
Student Name:

Class Account Username:

Instructions: Read them carefully!

The exam begins at 8:10pm and ends at 10:00pm. 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 than 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: 189 + 10 You Scored: _____ + Extra _____

1. Please fill in each of the blanks with an appropriate answer. *2 points each blank, 38 total*

If the singular value decomposition of a matrix is $A = USV^T$, then the psuedo-inverse of the matrix is given by $A^{-P} =$ _____.

The _____ of the tangent vectors of a parametric surface generally can be used to computed the surface normal vector.

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

The _____ method assumes that all materials in a scene are diffuse.

The _____ method computes a view-independent solution..

Field Radiance is measured in units of _____.

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

A B-spline curve is always enclosed by the _____ of its control points.

In Catmull-Clark subdivision, the number of new extraordinary points introduced on the fourth round of subdivision will be _____ .

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

_____ encode 3D rotations as 3D points inside a ball of radius π .

The special case of a perspective camera that is infinitely far away from a scene is termed a(n) _____ camera.

A texture mapping method called _____ is used to change the *apparent* shape of an object during shading.

NURBS are non-uniform _____ B-Splines that use homogeneous coordinates for control points.

_____ are the dimensionless units used to measure solid angles.

Finding the intersection of a ray with an ellipse requires solving a _____ equation.

Finding the intersection of a ray with a three-sided triangle requires solving a _____ of equations.

The dynamic range of the human eye is much _____ than the dynamic range of a typical television set.

If a spring with length l has stiffness coefficient k , then a pair of springs in serial with length $l/4$ should have stiffness _____ if they are to replicate the behavior of the original spring.

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

2 points each, 78 total

_____ Light transport can be modeled reasonably well using a collection of particles attached by photon-links.

_____ The Jacobian of a valid kinematic system will never be invertible.

_____ Shiny plastic surfaces typically have bright green specularities.

_____ In a smoke-filled room the radiance along a straight line would fall off exponentially.

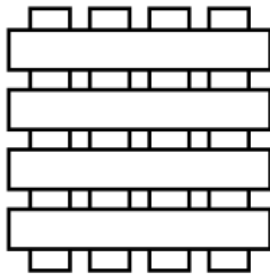
_____ The rods in the human eye have a spectral response function that peaks somewhere between the short and long cones' responses.

_____ Under linear perspective projection, squares always appear as quadrilaterals unless the projection is degenerate.

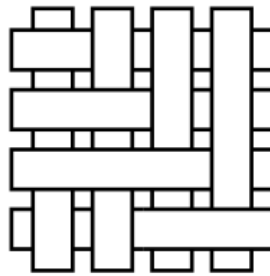
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- _____ Under linear perspective projection, triangles always will appear to have at least one angle equal to 90 degrees.
- _____ Quaternions represent rotations as points in 3D space on the surface of a hyper-torus.
- _____ Shining an ultraviolet light on scorpions makes them glow green due to photo multiplication of the electrons.
- _____ The force exerted by a linear-strength spring with non-zero rest length is given by a function that is non-linear in terms of the endpoint locations.
- _____ Cubic Bezier curves will be C^2 across segment boundaries.
- _____ Light fields are generated by non-normalized permutation maps.
- _____ In a kinematic skeleton, every child body must not be left behind when applying loop-joint transformations.
- _____ A rotation matrix always has determinant that is greater than zero.
- _____ Homeomorphic coordinates facilitate representing perspective and translation using matrices.
- _____ Ambient occlusion tends to enhance the appearance of surface detail.
- _____ The sky is blue because water vapor scatters light in the short part of the spectrum.
- _____ In some women red-green color blindness is caused by a mutation in the coding for the cones.
- _____ In a rectilinear spring mesh, adding "jump" springs will help to limit bending movement.
- _____ Motion graphs used to animation human figures should never contain cycles.
- _____ Given two recorded human motion sequences that appear natural, motions created by blending them will also appear natural and human-like because human perception is linear.
- _____ Planar inverse kinematics problems will typically have simple closed-form solutions.
-

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- _____ A ball joint represented with an exponential map has three degrees of freedom.
- _____ C^1 continuity does not always imply G^1 continuity
- _____ G^1 continuity does not always imply C^1 continuity
- _____ The Hermite basis functions are affine invariant.
- _____ The fully explicit version of Euler's method (a.k.a. forward Euler) is unconditionally stable.
- _____ Some motion capture systems use magnetic fields to determine the location and orientation of tracker objects.
- _____ Pixel-based image representations have infinite resolution.
- _____ Non-zero winding number and parity testing will produce the same result for a polygon with non-self-intersecting boundary.
- _____ Particle systems simulate objects such as waterfalls by modeling the detailed interactions between individual molecules of water.
- _____ The result of applying subdivision to a cubic curve is two quadratic curves.
- _____ Raytracing can be accelerated using BSP-Trees or K-D Trees.
- _____ The short cones in the human eye only sense blue light.
- _____ In a bounding-box tree, the bounding-box stored at a root node may not encompass the boxes of its children nodes.
- _____ The Hermite basis functions have longitudinal support.
- _____ Displacement-mapping will not change an object's silhouette.
- _____ Rational polynomial basis functions can be used to build perfect circles.
- _____ Turning your final assignment in late will result in a zero on the assignment!
-

