November 20, 2014 Name _____

CS445 Exam 2

Fall 2014

1.	(max = 15)	5.	(max = 21)
2.	(max = 8)	6.	(max = 16)
3.	(max = 10)	7.	(max = 16)
4.	(max = 14)		
Final Score:		(max=100)	

Please try to write legibly. The instructor's complete failure to decipher what you write will be considered an incorrect answer.

In all of the following problems, assume the following terminology

Scale: **$S(s_x,s_y,s_z)$**

Translation: **T(x,y,z)**

Rotation: **$R_X(\Theta)$, $R_Y(\Theta)$, $R_Z(\Theta)$**

Object coordinate system: **OCS**

World coordinate system: **WCS**

Camera coordinate system: **CCS**

Model matrix: **M**

View matrix: **V**

Rotational component of V, i.e. the view rotation matrix: **V_{rot}**

Location of the camera *expressed in the WCS*: **Eye**

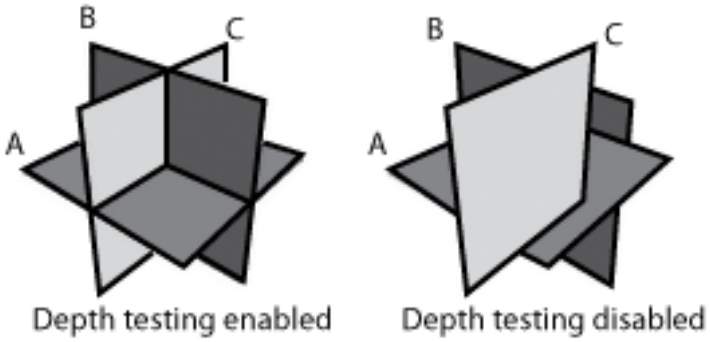
A point **P** expressed in the OCS will be written as **P_{ocs}**. Similarly, points in the WCS or CCS will be written as **P_{wcs}** and **P_{ccs}**, respectively.

1. (5 pts each, 15 pts total) **Fly-Through Navigation**: Suppose you are flying a plane through a scene with the camera attached to the front of plane (as was done in the lab).
   a) In the lab, how did you update V_{rot} and Eye in order to turn your plane some small angle Θ to the right?

   b) How did you update V_{rot} and Eye in order to move the camera forward by some small amount α?

   c) How did you calculate the view matrix, V, from Eye and V_{rot}?

2. (8 pts total) **Blending**: In openGL, suppose you render 3 perpendicular planes, A, B, and C. If you have enabled depth testing, you get the picture on the left. If you disable depth testing, you get the picture on the right.



Depth testing enabled Depth testing disabled

a) (2 pts) Based on the pictures, which plane did openGL draw first, second, and last?

First: _____

Second: _____

Last: _____

b) (6 pts) Explain why the images look the way they do. Please use complete sentences.

3. (5 pts each, 10 pts total**) Gouraud vs Phong Shading**: *Please answer in complete sentences.*
   a) What is the difference between Phong and Gouraud Shading?

   b) Which shading method (Gouraud vs Phong) in generally better and why?

4. (14 pts total) **Shaders**: *Please answer in complete sentences.*

a) (3 pts) What is a fragment?

b) (3 pts) What is the difference between a uniform variable and attribute variable?

c) (3 pts) What calculations are typically done in the vertex shader and what are done in the fragment shader?

d) (5 pts) What are at least 5 operations that opengl performs between the vertex and fragment shader?

5. (3 pts each. 21 pts total) **Coordinate Transformations, Part 1:** Match each of the items (a-g) with one of choices A-J.

a) $(0,0,0,1)^T_{CCS}$ Ans: _____

b) $(0,0,0,1)^T_{OCS}$ Ans: _____

c) $(0,0,0,1)^T_{WCS}$ Ans: _____

d) V $(0,0,0,1)^T$ Ans: _____

e) M $(0,0,0,1)^T$ Ans: _____

f) M V $(0,0,0,1)^T$ Ans: _____

g) V M $(0,0,0,1)^T$ Ans: _____

Fill in the above answers with one of the letter choices below

A) The location of the camera as represented in the OCS.
B) The location of the camera as represented in the WCS.
C) The location of the camera as represented in the CCS.
D) The origin of the world as represented in the OCS.
E) The origin of the world as represented in the WCS.
F) The origin of the world as represented in the CCS.
G) The center of the object as represented in the OCS.
H) The center of the object as represented in the WCS.
I) The center of the object as represented in the CCS.
J) None of the above - The expression has no obvious interpretation.

6. (16 pts total) **Coordinate Transformations, Part 2:** How do you implement the following actions? Your answer should be expressed as the product of one or more transformations (e.g. S, T, R, M, V, V_{rot}) multiplied by $\mathbf{P_{ocs}}$, where $\mathbf{P_{ocs}}$ is some point in the **OCS**. Please take your time to read the question carefully – these are tricky!

Example:

A rotation of $\boldsymbol{P_{ocs}}$ by Θ about the OCS x-axis, as expressed in the OCS.

$$Ans = \boldsymbol{R_x(\Theta)\, P_{ocs}}$$

a) (3 pts) A rotation of $\mathbf{P_{ocs}}$ by Θ about the **OCS** x-axis, as expressed in the **CCS**.

Ans: _____

b) (3 pts) A rotation of $\mathbf{P_{ocs}}$ by Θ about the **WCS** y-axis, as expressed in the **CCS**.

Ans: _____

c) (5 pts) A uniform scale by 2 of $\mathbf{P_{ocs}}$ about a point $\mathbf{Q_{ocs}}$, as expressed in the **WCS**.

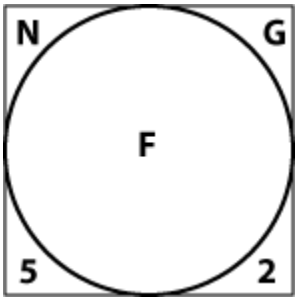
Ans: _____

d) (5 pts) A uniform scale by 2 of $\mathbf{P_{ocs}}$ about a point $\mathbf{Q_{wcs}}$, as expressed in the **CCS**.

Ans: _____

7. (4 pts each, 16 pts total) **Texture Coordinates**: Suppose you want to use the image below as a texture on a square (e.g. a quad modeled as 2 triangles, although this doesn't matter for this problem).

image to be used as a texture object:



For each of the following possible texture coordinates, draw how the texture will look on the square. *Assume that the texture wrap parameter is set to repeat in both dimensions*.