COS 426, Spring 2017
Exam 1

Name:

NetID:

Honor Code pledge:

Signature:

This exam consists of 6 questions. Do all of your work on these pages (using the back for scratch space), and give 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 pts)

Imagine that you have an RGB monitor in which the wires have been swapped so that the red, green, and blue outputs from the computer have been attached to the green, blue, and red inputs on the monitor, respectively. When you attempt to display the following colors, what color will actually appear on the screen? (3 pts each)

a. **Dark red** dark green

b. **Yellow** cyan

c. **Orange** bluish-green

d. **Light gray** light gray

e. Now imagine that you have a printer that expects CMY input, but you send it an RGB image instead. What, if any, colors will the printer print correctly? (3 pts)

Only the color $(0.5, 0.5, 0.5)$, or mid-gray.

2. Blur (16 pts)

You are implementing a Gaussian blur operation, but don't have some of the details quite right. ***Explain in a few words*** how the output of the filter will differ from the ideal output, given the following: (4 pts each)

a. The weights of the filter kernel do not sum to 1.

The output image will be too light or too dark.

b. The size of the filter is held at 5×5, regardless of σ.

(In particular, what happens for very small σ and very large σ?)

Small σ: correct output; Big σ: output is the result of a 5×5 box filter, not a Gaussian.

Now explain how the results of a ***bilateral*** filter will differ from Gaussian blur in the following situations: (4 pts each)

c. The range filter width σ_R grows to infinity.

The result of this bilateral filter approaches the result of a Gaussian blur with the same σ_S.

d. The range filter width σ_R shrinks to zero.

The result approaches not doing any filtering.

3. Warp (20 pts)

You are implementing code that will warp an N-pixel input image to an M-pixel output image. For each of the following strategies, ***how many times*** will pixels in the input and output images be accessed, as a function of N and M? You should ignore edge effects and assume that the output covers the entire input image, and vice versa. (2 pts each)

a. **Reverse mapping with point sampling:**

Accesses to input image: M

Accesses to output image: M

b. **Reverse mapping with bilinear sampling:**

Accesses to input image: 4M

Accesses to output image: M

c. **Reverse mapping with Gaussian sampling using a** 5×5 **kernel:**

Accesses to input image: 25M

Accesses to output image: M

d. **Forward mapping with Gaussian splatting using a** 5×5 **kernel:**

(Count normalization as 1 access per pixel, and do not include accesses to the weight buffer.)

Accesses to input image: N

Accesses to output image: 25N + M

e. Describe conditions on the ***input image*** and/or the ***mapping*** used for warp such that reverse mapping with bilinear sampling ***will not introduce aliasing***: (4 pts)

Either the input is bandlimited at the output sampling rate, or the mapping does not minify (shrink) the image anywhere.

4. Shape (20 pts)

Consider the following shape representations:

1. CSG
2. parametric surface
3. sweep
4. triangular mesh
5. voxel grid

For each of the following objects or scenes, ***write the number*** of the most appropriate representation and ***give a short explanation*** (a few words) of why the chosen representation is most suitable for that scene. You will use each representation once. (4 pts each)

a. **A garden hose.**

Best representation: 3 Explanation: Constant cross section

b. **A 3D-scanned bunny figurine.**

Best representation: 4 Explanation: Densely sampled surface, details throughout

c. **A mobile-phone case during its design stages.**

Best representation: 2 Explanation: Multiple curved sections; control over continuity

d. **Smoke dispersed from a fire.**

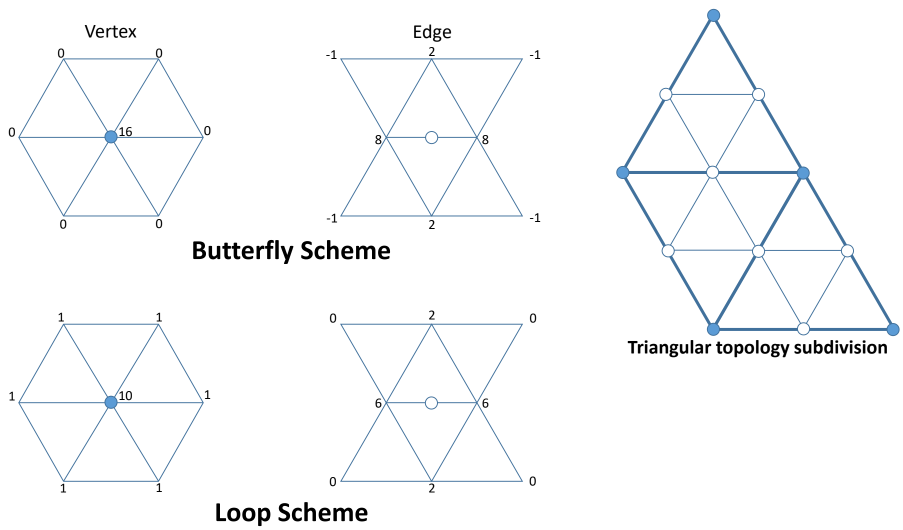
Best representation: 5 Explanation: Density and scattering vary throughout volume

e. **A drill mechanism.**

Best representation: 1 Explanation: Union and difference are natural fit for gears, drill bits

5. Subdivision (12 pts)

The Loop and Butterfly schemes subdivide a triangular mesh by introducing a new vertex for each edge, and splitting every original triangle into four smaller ones, as shown on the right. Each scheme has rules for calculating the locations of the new vertices, and moving the old vertices, based on the locations of the old vertices. These rules are shown in the figure, where ***all the numbers must be multiplied by*** $1/16$.



a. For each of these two schemes, state whether it ***interpolates the original datapoints***. What properties of the subdivision rules did you look at to arrive at the answer? (4 pts)

Butterfly: yes. Loop: no. Interpolating if and only if weights for old vertices have central vertex with a weight of 1, all other vertices with a weight of zero.

b. For each of these two schemes, state whether it has the ***convex hull*** property. What properties of the subdivision rules did you look at to arrive at the answer? (4 pts)

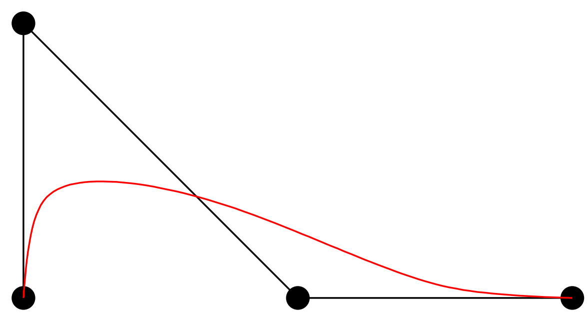
Butterfly: no. Loop: yes. Convex hull property if and only if all weights are non-negative.

c. What would happen if we multiplied all weights by $1/10$ instead of $1/16$? (4 pts)

The shape would grow by a factor of 16/10 with each subdivision pass.

6. Bézier (16 pts)

a. Given the control polygon below, ***draw the corresponding cubic Bézier curve***. Your drawing does not have to be exact, but make sure that the positions and tangents are correct at the beginning and end of the curve. (4 pts)



True / False – circle one: (3 pts each)

b. Cubic Bézier curves are always C^3 away from the endpoints.

True   False

c. Two Cubic Bézier curves connected at the same control point always have C^2 continuity at that point.

True   False

d. Two Cubic Bézier curves connected at the same control point can never have C^3 continuity at that point.

True   False

e. If the control polygon of a Bézier curve is convex, the curve is guaranteed to be contained within that control polygon.

True   False