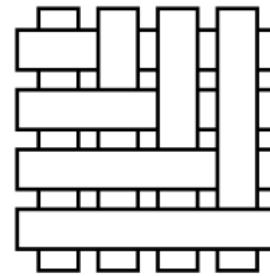
3. Which of the following scenes would cause problems for the Painter's Algorithm? 3 points



(a)

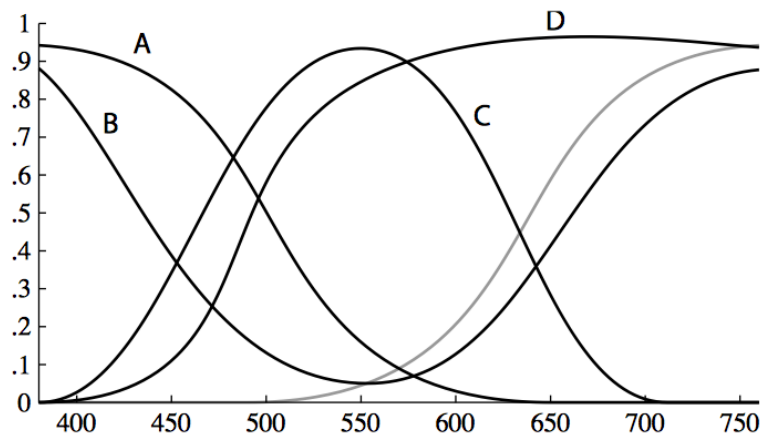


(b)



(c)

4. Write the common English name for each of the color matching each of the following spectral density curves. For example, the unlabeled gray curve would be red. 8 points



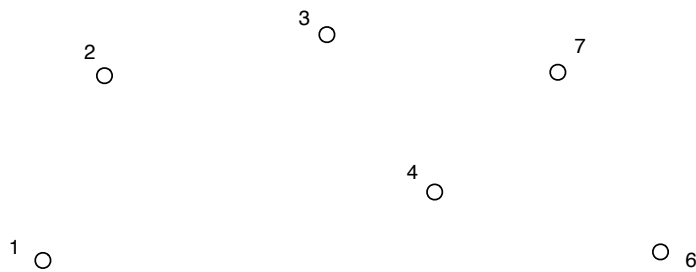
A. _____

B. _____

C. _____

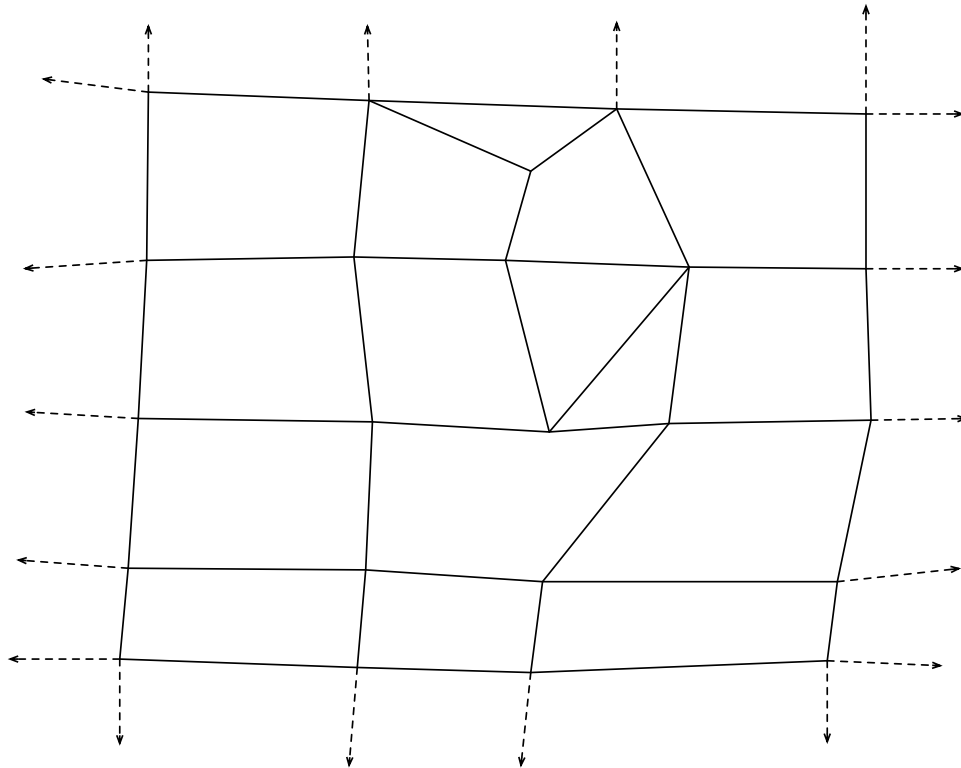
D. _____

5. The diagram below shows control points for a curve made by joining two cubic Bezier segments. However control point #5 has been removed. Indicate a location where #5 may be placed to achieve C^1 continuity and draw the curve that would result. Also draw a line where #5 may be placed to achieve G^1 continuity. *Make sure your diagram is clear and geometrically reasonable.* 9 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
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7. 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



