CPSC 414 Computer Graphics
SAMPLE Final exam, April 17, 2002
Total marks = 150, Total Time: 2.5 hours (150 minutes).

Instructions:

- Do not open the exam book until told to do so.
- This is a closed book exam. Show all your work. You are allowed to use a calculator if needed. Everything else should be put away.
- Write your student number on each page.
- You must sit in the space assigned. Place your student ID on the table for TAs to check.
- No one will be permitted to leave the exam room during the first 60 minutes of the exam, or allowed to enter after the first 60 minutes.
- Cheating is an academic offense. Your signature on the exam indicates that you understand and agree to the University's policies regarding cheating on exams.
- Sign here:

NOTE: USE THIS ONLY TO GET AN IDEA OF THE GENERAL LOOK AND FEEL OF THE EXAM. The questions are drawn from previous exams and the text, and will not be the same in your final. Obviously, I can not balance and test these questions as carefully as I would the real final. Do not rely on this exam to decide on topics to study, but mainly as a guide to pacing yourself in the exam.

1. (54 marks, 2 marks each)

   The following terms or people's names are possible answers for the questions on subsequent pages. Use the number corresponding to a term or name below as an in the space provided answer if you think it is the best match for one of the concepts or terms on subsequent pages. Each term may be used once, more than once, or not at all.

   (1) affective
   (2) affine
   (3) associative
   (4) callback
   (5) CIE chromaticity diagram
   (6) CIE RGB
   (7) CIE XYZ
   (8) commutative
   (9) concave
   (10) convex
   (11) DAG
   (12) dominant
   (13) glBeginList()
   (14) geometry
   (15) Fittss law
   (16) graphics pipeline
   (17) matching
   (18) non-uniform
   (19) non-uniform scaling
   (20) orthographi
   (21) outcodes
   (22) pseudodepth
   (23) pseudopod
   (24) purple line
   (25) refresh rate
   (26) rotation about x
   (27) rotation about y
   (28) rotation about z
   (29) screen window
   (30) Sutherland, Ivan
   (31) topology
   (32) translation
   (33) tree
   (34) tristimulus
   (35) uniform
   (36) uniform scaling
   (37) unsaturated
   (38) update rate
   (39) vertex program
   (40) viewport
   (41) window
   (42) winged edge

   For each statement below, write the number of the term listed above that that best fits into the missing space marked by ********* in the sentence or answers the question.

   ___ (a) A weighted sum of vectors whose weights sum to unity (1) is called *******

   ___ (b) A weighted sum of vectors whose weights are all non-negative and sum to unity (1) is called ******

   ___ (c) In a z-buffer algorithm, we use the ****** as an approximation for the actual distance from the eye to a point on an object because this

is easier to compute than the true distance, but it still gives a correct depth comparison.

___ (d) A 4 ×4 matrix $\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & a & -b & 0 \\ 0 & b & a & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$ where $a^2 + b^2 = 1$ is a ******* transformation.

___ (e) A 4 ×4 matrix $\begin{pmatrix} 1 & 0 & 0 & a \\ 0 & 1 & 0 & b \\ 0 & 0 & 0 & c \\ 0 & 0 & 0 & 1 \end{pmatrix}$ corresponds to a ****** transformation.

___ (f) A 4 ×4 matrix $\begin{pmatrix} a & 0 & 0 & 0 \\ 0 & b & 0 & 0 \\ 0 & 0 & c & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$ corresponds to a ****** transformation.

___ (g) Two matrices A and B are ****** if AB = BA.

___ (h) In general, two scaling matrices A and B satisfy the equation AB = BA only if they are both ****** scaling matrices. NOTE: Either 18 or 19 (non-uniform [scaling]) will be accepted as a correct answer for this question, as will any one of 36 or 37 (uniform [scaling]) or 2 (affine).

___ (i) The one-bit quantities that specify whether a point is "in" or "out" with respect to each of the boundaries of a clipping region are called ******

___ (j) This person is often referred to as the "father of computer graphics" because of his many early contributions to the field, starting with his doctoral dissertation Sketchpad.

___ (k) The portion of a 3D model that specifies the coordinates of the points, lines, and planes that comprise the model.

___ (l) The portion of a 3D model that specifies the connectivity of the points, lines, and planes that comprise the model.

___ (m) The ****** theory tells us that human colour vision can be modeled as a three-dimensional vector space.

___ (n) The 3D ****** colour space is derived from the colour space obtained from experimental data by choosing a new set of axes so that all spectral colours have non-negative coordinates.

___ (o) A parallel projection in which all projection lines are normal to the projection plane.

___ (p) A new feature of recent consumer graphics hardware, introduced in the GeForce3.

___ (q) Another colour term that means the same as "pure" is ******.

___ (r) The CIE colour system was determined in the 1920's and 1930's by a series of colour ****** experiments conducted with human observers.

___ (s) The update rate is the number of times per second (usually 30-72 Hz, but a minimum of 10-15 Hz) that the image being displayed on a screen must be modified to produce the illusion of continuous, smooth motion.

