University of California San Diego
Department of Computer Science
CSE167: Introduction to Computer Graphics
Fall Quarter 2014
Midterm Examination #1
Thursday, October 30th, 2014
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	12	
2	9	
3	10	
4	9	
5	8	
6	10	
7	10	
8	12	
9	10	
Total	90	

1. Vector Properties (12 Points)

a) Given two vectors **a** and **b** in three-dimensional space, how do you calculate the angle between these vectors? (4 points)

b) If the vectors **a** and **b** were two sides of a triangle, how would you find the area of the triangle (employing the cross product)? (4 points)

c) How do two vectors **c** and **d** in 3D space have to be oriented with respect to one another to:

- maximize the dot product? (2 points)

- minimize the absolute value of the dot product ($|c \cdot d|$)? (2 points)
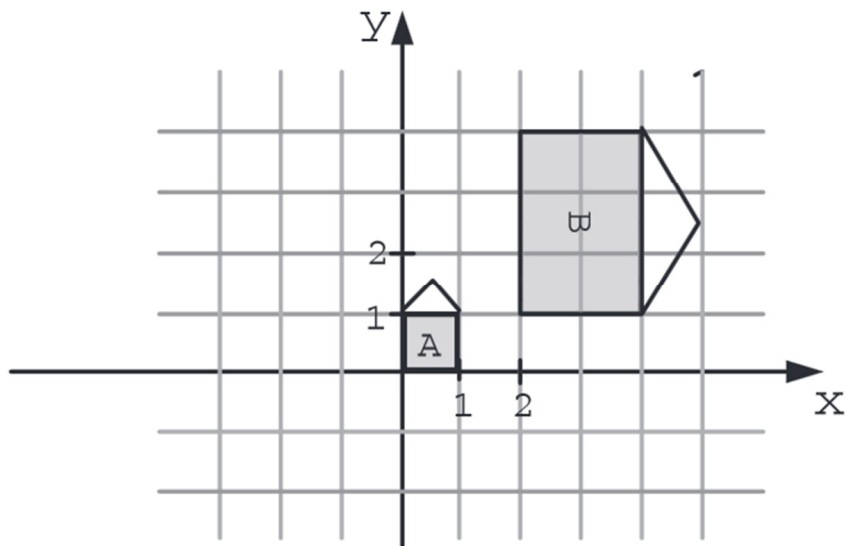
2. Coordinate Systems (9 Points)

a) Given two non-parallel three-dimensional vectors **a** and **b**, come up with two new vectors which form a Cartesian, right-handed coordinate system such that vector **b** forms the positive x-axis in the newly created coordinate system (answer in terms of **a** and **b**). (7 points)

