CSE 4200 Homework 2- Spencer Wallace

Summary:

All parts completed successfully. Because I was able to complete all parts, I am giving myself a full score **60/60**.

Part 1) (10 points) For each of the following triplets of points, find the normal vectors manually to the plane (if it exists) that passes through the triplet. Show your steps.

a. **P1**(1, 1, 1), **P2**(1, 2, 1), **P3**(3, 0, 4)

A = P2 – P1 = (1,2,1) - (1,1,1) = (0,1,0)
B = P3 – P1 = (3,0,4) - (1,1,1) = (2,-1,3)
n = AxB
|0 1 0| = i(3-0) - j(0-0) + k(0-2) = 3i – 2k = **(3,0,-2)**
|2 -1 3|
n = n/|n| = (3,0,-2)/$(3^2+0+(-2)^2)^{1/2}$ = (3,0,-2)/$(13^{1/2})$ = **(0.832, 0, -0.555) <= normalized**

b. **P1**(6, 3, -4), **P2**(0, 0, 0), **P3**(2, 1, -1)

A = P2 – P1 = (0,0,0) - (6,3,-4) = (-6, -3, 4)
B = P3 – P1 = (2,1,-1) - (6,3,-4) = (-4, -2, 3)
n = AxB
|-6 -3 4| = i(-9 - -8) - j(-18 - -16) + k(12 - 12) = -i – -2j = **(-1,2,0)**
|-4 -2 3|
n = n/|n| = (-1,2,0)/($(-1)^2+2^2+0)^{1/2}$ = (-1,2,0)/$(5^{1/2})$ = **(-0.447, 0.894, 0) <= normalized**

(You may check your answer using the program you wrote in the lab.)

Find the normalized normal to the plane 5x - 3y + 6z = 7 and determine if the points P1 = (1, 5, 2) and P2 = (-3, -1, 2) are on the same side of the plane.

n = n/|n| = (5, -3, 6)/($5^2 + (-3)^2 + 6^2)^{1/2}$ = (5, -3, 6)/$(70^{1/2})$ = $\left(\frac{5}{\sqrt{70}}, \frac{-3}{\sqrt{70}}, \frac{6}{\sqrt{70}}\right)$

Part 2) (10 points) Find the normalized normal at the point (1, 2, 3) for each of the following two cases:

a) A sphere: $x^2 + y^2 + z^2 = 14$

(1,2,3) – (0,0,0) = (1,2,3)
n = n/|n| = (1,2,3)/$(1+4+9)^{1/2}$ = $\left(\frac{1}{\sqrt{14}}, \frac{2}{\sqrt{14}}, \frac{3}{\sqrt{14}}\right)$
b) A plane: 3x - 4y + 2z - 1 = 0

“For a plane, one perpendicular direction is the same for every point on the surface” – Notes pt.6

n = n/|n| = (3,-4,2)/$(9+16+4)^{1/2}$ = $\left(\frac{-3}{\sqrt{29}}, \frac{-4}{\sqrt{29}}, \frac{2}{\sqrt{29}}\right)$

Part 3) (10 points) A robust method to find the normal to any polygon with N vertices is called the Newell's method.

a) Apply the Newell's method to a. of Question 1, and see whether you get the same answer.

(1,1,1) (1,2,1) (3,0,4)

Nx = (1-2)*(1+1) + (2-0)*(1+4) + (0-1)*(4+1)= -2 + 10 - 5 = **3**
Ny = (1-1) **0** + (1-4)*(1+3) + (4-1)*(3+1)= 0 + -12 + 12 = **0**
Nz = (1-1) **0** + (1-3)*(2+0) + (3-1)*(0+1) = 0 + -4 + 2 = **-2**
Using Newell’s method does give the same answer ✓

b) Find the normal to the polygon (0, 0, 3), (3, 0, 0), (2, 2, -1), (-1, 5, -1), (1, 1, 1)

Nx = (0-0) **0** + (0-2)*(0+ -1) + (2-5)*(-1 + -1) + (5-1)*(**0**) + (1-0)*(1+3) = 0 + 2 + 6 + 0 + 4 = **12**
Ny = (3-0)*(0+3) + (0 - -1)*(3+2) + (-1 - -1)**0** + (-1 – 1)*(-1+1)**0** + (1-3)*(1+0) = 9 + 5 + -2 = **12**
Nz = (0-3)*(**0**) + (3-2)*(0+2) + (2 - -1)*(2+5) + (-1 - 1)*(5+1) + (1 - 0)*(1+0) = 0 +2 + 21 + -12 +1 = **12**
N = (12,12,12)

