COS 426, Spring 2011
Midterm 1

Name:

NetID:

Honor Code pledge:

Signature:

This exam consists of 6 questions. Do all of your work on these pages (use the back for scratch space), giving the answer in the space provided. This is a closed-book exam, but you may use one page of notes during the exam. **Put your NetID on every page (1 point), and write out and sign the Honor Code pledge before turning in the test:**

"I pledge my honor that I have not violated the Honor Code during this examination."

Question	**Score**
1	
2	
3	
4	
5	
6	
NetID on every page	
Total	

1. Color (15 points)

a) For each statement, list ***all*** the colorspaces from the following list to which it applies:
RGB, HSV, XYZ, CMY

- Can represent all pure spectral colors with positive values:
- Represents white with (0,0,0):
- Is a linear transformation of RGB:
- Is an affine transformation of RGB:
- Is especially well suited for sending colors to printers:
- Represents each color uniquely:

b) The U-store is designing orange-tinted sunglasses to sell to rabid Princeton fans, and receives two samples of "orange" color filters: filter A and filter B. You look through each filter at a white wall and, sure enough, it appears orange through both. However, when looking at a red car, you notice that it appears red through filter material A and black through filter material B. Explain why this may be the case. (Hint: think spectrally.)

2. Signal processing (15 points)

Complete the following sentences:

a) A ***pixel*** is . . .

b) ***Dithering*** is used to . . .

c) For a signal with bandwidth b, the ***Nyquist rate*** is . . .

d) ***Aliasing*** can occur when . . .

and may have some of the following manifestations:

e) ***Resampling*** is used to . . .

3. Morphing (25 points)

Beier and Neely, in their 1992 paper, determined warps based on line correspondences. What if they had used point correspondences instead? Let us try to devise a morphing method for a user interface that only provides point correspondences. Keep in mind that there are several equally good ways to solve this problem.

Notation: given source image $A(x,y)$ and target image $B(x,y)$ with source points $(a_1, a_2, \ldots, a_n)$ and corresponding target points $(b_1, b_2, \ldots, b_n)$, determine the intermediate image $I_t(x,y)$ at some time $0 < t < 1$.

In case you find it useful, here is equation 4 of the Beier-Neely paper:

$$weight = \left(\frac{length^{\,p}}{a + dist} \right)^{b}.$$

a) Suppose $n = 1$ (i.e., one point correspondence is specified). Describe how would you find $I_t(x,y)$. Give an exact formula in terms of A, B, a_1, and b_1.

b) For arbitrary n and some time t, describe how you would find the intermediate locations of feature points $\big(i_1(t), i_2(t), \ldots, i_n(t)\big)$.

c) Now describe how you would find $I_t(x,y)$ for an arbitrary number of corresponding points. You can re-use formulas you defined in (a) and (b).

d) Describe the difference, if any, between the Beier-Neely method with a single line correspondence, and your scheme with $n = 1$ point.

e) Describe the difference, if any, between the Beier-Neely method with a single line correspondence, and your scheme with $n = 2$ points.

f) What are the advantages and disadvantages, if any, of using points over lines? If applicable, describe potential scenarios in which points or lines would work better.

4. 3D Representations (8 points)

After graduating from Princeton and earning multiple metric tons of money, you decide to have a custom jet designed for you. Of the following 3D representations:

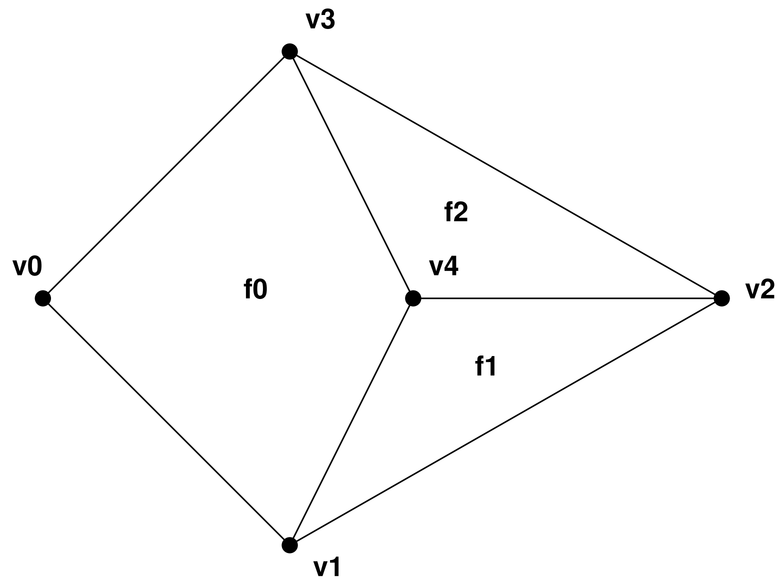
implicit function, triangle mesh, B-spline

which one will your private horde of engineers find most convenient for performing each of the following tasks? Choose the ***single best*** answer for each question.

- Efficient graphics-hardware-based rendering:
- During an airflow simulation, checking whether a 3D point is inside or outside the airplane:
- Ensuring that the wing design is C^2 continuous:
- Given separate models of the wings and fuselage, combining them into a single model of the surface of the whole airplane:
- Representing the final shape of the fuselage as exactly and compactly as possible:
- Ensuring that, when part of the design is outsourced, what comes back is guaranteed to be a valid manifold surface:
- Accurately representing the crease between the wing and fuselage:
- Finding the exact curve representing the wing's leading edge:

5. Half-edge data structure (16 points)

Consider the following patch of a polygonal mesh.



a) Draw and number the half-edges in the diagram.

b) Write out the complete contents of the half-edge, face, and vertex tables (omitting the vertex coordinates) for this mesh. Make your arrays 0-based, and use indices instead of pointers.

c) Suppose that vertex **v4** is removed from the mesh. Which half-edges must be removed from your data structure?

d) For the scenario in (c), list all other changes that must be made to your half-edge, face, and vertex tables.

6. Transformations (20 points)

a) Write down a 2×2 transformation matrix that reflects a 2-D point (represented as a 2×1 column vector) about the line $ax + by = 0$ (assuming $a^2 + b^2 = 1$).

b) Sketch a proof that the composition of any two such reflections is a rotation about the origin. (The proof need not use the matrix formula you derived above; it is fine to argue geometrically.) What is the angle of the resulting rotation, as a function of the angle between the two lines?