8. 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

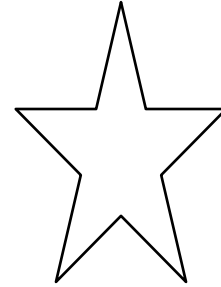
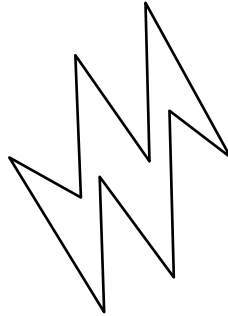
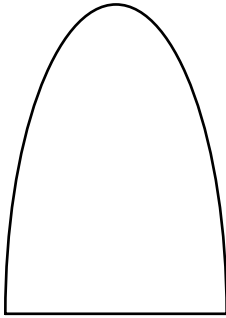
$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 2 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 4 & 0 \\ 0 & 0 & 0 & 8 \end{bmatrix}$$

The first one will: _____

The second one will: _____

9. Neatly draw the convex hull for each of the three shapes shown below.

6 points



10. Write out an implicit equation for a 2D ellipse where the long axis is the X axis with radius 2 and the short axis is the Y axis with radius 1.

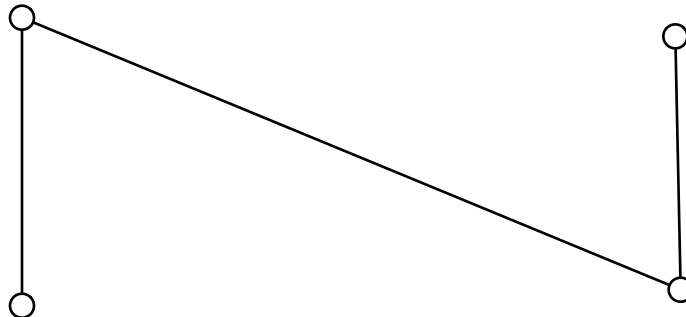
8 points

11. Write out a parametric equation for a plane in 3D that is normal to the Z axis and passes through some point P.

3 points

12. 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 equal halves. Make sure your drawing is geometrically reasonable and shows correct curve tangents for the beginning, middle, and end of each segment.

5 points

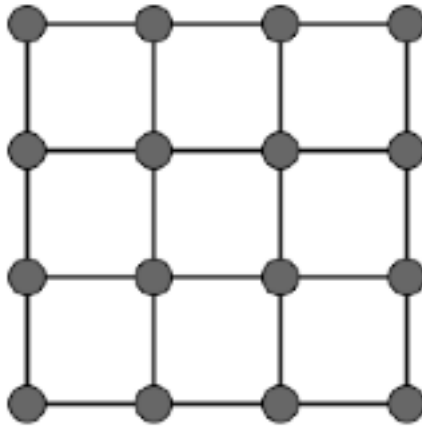


13. In the space below draw a diagram illustrating the formation of a tight *refraction caustic*. Your diagram should be clear and concise, and clearly show the light source(s), the reflecting surface(s), the surface where the caustic forms, and the paths of representative rays. A 2D diagram is suggested. 3 points

14. Given three points, A, B and C, write out a parametric equation in two variables, *u and v*, for the triangle formed by these three points. 4 points

15. When rendering a scene with a *photon-mapping* method, what part of the solution must be recomputed when the viewer moves? 4 points

16. On the diagram below, draw the springs that should be added to provide some resistance to in-plane shearing. *4 points*



17. Would the differences between Phong interpolation (interpolating normals) and Gouraud interpolation (interpolating colors) be more noticeable on diffuse or specular surface? *2 points*

EXTRA CREDIT*10 points***Given a sphere and plane:**

Sphere: $\|\mathbf{x} - \mathbf{c}\| - r^2 = 0$

Plane: $\mathbf{x}(u, v) = u\mathbf{v}_1 + v\mathbf{v}_2 + \mathbf{p}$

Write out an explicit parametric equation that produces the circle where the sphere and plane intersect. Also indicate when this circle is undefined. You may assume that \mathbf{v}_1 and \mathbf{v}_2 are both of unit length and mutually orthogonal.

Your answer must be neat and clear. No points will be awarded for imprecise or messy answers. Your answer should be in the form of a simple explicit equation 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.
