Answers to Assignment 3

Qn 1

```
GLdouble  XC;

glMatrixMode (GL_MODELVIEW);
glLookAt (XC, 0, 100, 20, 0, 20, 0, 1, 0);


void animate ( void )
{
      double      t;
      double operation_time  = 2000.0;

      t = glutGet (GLUT_ELAPSED_TIME);

      XC = 100.0 + 100.0 * (1 - pow(cos ( PI * t/(2.0 * operation_time) ), exponent) );

      glutPostRedisplay ();
}
```


Qn 2

a)

```
glEnable (GL_LIGHTING);
GLdouble V1 [ ] = {0.0, 1.0, 0.0, 0.0}
GLdouble V2 [ ] = {0.5, 0.5, 0.5, 1.0}
glLightfv (GL_LIGHT1, GL_POSITION, V1);
glEnable (GL_LIGHT1);
glLightfv (GL_LIGHT1, GL_AMBIENT, V2);
glLightfv (GL_LIGHT1, GL_DIFFUSE, V2);
glLightfv (GL_LIGHT1, GL_SPECULAR, V2);
```

b)

```
GLdouble V3 [ ] = {0.1, 0.1, 0.1, 1.0}
GLdouble V4 [ ] = {0.3, 0.3, 0.3, 1.0}
GLdouble V5 [ ] = {0.9, 0.9, 0.9, 1.0}
glMaterialfv (GL_FRONT_AND_BACK, GL_AMBIENT, V3);
glMaterialfv (GL_FRONT_AND_BACK, GL_DIFFUSE, V4);
glMaterialfv (GL_FRONT_AND_BACK, GL_SPECULAR, V5);
glMaterialf  (GL_FRONT_AND_BACK, GL_SHININESS, 2.0);
```

c)

$L = (0,1,0)$
$I_a = 0.5$
$I_l = 0.5$
$k_a = 0.1$
$k_d = 0.3$
$k_s = 0.9 \quad n_s = 2$

$$V = |(100,0,100) - (0,0,0)| = \left(\frac{1}{\sqrt{2}}, 0, \frac{1}{\sqrt{2}}\right)$$

$$N = \left(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}, 0\right)$$

$$R = 2(N \cdot L)N - L = (1,0,0)$$

$$I = k_a I_a + k_d I_l (N \cdot L) + k_s I_l (V \cdot R)^{n_s}$$

$$= (0.1)(0.5) + (0.3)(0.5)\left(\frac{1}{\sqrt{2}}\right) + (0.9)(0.5)\left(\frac{1}{\sqrt{2}}\right)^2$$

$$= 0.381066017$$

d) Phong shading

Because $k_s \gg k_d, k_a$, the object is specular. Phong shading will make sure that the specular highlight is not missing. (Or any other reasonable answer.)

Qn 3

a)

$$I_D = \frac{1}{5} I_C + \frac{4}{5} I_A = \frac{1}{5}(1.0) + \frac{4}{5}(0.5) = 0.6$$

b)

$$x_D = \frac{1}{5} x_C + \frac{4}{5} x_A = \frac{1}{5}(10) + \frac{4}{5}(0) = 2$$
$$x_E = 10$$

$$N_P(x) = \frac{x-2}{8} N_E + \frac{10-x}{8} N_D = \frac{(x-1)-2}{8} N_E + \frac{10-(x-1)}{8} N_D + \frac{N_E - N_D}{8}$$
$$= N_P(x-1) + \frac{(0,1,-1)}{8}$$

Qn 4

a)

$N \cdot V = 0.5 > 0 \implies$ Front face

Back face detection (or culling)

b)

i) Since the number of Z buffer operations is proportional to the number of pixels being projected, the number of Z buffer operations are

$$(30)(100)(100)(500) = 1.5 \times 10^8$$

ii) For each of the 2560×1440 pixel, we send out a pixel ray and test whether it intersects the 30 spheres, therefore the number of intersection calculations are

$$(2560)(1440)(30) = 1.10592 \times 10^8$$

iii) For each of the 30 objects, there are 100×100 quadrilaterals or $100 \times 100 \times 2$ triangles. Thus, the number of intersection calculations are

$$(2560)(1440)(30)(100)(100)(2) = 2.21184 \times 10^{12}$$