

GRAPHICS PROGRAMMING: OpenGL

STUDENT REGISTRATION ID (NRP): _____

NAME: _____

CLASS: _____

```
#include "GL/freeglut.h"
#include "GL/gl.h"

float angle = 0;

void renderFunction()
{
    glClearColor(0.0, 0.0, 0.0, 0.0);
    glClear(GL_COLOR_BUFFER_BIT);
    angle += 0.0001;
    glRotatef(angle, 0, 0, 1);
    glColor3f(1.0, 1.0, 1.0);
    glOrtho(-1.0, 1.0, -1.0, 1.0, -1.0, 1.0);
    glBegin(GL_POLYGON);
        glVertex2f(-0.5, -0.5);
        glVertex2f(-0.5, 0.5);
        glVertex2f(0.5, 0.5);
        glVertex2f(0.5, -0.5);
    glEnd();
    glFlush();
    glutPostRedisplay();
}

int main(int argc, char** argv)
{
    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_SINGLE);
    glutInitWindowSize(500,500);
    glutInitWindowPosition(100,100);
    glutCreateWindow("OpenGL - First window demo");
    glutDisplayFunc(renderFunction);
    glutMainLoop();
    return 0;
}
```

ACTIVITY

Which part of the program is responsible for (put comments in the program):

- * Making the background black
- * Making the square white
- * Drawing the square
- * Rotating the square

Which part of the program you don't understand? Write it down.

Can you:

- * Make a cube instead of a square?
- * Move the cube to the right, and move it back to the left instead of rotate it?

GRAPHICS PROGRAMMING: 3D Transformation

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```
// Source: https://www.ntu.edu.sg/home/ehchua/programming/opengl/CG_Examples.html
// Compile: g++ 3d.cpp -o 3d -lglut -lGL -lGLU

#include "GL/glut.h"

GLfloat anglePyramid = 0.0f;
GLfloat angleCube = 0.0f;

void initGL() {
    glClearColor(0.0f, 0.0f, 0.0f, 1.0f);
    glClearDepth(1.0f);
    glEnable(GL_DEPTH_TEST);
    glDepthFunc(GL_LEQUAL);
    glShadeModel(GL_SMOOTH);
    glHint(GL_PERSPECTIVE_CORRECTION_HINT, GL_NICEST);
}

void display() {
    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
    glMatrixMode(GL_MODELVIEW);

    glLoadIdentity();
    glTranslatef(1.5f, 0.0f, -7.0f);
    glRotatef(angleCube, 1.0f, 1.0f, 1.0f);

    glBegin(GL_QUADS);
        glColor3f(0.0f, 1.0f, 0.0f);
        glVertex3f( 1.0f, 1.0f, -1.0f);
        glVertex3f(-1.0f, 1.0f, -1.0f);
        glVertex3f(-1.0f, 1.0f,  1.0f);
        glVertex3f( 1.0f, 1.0f,  1.0f);

        glColor3f(1.0f, 0.5f, 0.0f);
        glVertex3f( 1.0f, -1.0f,  1.0f);
        glVertex3f(-1.0f, -1.0f,  1.0f);
        glVertex3f(-1.0f, -1.0f, -1.0f);
        glVertex3f( 1.0f, -1.0f, -1.0f);

        glColor3f(1.0f, 0.0f, 0.0f);
        glVertex3f( 1.0f,  1.0f, 1.0f);
        glVertex3f(-1.0f,  1.0f, 1.0f);
        glVertex3f(-1.0f, -1.0f, 1.0f);
        glVertex3f( 1.0f, -1.0f, 1.0f);

        glColor3f(1.0f, 1.0f, 0.0f);
        glVertex3f( 1.0f, -1.0f, -1.0f);
        glVertex3f(-1.0f, -1.0f, -1.0f);
        glVertex3f(-1.0f,  1.0f, -1.0f);
        glVertex3f( 1.0f,  1.0f, -1.0f);

        glColor3f(0.0f, 0.0f, 1.0f);
        glVertex3f(-1.0f,  1.0f,  1.0f);
        glVertex3f(-1.0f, -1.0f,  1.0f);
        glVertex3f( 1.0f, -1.0f,  1.0f);
        glVertex3f( 1.0f,  1.0f,  1.0f);

