CPSC 314
Final Exam

April 22, 2006

Answer the questions in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page.

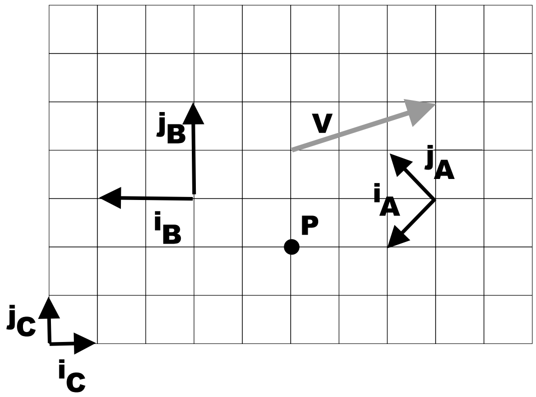
Name: ____________________

Student Number: ____________________

Question 1	/ 6
Question 2	/ 6
Question 3	/ 4
Question 4	/ 10
Question 5	/ 8
Question 6	/ 5
Question 7	/ 7
Question 8	/ 6
TOTAL	/ 52

This exam has 8 questions, for a total of 52 points.

1. Coordinate Frames



(a) (2 points) Express point P and vector V coordinate frame A.

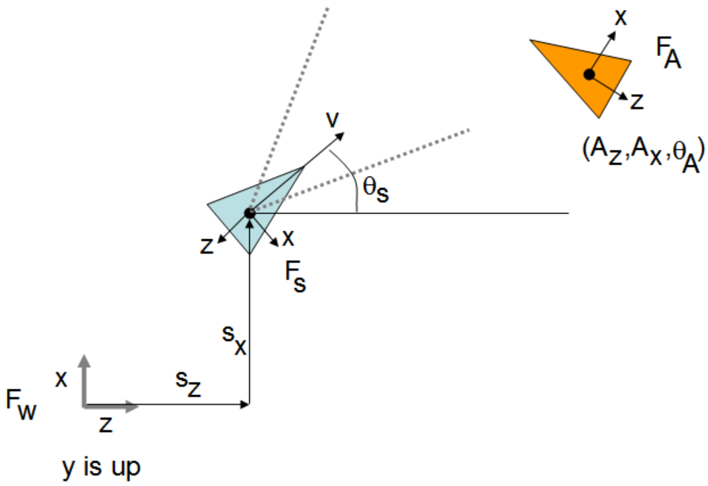
(b) (2 points) Find the 3×3 homogeneous transformation matrix which takes a point from frame A coordinates and expresses it in terms of frame B coordinates. I.e., determine $M_{A \to B}$, where $P_B = M_{A \to B} P_A$.

(c) (2 points) Suppose that coordinate frame C as shown on the figure is the current coordinate frame. The following OpenGL transformations are then applied. Sketch the new coordinate frame on the figure and label it as coordinate frame D.

```
glRotatef(90,0,0,1);
glTranslatef(1,-2,0);
```

2. Transformations

You are developing a game that involves spaceships. As shown below, the spaceship controlled by the player has position (s_z, s_x) and an orientation given by θ_s. You would like to display the world as seen from the player's spaceship, i.e., a first-person point of view. Note that the viewing coordinate system corresponds directly to the spaceship's coordinate system, with the viewer looking down the negative z-axis in the viewing direction v.



(a) (2 points) Determine an expression for M_{WS}, where $P_W = M_{WS} P_S$, i.e., it takes a point from local spaceship coordinates (equivalently the eye coordinates) and re-expresses that point in terms of world coordinates. Express this as a compound series of translations and rotations.

(b) (4 points) You would like to draw spaceship **A** as seen from the point of view of your spaceship. The position and orientation of spaceship **A** are given by (A_z, A_x, θ_A). Determine an expression for M_{MV}, the required modelview matrix that needs to be applied when drawing spaceship **A**. I.e., $P_{eye} = P_S = M_{MV} P_A$. Write the full sequence of OpenGL calls that are needed to create this modelview matrix. You may find your answer from part (a) helpful.

