University of California San Diego
Department of Computer Science
CSE167: Introduction to Computer Graphics
Spring Quarter 2015
Midterm Examination #1
Thursday, April 23rd, 2015
Instructor: Dr. Jürgen P. Schulze

Name:_____

Your answers must include all steps of your derivations, or points will be deducted.

This is closed book exam. You may not use electronic devices, notes, textbooks or other written materials.

Good luck!

Do not write below this line

Exercise	Max.	Points
1	10	
2	10	
3	10	
4	12	
5	10	
6	10	
7	10	
8	8	
Total	80	

1. Linear Algebra (10 Points)

a) Here is a 3D homogeneous point: (2,3,4,2). What Cartesian point does it correspond to? (you get Cartesian points by dehomogenizing) (1 point)

b) This is a 3D translation matrix: $\begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 3 \\ 0 & 0 & 1 & 4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$. Use it to translate the homogeneous point (2,2,2,2). What is the Cartesian equivalent of the result? (2 points)

c) Give the 4x4 matrix for a uniform scale by a factor of 2 followed by a translation by (0,0,3). (2 points)

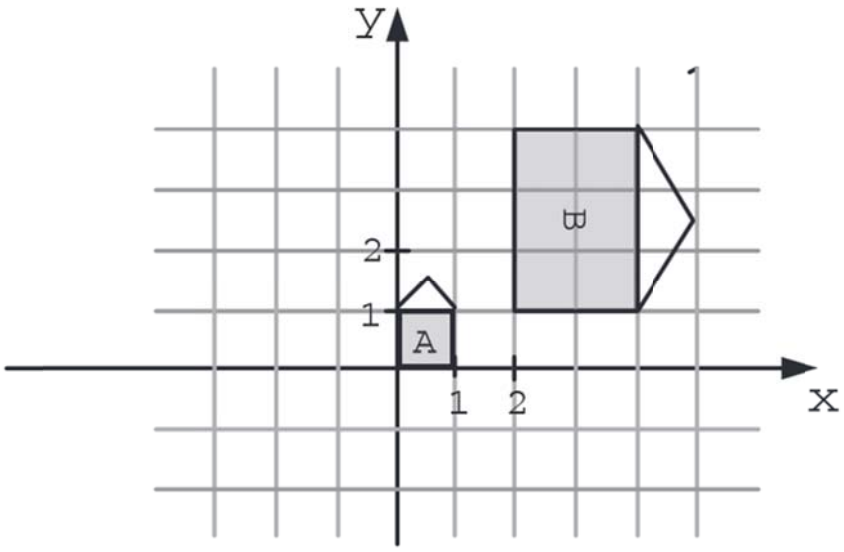
d) Construct a 2x2 matrix that reflects (mirrors) any 2D point about the x-axis of a cartesian 2D coordinate system. (3 points)

e) Is the 2x2 matrix from part d) a rotation matrix? Why or why not? (2 points)

2. Affine Transformations (10 Points)

Find the 3x3 homogeneous matrix that transforms the 2D vertices of object **A** to the corresponding vertices of object **B** in the figure below. Express the matrix as a composition of elementary transformations such as translation, scaling, or rotation.

Note that for rotations which are multiples of 90 degrees, the sin and cos terms in the rotation matrix simplify to 1, -1, and 0, depending on the angle. If you cannot remember what the rotation matrix you need looks like, try to derive it based on this knowledge.



3. Coordinate System Transformation (10 Points)

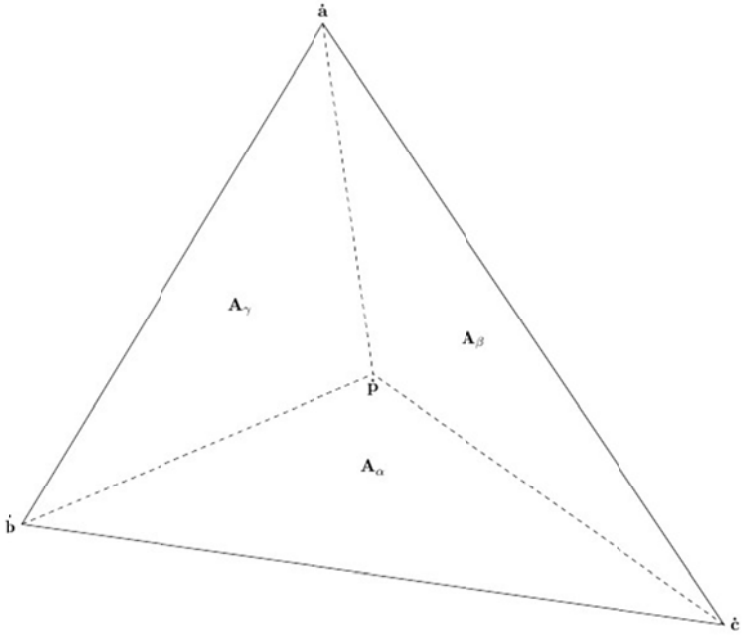
Given a point p with *camera space* coordinates p = (2, 1, 1).