        glColor3f(1.0f, 0.0f, 1.0f);
        glVertex3f( 1.0f,  1.0f, -1.0f);
        glVertex3f(-1.0f,  1.0f, -1.0f);
        glVertex3f(-1.0f, -1.0f, -1.0f);
        glVertex3f( 1.0f, -1.0f, -1.0f);

    glEnd();

    glLoadIdentity();
    glTranslatef(-1.5f, 0.0f, -6.0f);
    glRotatef(anglePyramid, 1.0f, 1.0f, 0.0f);

    glBegin(GL_TRIANGLES);
        glColor3f(1.0f, 0.0f, 0.0f);
        glVertex3f( 0.0f, 1.0f, 0.0f);
        glColor3f(0.0f, 1.0f, 0.0f);
        glVertex3f(-1.0f, -1.0f, 1.0f);
        glColor3f(0.0f, 0.0f, 1.0f);
        glVertex3f(1.0f, -1.0f, 1.0f);

        glColor3f(1.0f, 0.0f, 0.0f);
        glVertex3f(0.0f, 1.0f, 0.0f);
        glColor3f(0.0f, 0.0f, 1.0f);
        glVertex3f(1.0f, -1.0f, 1.0f);
        glColor3f(0.0f, 1.0f, 0.0f);
        glVertex3f(1.0f, -1.0f, -1.0f);

        glColor3f(1.0f, 0.0f, 0.0f);
        glVertex3f(0.0f, 1.0f, 0.0f);
        glColor3f(0.0f, 1.0f, 0.0f);
        glVertex3f(1.0f, -1.0f, 1.0f);
        glColor3f(0.0f, 0.0f, 1.0f);
        glVertex3f(-1.0f, -1.0f, 1.0f);
        glColor3f(1.0f, 0.0f, 0.0f);
        glVertex3f(-1.0f, -1.0f, -1.0f);

        glColor3f(1.0f, 0.0f, 0.0f);
        glVertex3f(0.0f, 1.0f, 0.0f);
        glColor3f(0.0f, 1.0f, 0.0f);
        glVertex3f(1.0f, -1.0f, 1.0f);
        glColor3f(0.0f, 0.0f, 1.0f);
        glVertex3f(-1.0f, -1.0f, 1.0f);
        glColor3f(1.0f, 0.0f, 0.0f);
        glVertex3f(-1.0f, -1.0f, -1.0f);

    glEnd();

    glutSwapBuffers();
    anglePyramid += 0.2f;
    angleCube -= 0.15f;
}

void timer(int value) {
    glutPostRedisplay();
    glutTimerFunc(15, timer, 0);
}

void reshape(GLsizei width, GLsizei height) {
    if (height == 0) height = 1;
    GLfloat aspect = (GLfloat)width / (GLfloat)height;
    glViewport(0, 0, width, height);
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    gluPerspective(45.0f, aspect, 0.1f, 100.0f);
}

