CSCE 4813 - Computer Graphics
Midterm Exam – Spring 2012

Student Name: ____________________________

Student UAID: ____________________________

I pledge that I have neither given nor received unauthorized help on this exam

Instructions: This is closed book exam. Students are allowed one 8.5x11 page of notes, but no calculators or other electronic devices. The exam worth a total of 100 points (10 questions worth 10 points each). Please read all questions before starting the test and schedule your time accordingly.

1) Geometric Objects (30 points)

We have discussed several approaches for creating “natural looking” geometric models using different forms of model subdivision.

a) Describe a subdivision algorithm that could be used to create a sequence of line segments starting at point (x1, y1) and going to (x2, y2) following a “rough looking” path. Use diagrams to illustrate how the algorithm works.

b) Polygon subdivision can be used to transform an initial triangle A, B, C into many smaller triangles, or to transform an initial rectangle A, B, C, D into many smaller rectangles. Draw a diagram that illustrates how this process works. Which do you prefer, triangles or rectangles?

c) Assume you are given the (x, y, z) coordinates of three points on a polygon A, B, C. Use diagrams and equations to describe how you can calculate the surface normal for this polygon at the point A. Is this normal unique? Explain.

2) Geometric Transformations (40 points)

We have discussed rotation, translation and scaling transformations in class. For this question, we will be using the following notation:
R(theta, axis) denotes a rotation by theta degrees around the specified (x, y, z) axis.
T(dx, dy, dz) denotes a translation by (dx, dy, dz) units.
S(sx, sy, sz) denotes a scaling by (sx, sy, sz) units.
a) Start with a 2x2 square centered at the origin. Draw a picture that shows what happens to this square when you first apply rotation \( R(90, z) \) followed by a scaling of \( S(1, 2, 1) \). What happens if you reverse the order of operations? Is this true for all \( R,S \)? Explain.

b) Draw a picture that shows what happens if you translate a 2x2 square by \( T(1, 1, 0) \) followed by a rotation of \( R(45, z) \). What happens if you reverse the order of operations? Is this true for all \( R,T \)? Explain.

c) Sometimes we want to scale an object arbitrary center point \((cx, cy, cz)\) to simplify user interaction or to get different visual effects. Use diagrams and equations to show how to perform this composite geometric transformation.

d) Demonstrate how the geometric transformations above can be implemented using 4x4 matrix operations (show the matrices for \( R, T, S \)). Why are 4x4 matrices needed instead of 3x3 matrices?

3) Computer Viewing (30 points)

The goal of perspective projection is to transform three-dimensional object coordinates \((x, y, z)\) into two-dimensional coordinates \((xp, yp)\) onto the projection plane \( z=d \). If we assume that the center of projection is at \((0, 0, 0)\) then the projection formulas are: \( xp = x \cdot d / z, yp = y \cdot d / z \).

a) Draw side view diagrams that illustrates the projection formulas above, showing how several 3D points on a tree will be projected onto the \( z=d \) plane.

b) Describe/illustrate what happens to the projected image if you translate the tree along the \( z \)-axis. Can you explain these results in terms of the projection formula?

c) Describe/illustrate what happens to the projected image if you scale the tree uniformly in all three dimensions. Can you explain these results in terms of the projection formula?