Computer Graphics
Final exam 2004

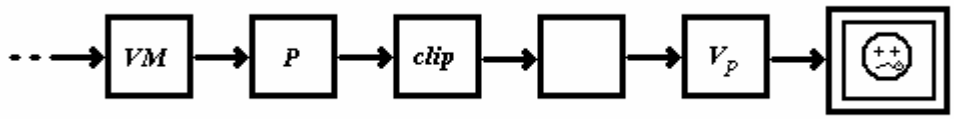
1. **The OpenGL state machine**
   What are the following OpenGL commands for. Where and how do they influence OpenGL calculations.

   a) glEnable(GL_NORMALIZE) (4%)

   b) glEnable(GL_DEPTH_TEST) (4%)

   c) glEnable(GL_ALPHA_TEST) (4%)

2. Here is a picture of the OpenGL graphics pipeline. The picture shows the way a model or scene goes through the pipeline starting when it's defined and ending when the final result is displayed on the screen. Between the boxes coordinates are in certain states but the boxes themselves stand for changes made to the coordinates. Label the following items with the letters a – d:
   a) (2%) Lighting calculations are done here.
   b) (2%) glTranslate3f() will under most circumstances influence this matrix.
   c) (2%) Here all 3D coordinates in the system lie within a 2x2x2 cube.
   d) (2%) Here coordinates are transformed with regard to the camera's location.



3. **Window to viewport mapping and clipping**
   A 2D wrold window is defined with a lower left corner in (-3, -2) and an upper right corner in (3, 2). A viewport is defined with a lower left corner in (0, 0) and an upper right corner in (360, 240).
   A line with endpoints (-1, 0) and (2, 3) is drawn in the "world".
   What are the endpoints of the line that will be displayed within the viewport? (12%)

4. **Intersection between a ray and a plane**
   3 points, (-1, 3, 1), (1, 5, 0) and (3, 2, 2) all lie in one plane in 3D space.
   A ray is shot from the point (1, 1, -2) in the direction (0, 1, 3).
   Show that the ray hits the plane and in which point that happens.
   (12%)

5. OpenGL transformation matrices

Here is a short part of an OpenGL program.

```
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();
gluLookat(-3, 4, 5, 0, 2, -3, 0, 1, 0);
glRotate(45, 1, 0, 0);
glMatrixMode(GL_PROJECTION);
glLoadIdentity();
gluPerspective(60.0, 1.25, 2.0, 12.0);

glBegin( GL_POINTS );
   glVertex3f( 0, 2, -3 );
glEnd();
```

Which matrix is being changed and what will it look like after each of the following lines has been run?

a) gluLookat(-3, 4, 5, 0, 2, -3, 0, 1, 0)
(15%)

b) glRotate(45, 1, 0, 0)
(5%)

c) gluPerspective(60.0, 1.25, 2.0, 12.0)
(10%)

d) Will the point (glVertex3f(0, 2, -3)) show in the final picture? Use the same method OpenGL would use to determine.
(6%)

6. Texture mapping

Following is the function drawTexQuad which draws a quadrangle and covers it with a texture so that the textures corners map to the corners of the quadrangle. Which texture is to be used and other such things will already have been initialized when the function is called so that is irrelevant to the function. To simplify matters this function draws a quadrangle with edges parallel to the corrdinate system's axes.

```
void drawTexQuad(float left, float right,
                 float top, float bott) {
     glBegin(GL_QUADS);
          glTexCoord2f(0.0, 1.0);
          glVertex2f(left, top);

          glTexCoord2f(1.0, 1.0);
          glVertex2f(right, top);

          glTexCoord2f(1.0, 0.0);
          glVertex2f(right, bott);

          glTexCoord2f(0.0, 0.0);
          glVertex2f(left, bott);
     glEnd();
}
```

The function is to be changed so that it takes an integer parameter which states how many rows and columns the quadrangle should be divided into. The function should then draw the same qudrangle with the same texture so that it looks basicly the same except that it is drawn in many smaller units instead of a single polygon.
For instance: if the new parameter is 1 the outcome will be exactly the same as from the original function. If the parameter is 2 the quad will be drawn in 4 pieces (2x2).

a) If the change is done correctly it should not have any effect on the area the quadrangle covers or where texture coordinates will map to it. Why would someone still want to divide it into smaller pieces? (6%)

b) Why would someone also want to have a parameter to state how many pieces to divide into rather than decide the division beforehand? (6%)

c) Make these changes to the function. (8%)

```
void drawTexQuad( float left, float right,
                  float top, float bott,
                  int ________________ )
{

}
```