Part 4) (10 points) Let vectors A = $(2, -1, 1)^T$ and B = $(1, 1, -1)^T$. Find

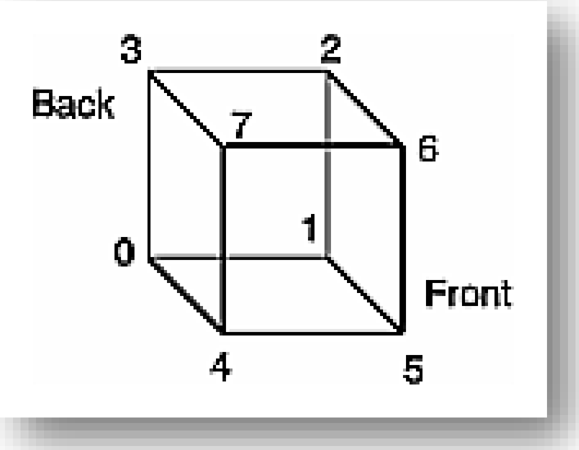
a. the angle between A and B,

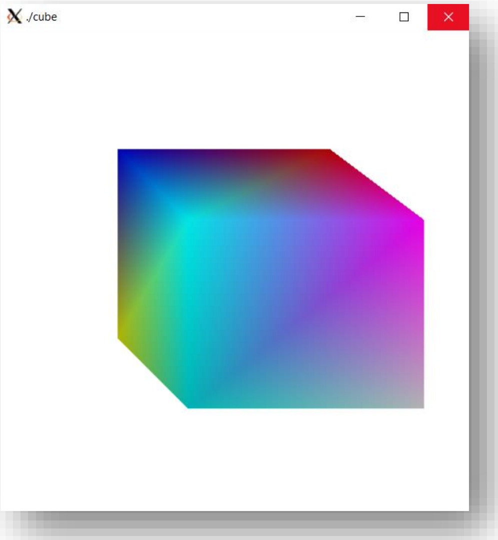
angle = cos^{-1}(A*B/(|A||B|))
A*B = 2 + -1 + -1 = **0**
(check that bottom isn’t 0 to check for undefined)
|A| = $(4 + 1 + 1)^{1/2}$ = $6^{1/2}$
|B| = $(1 + 1 + 1)^{1/2}$ = $3^{1/2}$
angle = cos^{-1}(0) = **90 degrees or 1/2π**

b. a unit vector perpendicular to both A and B.

AxB = | 2 -1 1 | = (1 - 1)i - (-2 – 1)j + (2 - -1)k = **$(0, 3, 3)^T$**
| 1 1 -1 |
V = v/|v| = (0,3,3)/$(0+9+9)^{1/2}$ = **$(0, 0.707, 0.707)^T$**

Part 5) (10 points) Use **glDrawElements()** to draw the following cube with each face having a different color.