b) Why is it important that the vectors from a) be non-parallel? (2 points)
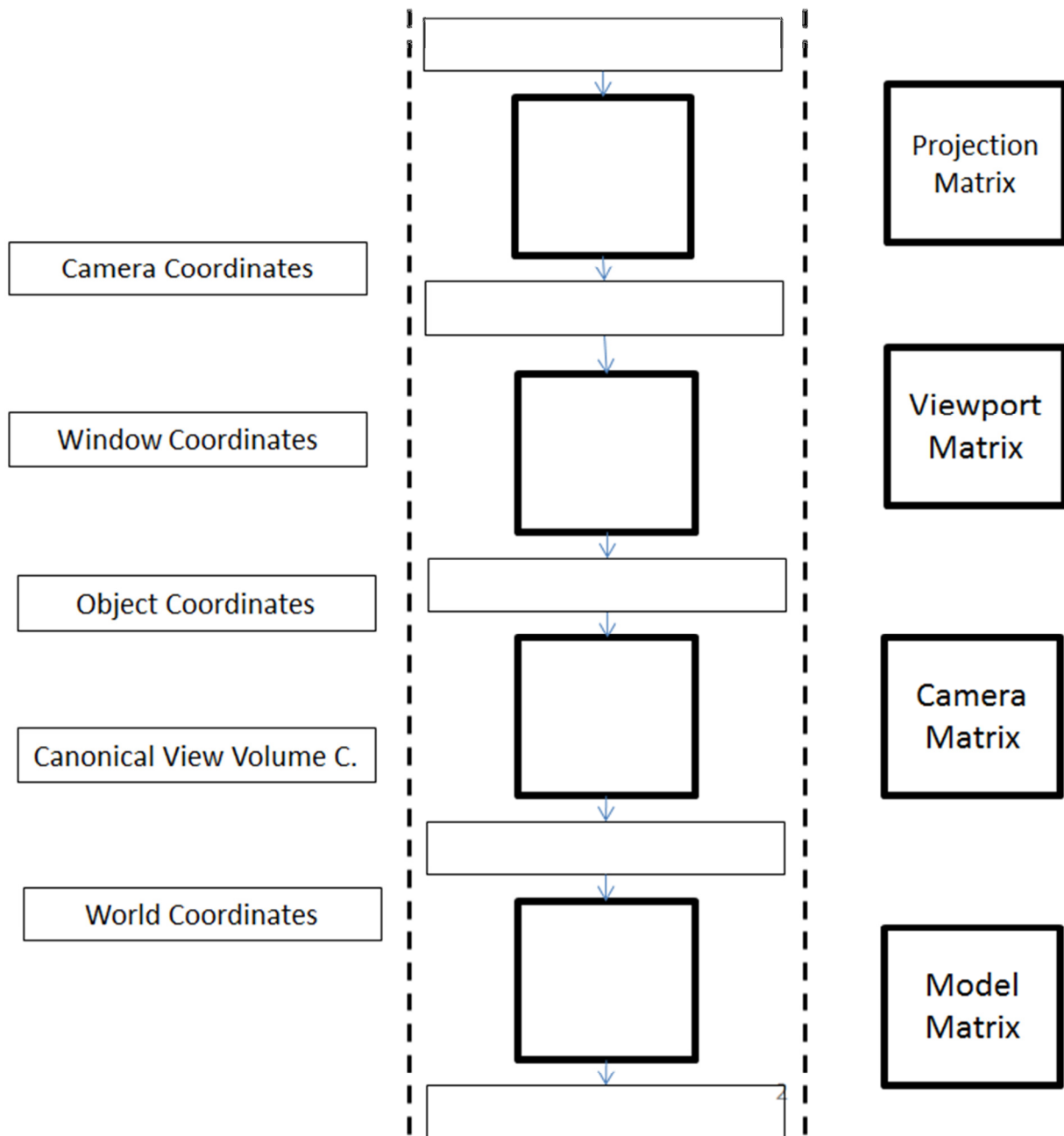
3. Affine Transformations (10 Points)

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.

4. Vertex Transformation (9 Points)

Fill in the Complete Vertex Transformation flow chart below (between the dashed lines) with the correct names for matrices (square boxes) and coordinate systems (flat boxes). You can save time by drawing arrows for where the respective elements (left and right of the dashed lines) go.

Camera Coordinates

Window Coordinates

Object Coordinates

Canonical View Volume C.

World Coordinates

Projection Matrix

Viewport Matrix

Camera Matrix

Model Matrix

5. OpenGL Pipeline (8 Points)

Put the following stages of the OpenGL pipeline in the correct order by copying them into their respective boxes below:
Rasterization, **Modeling and Viewing Transformation**, **Projection**, **Shading**.

