HÁSKÓLINN Í REYKJAVÍK
REYKJAVÍK UNIVERSITY

Computer Graphics

Teacher: **Kári Halldórsson**

Date: **21. November 2007**
Time: **09:00 – 12:00**

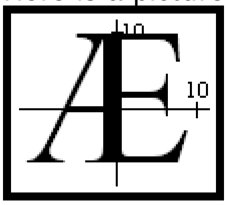
Alowed resources: Pocket calculator and the attached formula sheet
The front and the back of the last page can be used if you run out of space.

Name ____

SSN ____

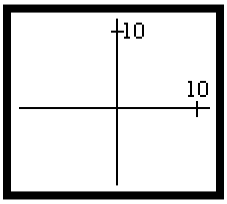
1. (12%)

Here is a picture. The axes are not a part of the picture being transformed.

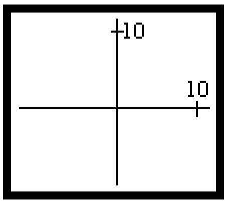


The points in this picture are all multiplied with a certain transformation matrix to get another picture. Approximate how the new picture looks like if the transformation matrix is:

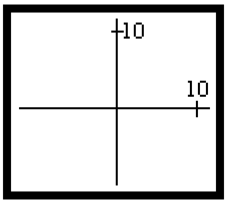
a) (4%) $\begin{pmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{pmatrix}$



b) (4%) $\begin{pmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$



c) (4%) $\begin{pmatrix} 1 & 0 & -5 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$



2. (5%)

Examine the following code:

```
glEnable(GL_DEPTH_TEST);
```

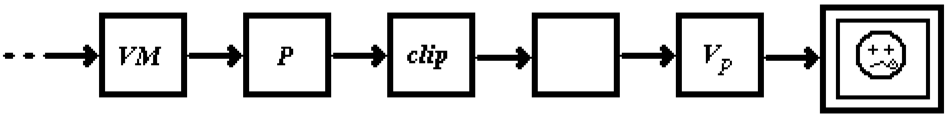
Briefly describe where in the OpenGL graphic pipline this has an effect on its calculations and how those calculation change.

3. (3%)
Here is a picture of the OpenGL graphic pipeline. The picture shows the path a model goes from being defined in a program to being displayed on screen. Between the boxes you find coordintaes at certain positions, but the boxes indicate the changes made to them. Using the letters a – c mark the following in the picture:

a) (1%) The lens width appears in this matrix

b) (1%) Here all coordinates have values between [-1;1]

c) (1%) Here coordinates are transformed according to the position and orientation of the camera



4. (10%)
Briefly describe (color) blending in OpenGL. Where does it occur, what kind and which values affect it.

5. (40%)
Values are entered this way into a matrix that transforms cooridnates relative to position and orientation of a camera:

$$\begin{bmatrix} u_X & u_Y & u_Z & -eye \circ u \\ v_X & v_Y & v_Z & -eye \circ v \\ n_X & n_Y & n_Z & -eye \circ n \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

a) How does this matrix look like after executing the following code ? (20%) (and what is this matrix called).

```
glLoadIdentity();
gluLookAt(4.0, 7.0, -2.0, 0.0, 1.0, 5.0, 0.0, 1.0, 0.0);
```

b) Describe what happens when the following code is executed and show the values entered into the appropriate matrix. (10%)

```
gluPerspective(60.0, 1.25, 10.0, 110.0);
```

c) According to the results of a) og b), determine if the point defined by the following code will appear on the screen. Argue your case using the same calculations as OpenGL would use to determine this. (10%)

```
glBegin(GL_POINTS);
      glVertext3f(-25.0, -12.0, 10.0);
glEnd();
```

6. (10%)

There is one light source in a lighting model of a OpenGL program. It has the ambient value (0.0, 0.0, 0.0), diffuse value (0.6, 0.4, 0.7), specular value (0.7, 0.7, 0.7) and is positioned at the point (4.0, 7.0, -2.0).

Additionally we have a global ambient factor of (0.2, 0.2, 0.2) in the model.

A camera is positioned in the point (3.0, 5.0, 4.0) and is directed at the point P.

P is defined with the color values: ambient (0.1, 0.3, 0.2), diffuse (0.3, 0.6, 0.3) and specular (0.5, 0.6, 0.6) and a shininess coefficiant of 13. It has the position (3.0, 3.0, 2.0) and the normal (0.0, 1.0, 0.0).

What will be the red color value of point P on the screen?

7. (10%)
Stuðlar í bezier ferlum fást með því að leysa upp og þátta Bernstein margliður:
$B^L = ((1-t)+t)^L$ fyrir bezier feril með $L+1$ stýripunktum.

Myndavél á að ferðast í tilteknu atriði eftir bezier ferli með 4 stýripunktum.
$P_1 = (3, 5, 6), \quad P_2 = (2, 10, 3), \quad P_3 = (-4, 8, 7), \quad P_4 = (0, 4, 11)$
Ferillinn á að hefjast 15 sekúndum eftir að keyrsla hefst (tíminn 15000) og honum á að ljúka 45 sekúndum eftir að keyrsla hefst (á tímanum 45000). Hvar er myndavélin staðsett í ramma sem teinaður er á tímanum 25000 (25 sekúndum eftir að keyrsla hefst) ?

Bezier curve coefficients can be calculated by expanding and then factoring Bernstein polynomials:

$B^L = ((1-t)+t)^L$ for a bezier curve with $L+1$ control points.

A camera in a certain scene is supposed to move along a bezier curve with 4 control points.
$P_1 = (3, 5, 6), \quad P_2 = (2, 10, 3), \quad P_3 = (-4, 8, 7), \quad P_4 = (0, 4, 11)$
The motion is supposed to start 15 seconds after the application gets executed (at time 15000) and it is supposed to stop 45 seconds after execution (at time 45000).
Where is the camera located when a frame is rendered 25 seconds after the execution of the application (at time 25000).

8. (10%)

A square is drawn inside a display function. A texture ID has been acquired from OpenGL and a corresponding texture has been loaded. The texture looks like 9 parts of equal size, arranged in a 3x3 pattern (like the numeric keys on a keyboard). Add to the following code what's missing to project the center part of the texture onto the rectangle being drawn. (the space below corresponds to the size of the page and not the size of the solution).

```
int textureID;  //Id acquired from OpenGL and texture has been loaded

//The following is somewhere inside display()
//Add to this part of the code.



glBegin(GL_QUADS);


      glNormal3f(0.0, 1.0, 0.0);


      glVertex3f(5.0, -1.0, 4.0);


      glVertex3f(8.0, -1.0, 4.0);


      glVertex3f(8.0, -1.0, 7.0);


      glVertex3f(5.0, -1.0, 7.0);


glEnd();
```

Hey, hey, hey!! Extra points!!! (3%)

A: Hey, Leatherface and I do all the work here. He does the killing, I do the grave digging. You don't do anything. You're just a cook!

B: Shut your mouth!

Who are talking and in which movie?