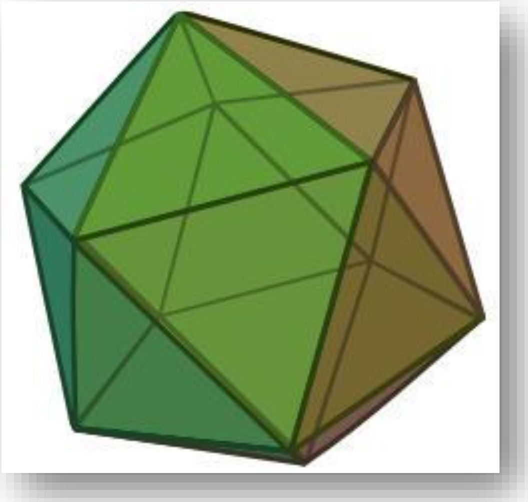
Code

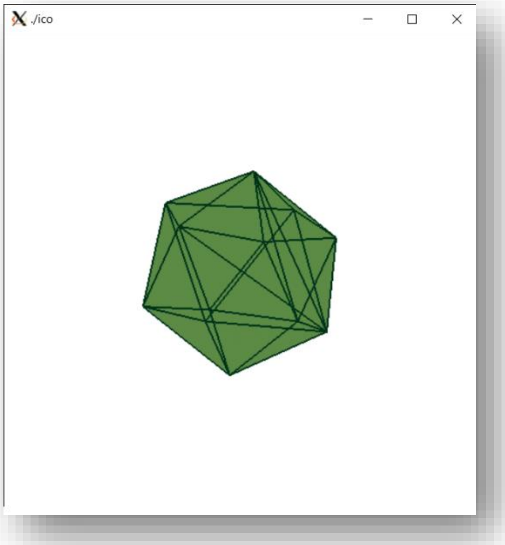
```
[007463307@csusb.edu@jb359-4 hw2]$ cat cube.cpp

#include <stdio.h>
#define GL_GLEXT_PROTOTYPES
#include <GL/gl.h>
#include <GL/glu.h>
#include <GL/glx.h>
#include <GL/glext.h>
#include <GL/glut.h>

GLfloat cube[] = {
	//back
	125, 175, 0.7, 0.7, 0,//0
	350, 175, 0.7, 0, 0.7,  //1
	350, 375, 0.7, 0,   0,  //2
	125, 375, 0,   0,   0.7,//3
	//front
	200, 100, 0,   0.7, 0.7,//4
	450, 100, 0.7, 0.7, 0.7,//5
	450, 300, 0.9, 0,   0.9,//6
	200, 300,  0,   0.9, 0.9//7
};

GLubyte front[] = {4,5,6,7};
GLubyte right[] = {1,2,6,5};
GLubyte left[] = {0,4,7,3};
GLubyte back[] = {0,3,2,1};
GLubyte top[] = {2,3,7,6};
GLubyte bottom[] = {0,1,5,4};




unsigned int vbo;    //vertex buffer object
unsigned int ind;
//initialization
void init( void )
{
  glClearColor( 1.0, 1.0, 1.0, 0.0 );   //get white background color
  glColor3f( 0.0f, 0.0f, 0.0f );        //set drawing color
  gluOrtho2D( 0.0, 500.0, 0.0, 500.0 );
  glGenBuffers ( 1,  &vbo );            //handle to vertex buffer object
  glBindBuffer ( GL_ARRAY_BUFFER, vbo );
  glBufferData ( GL_ARRAY_BUFFER, sizeof ( cube ), cube, GL_STATIC_DRAW );
}


void display( void )
{
  glClear( GL_COLOR_BUFFER_BIT );       //clear screen
  glEnableClientState(GL_VERTEX_ARRAY);
  glEnableClientState(GL_COLOR_ARRAY);
  glVertexPointer(2, GL_FLOAT, 5*sizeof(GLfloat), 0);
  glEnable(GL_CULL_FACE);
  glCullFace(GL_BACK);

  glColorPointer ( 3, GL_FLOAT, 5*sizeof(GLfloat), (void*)(2*sizeof(GLfloat)));
  glDrawElements ( GL_POLYGON, 4, GL_UNSIGNED_BYTE, front );

   // glColorPointer ( 3, GL_FLOAT, 3*sizeof(float), right);
  //glColor3f(0.7,0.7,0);
  glDrawElements ( GL_POLYGON, 4, GL_UNSIGNED_BYTE, right );

    //glColorPointer ( 3, GL_FLOAT, 3*sizeof(float), left);
 // glColor3f(0.7,0,0.7);
  glDrawElements ( GL_POLYGON, 4, GL_UNSIGNED_BYTE, left );

    //glColorPointer ( 3, GL_FLOAT, 3*sizeof(float), back);
  //glColor3f(0.7,0,0);
  glDrawElements ( GL_POLYGON, 4, GL_UNSIGNED_BYTE, back );
```

```
    //glColorPointer ( 3, GL_FLOAT, 3*sizeof(float), top);
//glColor3f(0,0.7,0.7);
  glDrawElements ( GL_POLYGON, 4, GL_UNSIGNED_BYTE, top );

    //glColorPointer ( 3, GL_FLOAT, 3*sizeof(float), bottom);
//glColor3f(0,0.7,0);
  glDrawElements ( GL_POLYGON, 4, GL_UNSIGNED_BYTE, bottom );


  glDisableClientState ( GL_VERTEX_ARRAY );
  glDisableClientState ( GL_COLOR_ARRAY );
  glFlush();                            //send all output to screen
}

void keyboard ( unsigned char key, int mousex, int mousey )
{
   switch ( key ) {
     case 27:       // escape
       exit ( -1 );
   }
   glutPostRedisplay();
}

void specialKey ( int key, int mousex, int mousey )
{
 switch ( key ) {
  case GLUT_KEY_UP:
       break;
  case GLUT_KEY_DOWN:
       break;
  case GLUT_KEY_LEFT:
        break;
  case GLUT_KEY_RIGHT:
        break;
  }
  glutPostRedisplay();
}

void myMouse( int button, int state, int x, int y )
{
  glFlush();                            //send all output to screen
}
```

```
/*  Main Loop
 *  Open window with initial window size, title bar,
 *  RGBA display mode, depth buffer.
 */
int main(int argc, char** argv)
{
  glutInit(&argc, argv);        //initialize toolkit
  glutInitDisplayMode (GLUT_SINGLE| GLUT_RGB ); //set display mode
  glutInitWindowSize(500, 500);         //set window size on screen
  glutInitWindowPosition( 100, 150 );   //set window position on screen
  glutCreateWindow(argv[0]);            //open screen widow
  init();
  glutDisplayFunc (display);            //points to display function
  glutKeyboardFunc ( keyboard );
//  glutSpecialFunc( specialKey );
  glutMouseFunc( myMouse );

  glutMainLoop();                       //go into perpetual loop
  return 0;
}
```

