University of California San Diego
Department of Computer Science
CSE167: Introduction to Computer Graphics
Fall Quarter 2016
Midterm Examination #1
Thursday, October 13th, 2016
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	10	
5	10	
6	10	
7	10	
8	10	
Total	80	

1) Linear Algebra (10 Points)

Let $\mathbf{a}$ and $\mathbf{b}$ be unit vectors, and $\mathbf{c} = \mathbf{a} \times \mathbf{b}$.

<u>Tips:</u>

- $|\mathbf{v}|$ represents the magnitude (length) of a vector $\mathbf{v}$
- The dot product is defined as: $\mathbf{a} \cdot \mathbf{b} = |\mathbf{a}|\ |\mathbf{b}| \cos(\theta)$

a) if $\mathbf{c} = (0,0,0)$, what is the value of $\mathbf{a} \cdot \mathbf{b}$? (3 points)

b) if $|\mathbf{c}| = 1$, what is the value of $\mathbf{a} \cdot \mathbf{b}$? (4 points)

c) if $|\mathbf{c}| = 1$, what is the value of $\mathbf{b} \times \mathbf{c}$? (3 points)

2) Affine Transformations (10 Points)

Create a 4x4 matrix that scales data by a factor of two, centered at the point (2,2,0). (Hint: a vertex at (2,2,0) shouldn't move.) Show your work, including intermediate matrices.

3) Camera Coordinates (10 Points)

Given:

e $=[2\ \frac{1}{\sqrt{2}}\ \frac{-1}{\sqrt{2}}]^T$

d $=[1\ \frac{1}{\sqrt{2}}\ 1-\frac{1}{\sqrt{2}}]^T$

up $=[0, 1, 0]^T$

a) Using the above center of projection **e**, look at point **d**, and up vector **up**, calculate the basis vectors of the camera coordinate system they describe. (3 points)

b) Calculate the 4x4 camera matrix **C**. (1 point)

c) Calculate the inverse camera matrix $\mathbf{C}^{-1}$ (with derivation). (4 points)

d) Let **p**' = $\mathbf{C}^{-1}$ **p**. Given a point **p**' = (1, 2, 1) in camera coordinates, find **p** in world coordinates. (2 points)

4) Projection (10 Points)

A projection matrix collapses data from higher dimensions (typically three in graphics) to lower dimensions (typically two).

a) Which of the matrices below are projection matrices? Circle them.

b) For each of the projection matrices indicate which dimension (x, y or z) collapses in the projection, assuming a typical x, y, z coordinate system.

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & \frac{1}{d} \end{bmatrix}$$

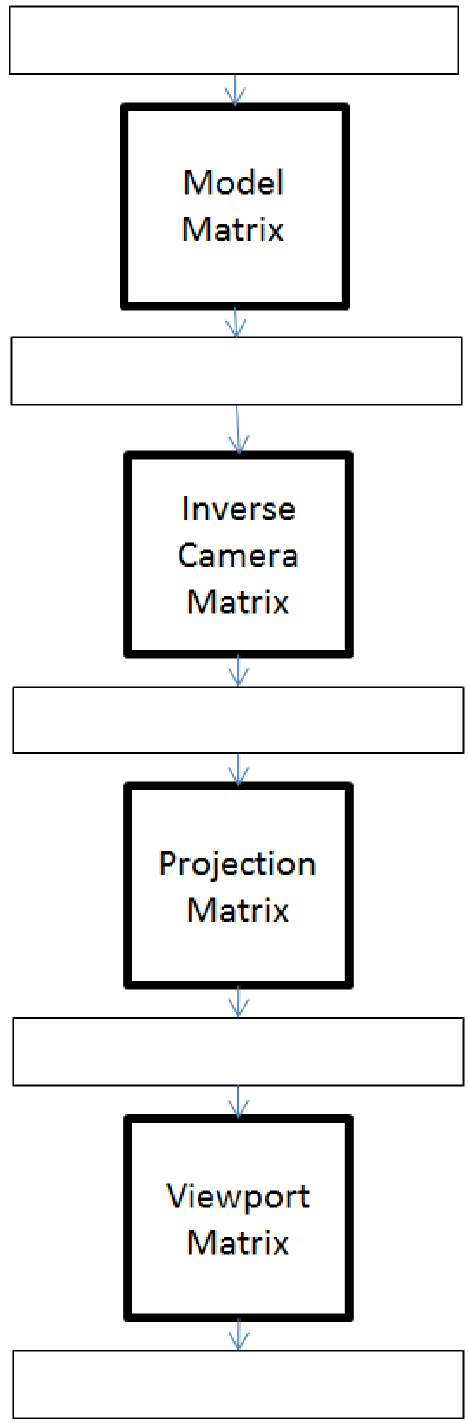
$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \frac{1}{d} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

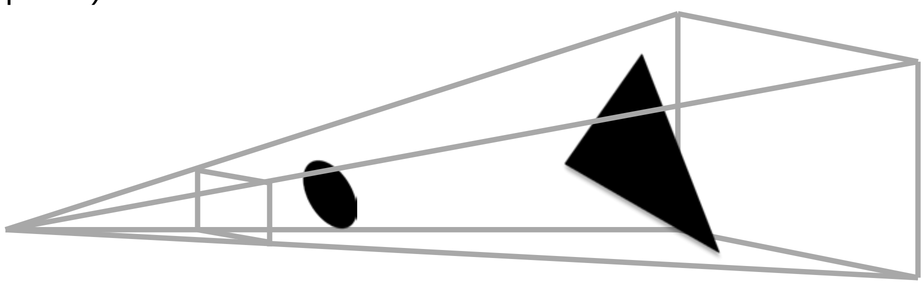
5) Vertex Transformation (10 Points)

Fill in the Complete Vertex Transformation flow chart below with the names of the coordinate systems the given matrices transform between. (2 points each)



6) Visibility (10 Points)

a) Bob, a new student in computer graphics, asks you how to solve a strange behavior that he is seeing on his project. He has a scene as shown in the figure below. He expects to see the big circle on his screen, but he only sees the triangle. He mentions that he has a very old machine that doesn't have a lot of memory available and no graphics acceleration, so he needs an algorithm that doesn't use a lot of memory to solve this problem. Explain an algorithm that will solve Bob's problem. (2 points)



b) Alice, Bob's teammate, comes back to you and points out that, although your previous solution works, it runs really slow on her machine. Alice has a newer machine with a lot of memory (but no graphics acceleration). Complete Alice's pseudo-code using a different algorithm that will work faster on Alice's machine. (4 points)

```
// Initialization
object = parse_object(file)
```

```
// Draw object
for each vertex in object
        x,y,z,c = GetScreenCoordinatesAndColor(vertex)
```

c) Alice is very happy that your latest algorithm works very well on her machine. However, she noticed that when she moves the circle close to the triangle, some flickering occurs when she moves the camera around. What is this problem called? Give two different solutions for the case in which the circle is close to the triangle and explain why they solve the issue. (4 points)

7) Illumination (10 Points)

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

b) Which three types of reflection (not light sources) does the simplified illumination model we covered in class distinguish? (3 points)

c) 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 points)

d) 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 points)

8) Lights (10 Points)

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

b) Name the three additional parameters spot lights have compared to point lights? (3 points)

c) How do the three distance attenuation options for point lights we covered in class differ from one another? (3 points)

d) Why are there multiple options for distance attenuation? (2 points)