Scene Data

Image
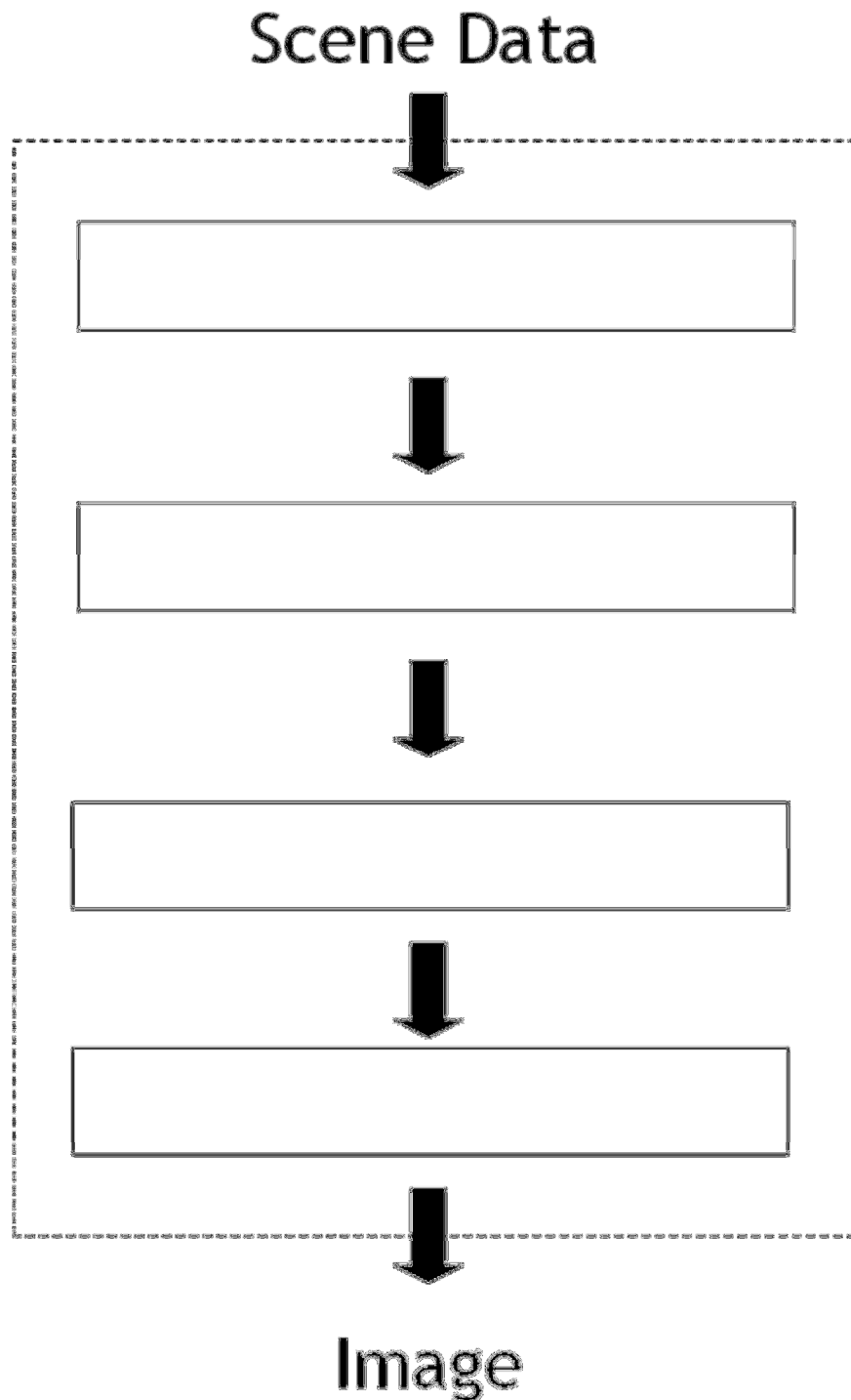
6. OpenGL Commands (10 Points)

a) What does this command do: glutDisplayFunc(display)   (2 points)

b) What does this command do: glMatrixMode(GL_PROJECTION)   (2 points)

c) Consider this sequence of calls:

```
glColor3f(1,1,1);
glColor3f(0,1,0);
glVertex3f(1,1,1);
glVertex3f(2,2,2);
```

- What color is the vertex (1,1,1)?   (2 points)

- What color is the vertex (2,2,2)?   (2 points)

d) Which one of the following code fragments would you be more likely to see? Why?
(2 points)

This?

```
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();
glMatrixMode(GL_PROJECTION);
glLoadIdentity();
glOrtho(2.0, 8.0, 0.0, 8.0, -0.5, 2.5);
```

Or this?

```
glMatrixMode(GL_PROJECTION);
glLoadIdentity();
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();
glOrtho(0.0, 8.0, 0.0, 8.0, -0.5, 2.5);
```

7. Shading (10 Points)

a) What does BRDF stand for? Which two directions are input to the BRDF? (3 points)

b) What are the three components of OpenGL's local illumination model? Which of the three represent light reflections off of a sheet of paper? (4 points)

c) For mirror reflections: given incident vector **L** and normal vector **N**, give a relation for finding reflection vector **R** in terms of **L** and **N**. Is the angle of reflection equal to the angle of incidence? (3 points)

8. Lights (12 Points)

a) Name two differences between directional lights and point lights. (4 points)

b) Which two additional parameters do OpenGL spot lights have compared to point lights? (4 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)

9. Texture mapping (10 Points)

Describe all the steps needed to create and apply a texture map in OpenGL. The exact name/syntax of function calls is not as important as the concepts.