Part 6) (10 points) Write a program or programs to reproduce one of the following figures of **icosahedron** and dodecahedron





Code

```
#include <GL/glut.h>
#include <GL/gl.h>
#include <stdlib.h>
using namespace std;

#define a .525731112119133606
#define b .850650808352039932

GLfloat vdata[12][3] =
  {
   {-a, 0.0, b}, {a, 0.0, b}, {-a, 0.0,-b}, {a, 0.0,-b},
   {0.0, b, a}, {0.0, b,-a}, {0.0,-b, a}, {0.0,-b,-a},
   {b, a, 0.0}, {-b, a, 0.0}, {b,-a, 0.0}, {-b,-a, 0.0}
  };
GLuint tindices[20][3] =
  {
   {0,4,1}, {0,9,4}, {9,5,4}, {4,5,8}, {4,8,1},
   {8,10,1}, {8,3,10}, {5,3,8}, {5,2,3}, {2,7,3},
   {7,10,3}, {7,6,10}, {7,11,6}, {11,0,6}, {0,1,6},
   {6,1,10}, {9,0,11}, {9,11,2}, {9,2,5}, {7,2,11}
  };

void init(void)
{
  glClearColor(1.0, 1.0, 1.0, 0.0); //get white background color
  glShadeModel(GL_SMOOTH);
  glEnable(GL_SMOOTH);
  glEnable(GL_POINT_SMOOTH);
  glEnableClientState(GL_VERTEX_ARRAY);
  glBlendFunc(GL_SRC_ALPHA, GL_ONE_MINUS_SRC_ALPHA);
  glEnable( GL_BLEND );

}

void display()
{
  glLoadIdentity();
  gluLookAt(2.0, 2.0, 2.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
  glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);

  glRotatef(25, 0, 0, 1);
  glBegin(GL_TRIANGLES);
      glColor4f(0.3, 0.5, 0.2, 0.7);
  for (int i = 0; i < 20; i++) {
    glVertex3fv(&vdata[tindices[i][0]][0]);
    glVertex3fv(&vdata[tindices[i][1]][0]);
    glVertex3fv(&vdata[tindices[i][2]][0]);
  }
  glEnd();

  glColor4f(0.0, 0.2, 0.1, 1);
  glLineWidth(2.25);
  for (int i = 0; i < 20; i++) {
    glBegin(GL_LINE_LOOP);
    glVertex3fv(&vdata[tindices[i][0]][0]);
    glVertex3fv(&vdata[tindices[i][1]][0]);
    glVertex3fv(&vdata[tindices[i][2]][0]);
  }
  glEnd();
  glFlush();
}

void reshape(int w, int h)
{
  glViewport(0, 0, (GLsizei)w, (GLsizei)h);
  glMatrixMode(GL_PROJECTION);
  glLoadIdentity();
  glFrustum(-1.0, 1.0, -1.0, 1.0, 1.5, 20.0);
  glMatrixMode(GL_MODELVIEW);
}


int main(int argc, char** argv)
{
  glutInit(&argc, argv); //initialize toolkit
  glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB); //set display mode: single bufferring, RGB model
  glutInitWindowPosition(500, 150); //set window position on screen
  glutInitWindowSize(500, 500);
  glutCreateWindow(*argv); //open screen window
  init();
  glutDisplayFunc(display); //points to display function
  glutReshapeFunc(reshape);
  glutMainLoop(); //go into perpetual loop
  return 0;
}
```