3. Local Illumination

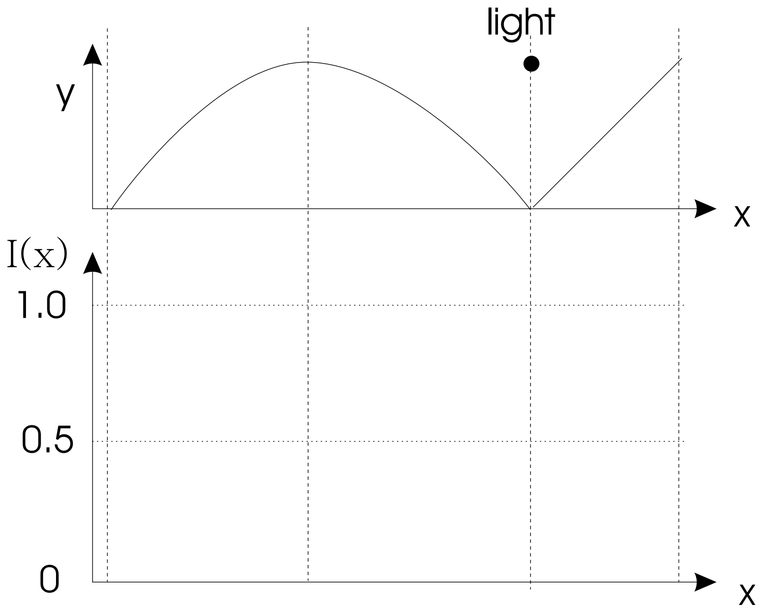
(a) (3 points) Sketch the illumination that would be computed for the following scene using the Phong illumination model. The scene is viewed from far above the surface and is lit by the single light source L. Draw 3 sketches, one for each of ambient, diffuse, and specular illumination. You do not need to draw the total illumination.

The Phong illumination model is given by:

$$I = k_a I_a + k_d I_d (N \cdot L) + k_s I_s (R \cdot V)^n$$

and the values of the various parameters are:

$$I_a = I_d = I_s = 1.0, k_a = 0.2, k_d = 0.8, k_s = 0.7, n = 200.$$



(b) (1 point) Why is it hard to recreate realistic illumination models of materials such as skin, porcelain, milk, and marble ?

4. Short Answer
   (a) (1 point) Name the three parameters that are commonly used to define the viewing transformation, i.e., to specify the position and orientation of the camera in the world.

   (b) (1 point) True or False: Decreasing the field of view will result in a 'zooming' effect, i.e., the objects at the center of the image will appear larger.

   (c) (1 point) True or False: The implicit equation for any given plane, $Ax + By + Cz + D = 0$ is unique, i.e., for any given plane, there is only one possible set of values for A, B, C, D.

   (d) (1 point) Name three techniques that are commonly used for rendering shadows.

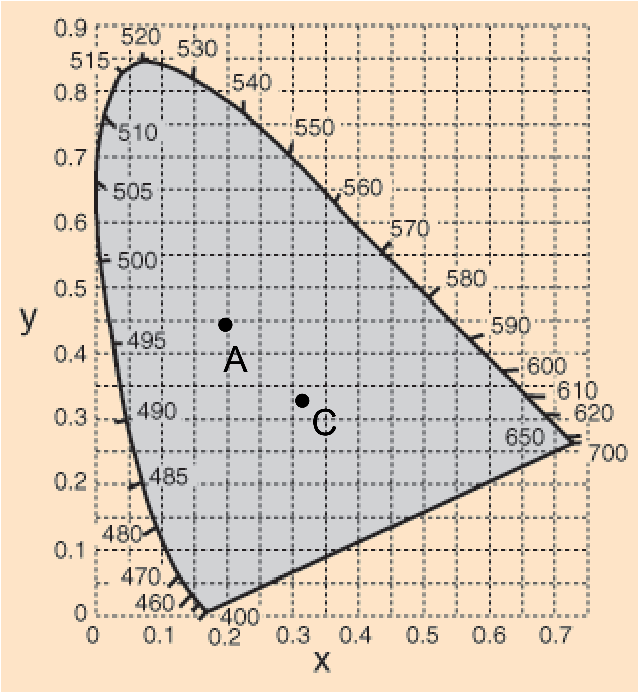
   (e) (1 point) What is photon mapping? Given an example of when it is typically used.

   (f) (1 point) True or False: The three barycentric coordinates always sum to 1 for a point in a triangle.

   (g) (2 points) Give four uses for the memory that is commonly found on graphics cards.

   (h) (2 points) In Assignment 2 you implemented triangle scan conversion. Give the psuedocode for scan-converting a circle of radius r and centred at (x_0, y_0).

5. Colour Representation



Note: 'C' indicates the 'white point'.