In addition, camera space has its origin at $(2,\frac{1}{\sqrt{2}},-\frac{1}{\sqrt{2}})$ in *world space*, and the basis vectors of camera space have *world coordinates* $(0,1,0)$, $\left(\frac{1}{\sqrt{2}},0,\frac{1}{\sqrt{2}}\right)$, $\left(\frac{1}{\sqrt{2}},0,-\frac{1}{\sqrt{2}}\right)$.

What are the *world space* coordinates of p?

4. Barycentric Coordinates (12 Points)

When determining barycentric coordinates, α, β, and γ represent a signed ratio of the areas of the three subtriangles (denoted A_α, A_β, A_γ) to the total area of the triangle (A).



a. The area of these four triangles can be determined using only five vectors. Using the image above, fill in the spaces below with those vectors in terms of **a**, **b**, **c**, and **p**. (5 points)

1.

2.

3.

4.

5.

b. Using **ONLY** the five vectors from part a, find the areas A_{α}, A_{β}, A_{γ}, and A. (4 points)

1. A_{α} =

2. A_{β} =

3. A_{γ} =

4. A =

c. We define a symbol $\oint_x$ such that:

$$\oint_x = \frac{\overrightarrow{n} \cdot \overrightarrow{n_x}}{\| \overrightarrow{n} \| * \| \overrightarrow{n_x} \|}$$

Find $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, and $\boldsymbol{\gamma}$ by completing the equations below. (3 points)

1. $\boldsymbol{\alpha} = \oint_a$ *

2. $\boldsymbol{\beta} = \oint_{\mathbf{b}}$ *

3. $\boldsymbol{\gamma} = \oint_c$ *

5. Depth Buffer (10 Points)

a) Describe the depth buffer (z-buffer) algorithm. What is its purpose? Write down pseudo-code for the depth test. (4 points)

b) What happens visually on the screen if the resolution of the depth buffer (i.e., the number of bits available to store the depth) is insufficient? (2 points)

c) In the context of the depth buffer, what is the role of the near and far planes? (2 points)

d) Name an advantage and a disadvantage the z-buffer algorithm has over the Painter's Algorithm. (2 points)

6. Shading (10 Points)

a) Both Gouraud and Phong Shading interpolate along polygon edges to compute intensities. But the two shading models interpolate different things.

1) What does Gouraud Shading interpolate along edges? (1 point)

2) What does Phong Shading interpolate along edges? (1 point)

b) What is the difference between Phong Shading and the Phong Illumination Model? (2 points)

c) What two parameters does a Bidirectional Reflectance Distribution Function (BRDF) take in, and what does it calculate? (3 points)

d) Which three components (types of light, not light sources) does the simplified illumination model OpenGL uses consist of? (3 points)

7. Illumination (10 Points)

a) In the diagram below, indicate the point on the line that will appear brightest to the observer if the line acts like a diffuse reflector. (2.5 points)

b) In the diagram below, indicate the point on the line that will appear brightest to the observer if the line acts like a specular reflector. (2.5 points)

c) The diagram below shows a triangle with vertices labeled a, b, and c. Several locations have been indicated with circles. The list of numbers to the left contains triples of numbers, named A through E, representing the barycentric coordinates of these circles. Label each of the circles with the letter of the corresponding number triple. (1 point each)

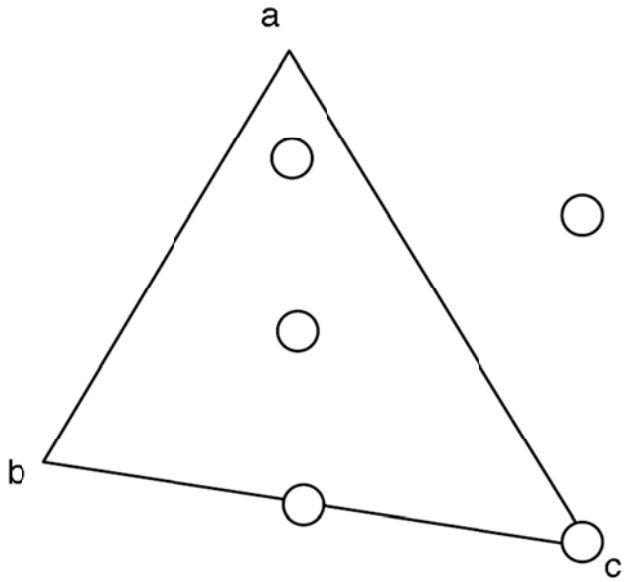
A: 0, 0, 1

B: 0.333, 0.333, 0.333

C: 0, 0.5, 0.5

D: 0.75, -0.5, 0.75

E: 0.8, 0.1, 0.1



8. Lights (8 Points)

a) Name two differences between directional lights and point lights. (2 points)

b) Which two additional parameters do OpenGL spot lights have compared to point lights? (2 points)

c) How do the three distance attenuation options for point lights in OpenGL differ from one another? Why are there three different options? (4 points)