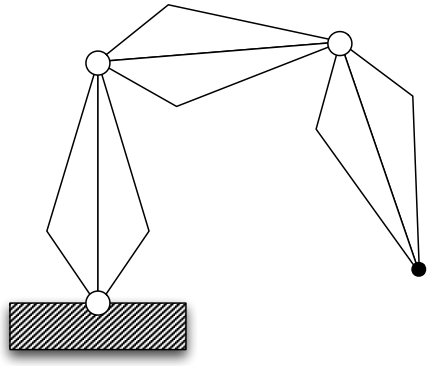
$E(\mathbf{x},\mathbf{x}')$ _____

$||\mathbf{x}'-\mathbf{x}''||^2$ _____

$\cos(\theta')$ _____

$\rho_{x'}(\mathbf{x},\mathbf{x}'')$ _____

19. Consider this diagram showing a three-joint arm in 2D where each joint is a simple pin joint and the base is fixed in space.



If we are solving an IK problem to place the tip of the arm (the black dot) at a particular location, what is the size of the Jacobian matrix we will be working with? *3 points*

Draw any one configuration of the arm where the rows of the Jacobian will not be linearly independent. *5 points*

Draw any one configuration of the arm where the columns of the Jacobian will not be linearly independent. *5 points*

Important: You may not draw the same configuration twice!

20. Name two types of useful image effects that would require shooting more than one ray per pixel in a ray-tracer. *4 points*

21. The "Painter's algorithm" sorts polygons by the depth of their center of gravity, and draws the furthest polygon first. Sketch one example where this algorithm fails. *3 points*

22. Consider the two diagrams below. All four surfaces are identical ideal diffuse reflectors. In each diagram circle the surface that will appear brighter to the observer. *4 points*

Diagram #1

Diagram #2

EXTRA CREDIT *5 points*

Given a line and a sphere:

Parametric Line: $\mathbf{l}(t) = \mathbf{a} + t\,\mathbf{b}$

Implicit Sphere: $s(\mathbf{x}) = ||\mathbf{c} - \mathbf{x}|| - r = 0$

Write out an equation that will, for the case where the line does not intersect the sphere, compute the t value where the line is closes to the sphere.

Your answer must be neat and clear. No points will be awarded for imprecise answers. Your answer should be in the form of a simple explicit equation for t that you have drawn a box around. Do not attempt this question until you have completed the rest of the exam! There will be no partial credit for this question.

Final project report submission instructions:

- **The report for your final project is due tomorrow (Friday the 19th) no later than 5pm.**
- **Reports should be printed on paper.**
- **You may include images and videos on a CD or DVD.**
- **Your report should be stapled and placed in an folder or envelope with your CD/DVD.**
- **The names and login IDs for all project members should be on your report and CD/DVD.**
- **There is no leeway for accepting late submissions. Once I go home on Friday I will not be back on campus until after grades have been submitted.**
- **Submissions by e-mail will not be accepted.**