(a) (2 points) Sketch a typical RGB monitor gamut on the CIE chromaticity diagram shown above. Label each of the R, G, and B locations.

(b) (1 point) What is the dominant wavelength of the colour A on the chromaticity diagram?

(c) (1 point) Compute an estimate of the saturation of colour A.

(d) (1 point) Given the colours on the rainbow (roughly speaking: red, orange, yellow, green, blue, violet), label these spectral colours on the diagram.

(e) (1 point) It is sometimes argued that 'cyan' should also be listed as one of the colours of the rainbow. Knowing that cyan is complementary to red, label on the diagram where (approximately) spectral cyan would be located on the diagram.

(f) (1 point) What mix of RGB can be used to create yellow ?

(g) (1 point) A cyan coloured surface absorbs red light and reflects green and blue light. What colour would result from illuminating a cyan surface with yellow light?

6. (5 points) Transforming Normals

   Given a point P, it can be transformed to a new coordinate system using $P' = MP$, where $P = [x \;\; y \;\; z \;\; 1]^T$. In this question, you will determine how to transform a plane equation, thereby also telling us how to correctly transform normals between coordinate systems. The untransformed plane equation, $Ax + By + Cz + D = 0$ can be written as $N^T P = 0$, where $N^T = [A \;\; B \;\; C \;\; D]$ and P is a point expressed in homogeneous coordinates. After the transformation, we require a similar plane equation to hold, namely $N'^T P' = 0$, where $P' = MP$ is the transformed point, and N' is the set of transformed plane equation parameters.

   The new plane equation parameters can be obtained as a function of the original plane equation parameters using $N' = QN$, where Q is an (unknown) 4×4 transformation matrix. By using the before-and-after plane equations and the known point transformations, $P' = MP$, determine the matrix Q required to transform plane equation parameters. What does this tell us about how to transform a normal ?

7. Animation

   (a) (1 point) How many frames per second are typically used in film? North American television ? for motion capture ?

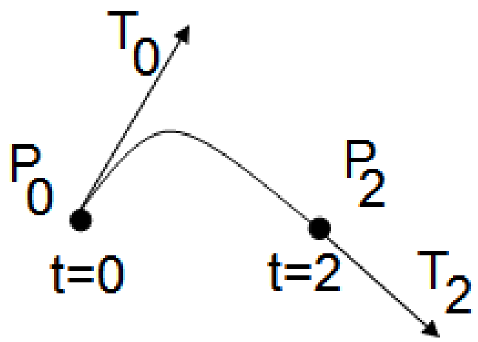
   (b) (2 points) Give three very different techniques that could be used to create the animated motion of a character falling to the ground.

   (c) (2 points) List three different kinds of motion capture technology.

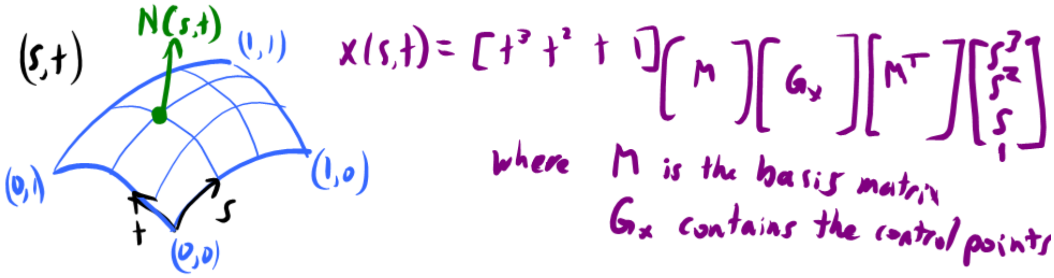
   (d) (2 points) You are hired by a company to produce the animated motion for a basketball player in their game. You convince a friend to put on a motion capture suit and capture some of his or her motions. There are many problems that you might encounter in processing the data or trying to apply the data to animating the character in a game. List three of these problems.

8. Parametric Curves

   (a) (4 points) A Hermite curve is modified to use $t \in [0, 2]$ instead of the usual $t \in [0, 1]$, as shown below. Determine the modified Hermite basis matrix. Do not bother with numerically inverting any matrices.



(b) (2 points) The x-coordinate, $x(s,t)$ of a point on a parametric patch is defined as follows, with $y(s,t)$ and $z(s,t)$ being defined in a similar fashion:



Show how one might compute the normal $N(s,t)$ at given values of s and t.