___ (t) The refresh rate is the number of times per second (usually 60-72 Hz, but a minimum of 40 Hz - the critical fusion frequency) that an image must be displayed on a screen in order to maintain the illusion of a continuous image (persistence of vision).

___ (u) The toolkit that is built on top of OpenGL provides a set of widgets for interaction that use this type of function to communicate with the application program when interaction events occur.

___ (v) In OpenGL, this function groups a set of primitives so they can be included within other groups as if the set were itself a primitive.

___ (w) The graphics pipeline is the entire process of creating and perceiving an image on a CRT or other display device starting with a software application program and ending with the human visual system and brain.

___ (x) A window is the subset of the World Coordinate System that is eventually rendered as an image on the face of the CRT.

___ (y) A viewport is the portion of the virtual frame buffer provided by OpenGL into which a graphics program renders pixels for an image.

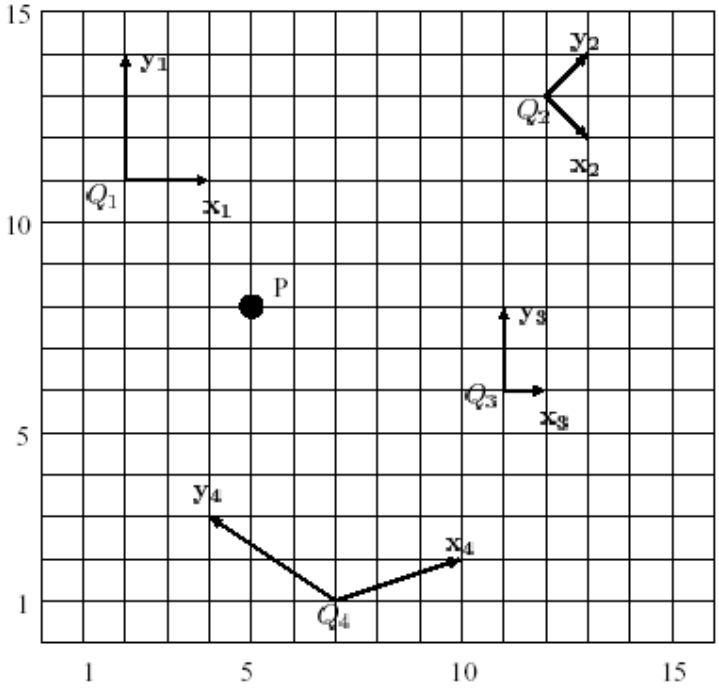
___ (z) A screen window is the portion of the face of the CRT that displays an image stored in the physical frame buffer

___ (aa) A data structure that stores a record for each vertex, face, and edge, where the edge record is the most important, is called the winged edge data structure. The edge record has pointers to the two vertex endpoints v1 and v2 incident with the edge, pointers to the two faces f1 and f2 on either side of the edge, and pointers to the clockwise and counter-clockwise predecessor and the successor edges incident with the edge on the boundaries of each of f1 and f2.

2. (12 marks)

Describe the point P in the following figure in terms of the coordinate systems given by the vectors $(\mathbf{x_i}, \mathbf{y_i})$ and origins Q_i, for $i = 1 \ldots 4$. That is, determine a_i and b_i such that

$$P = a_i \cdot \mathbf{x_i} + b_i \cdot \mathbf{y_i} + Q_i,$$



3. (8 marks) Draw a sketch of the typical OpenGL rendering pipeline we have been using in class. Give the names and purpose of 6 of the stages as well as specifying the order in which these stages occur in the pipeline.

4. (7 marks) Given a line in screen coordinates with starting point at (1.4, 2.6) and end point at (5.4, 12.6), compute the first 2 points drawn by Bresenham Algorithm and their corresponding decision variables.

5. (7 marks) Draw a brief sketch that clearly illustrates the perspective foreshortening problem when interpolating texture coordinates. Explain why this occurs in one sentence.

6. (7 marks) What are the 3 ways to model cubic parametric curves discussed in class? Give two drawbacks or benefits for each.

7. (9 marks)

   - What is the Fourier transform of a comb function with period T?

   - What is the Fourier transform of a box function $f(x) = 1$, if $x \in (0, 1)$, else $f(x) = 0$?

   - What is the Nyquist frequency? How is it related to aliasing?

8. (20 marks)

   Describe the blending functions $b_i(u)$ for Bezier cubics, where i is the index of a control point. Prove that

   $$b_i(u) \leq 1$$

   for all $u \in (0, 1)$ and

   $$\sum_{i=0}^{3} b_i(u) = 1.$$

9. (26 marks) Ray tracing in sphereland. Some physicists believe the universe is curved, like a sphere. To help them understand how things would look in such a space, they have asked you to write a program to render objects in a curved 2D universe, i.e. a unit two-dimensional sphere, like the surface of the earth. In this space the shortest line between two points is the "great circle," produced by cutting the sphere with a plane passing through the two points and the center of the sphere. Suppose the eye is at the north pole and image "plane" a 20 degree segment of circle centered at the eye. A single light source is located at the south pole. Describe, with pseudocode a ray-tracing program to render circles of different sizes in this universe. (Hint: How many specular highlights would you see?).

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