int main(int argc, char** argv) {
    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_DOUBLE | GLUT_DEPTH);
    glutInitWindowSize(640, 480);
    glutInitWindowPosition(50, 50);
    glutCreateWindow("3d-animation");
    glutDisplayFunc(display);
    glutReshapeFunc(reshape);
    initGL();
    glutTimerFunc(0, timer, 0);
    glutMainLoop();
    return 0;
}
```

ACTIVITY

* Determine what `glLoadIdentity`, `glTranslatef`, `glRotatef`, `glColor3f`, `glVertex3f`, `glBegin`, and `glEnd` are for

* Determine how to use `glLoadIdentity`, `glTranslatef`, `glRotatef`, `glColor3f`, and `glVertex3f`

GRAPHICS PROGRAMMING: 3D Transformation (Composition)

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```
// Compile: g++ 3d.cpp -o 3d -lglut -lGL -lGLU

#include "GL/glut.h"

GLfloat angle = 0;

void initGL()
{
    glClearColor(0.0f, 0.0f, 0.0f, 1.0f);
    glClearDepth(1.0f);
    glEnable(GL_DEPTH_TEST);
    glDepthFunc(GL_LEQUAL);
    glShadeModel(GL_SMOOTH);
    glHint(GL_PERSPECTIVE_CORRECTION_HINT, GL_NICEST);
}

void timer(int value)
{
    glutPostRedisplay();
    glutTimerFunc(15, timer, 0);
}

void reshape(GLsizei width, GLsizei height)
{
    if (height == 0)
        height = 1;
    GLfloat aspect = (GLfloat)width / (GLfloat)height;
    glViewport(0, 0, width, height);
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    gluPerspective(45.0f, aspect, 0.1f, 100.0f);
}

void display()
{
    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
    glMatrixMode(GL_MODELVIEW);

    // draw the white big square
    glLoadIdentity();
    glTranslatef(0, -4, -20);
    glColor3f(1, 1, 1);
    glBegin(GL_QUADS);
        glVertex3f(0, 10, 0);
        glVertex3f(10, 10, 0);
        glVertex3f(10, 0, 0);
        glVertex3f(0, 0, 0);
    glEnd();

    glLoadIdentity();
    glTranslatef(0, -4, -20);

    // X Rotation
    /* glRotatef(angle, 1, 0, 0); */

    // Y Rotation
    /* glRotatef(angle, 0, 1, 0); */

    // Z Rotation
    /* glRotatef(angle, 0, 0, 1); */

    // Y Rotation + Translation
    /*
    glTranslatef(-3, 0, 0);
    glRotatef(angle, 0, 1, 0);
    glTranslatef(3, 0, 0);
    */

    // purple square
    glColor3f(1, 0, 1);
    glBegin(GL_QUADS);
        glVertex3f(-3, 3, 0);
        glVertex3f(3, 3, 0);
        glVertex3f(3, -3, 0);
        glVertex3f(-3, -3, 0);
    glEnd();

    angle += 1;

    glutSwapBuffers();
}

int main(int argc, char **argv)
{
    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_DOUBLE | GLUT_DEPTH);
    glutInitWindowSize(640, 480);
    glutInitWindowPosition(50, 50);
    glutCreateWindow("3d-animation");
    glutDisplayFunc(display);
    glutReshapeFunc(reshape);
    initGL();
    glutTimerFunc(0, timer, 0);
    glutMainLoop();
    return 0;
}
```

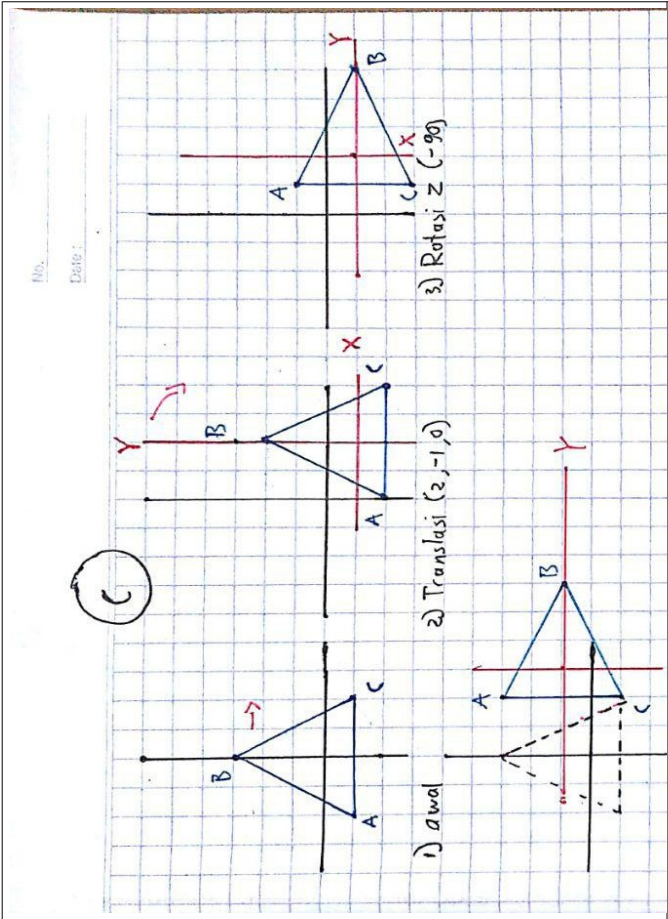
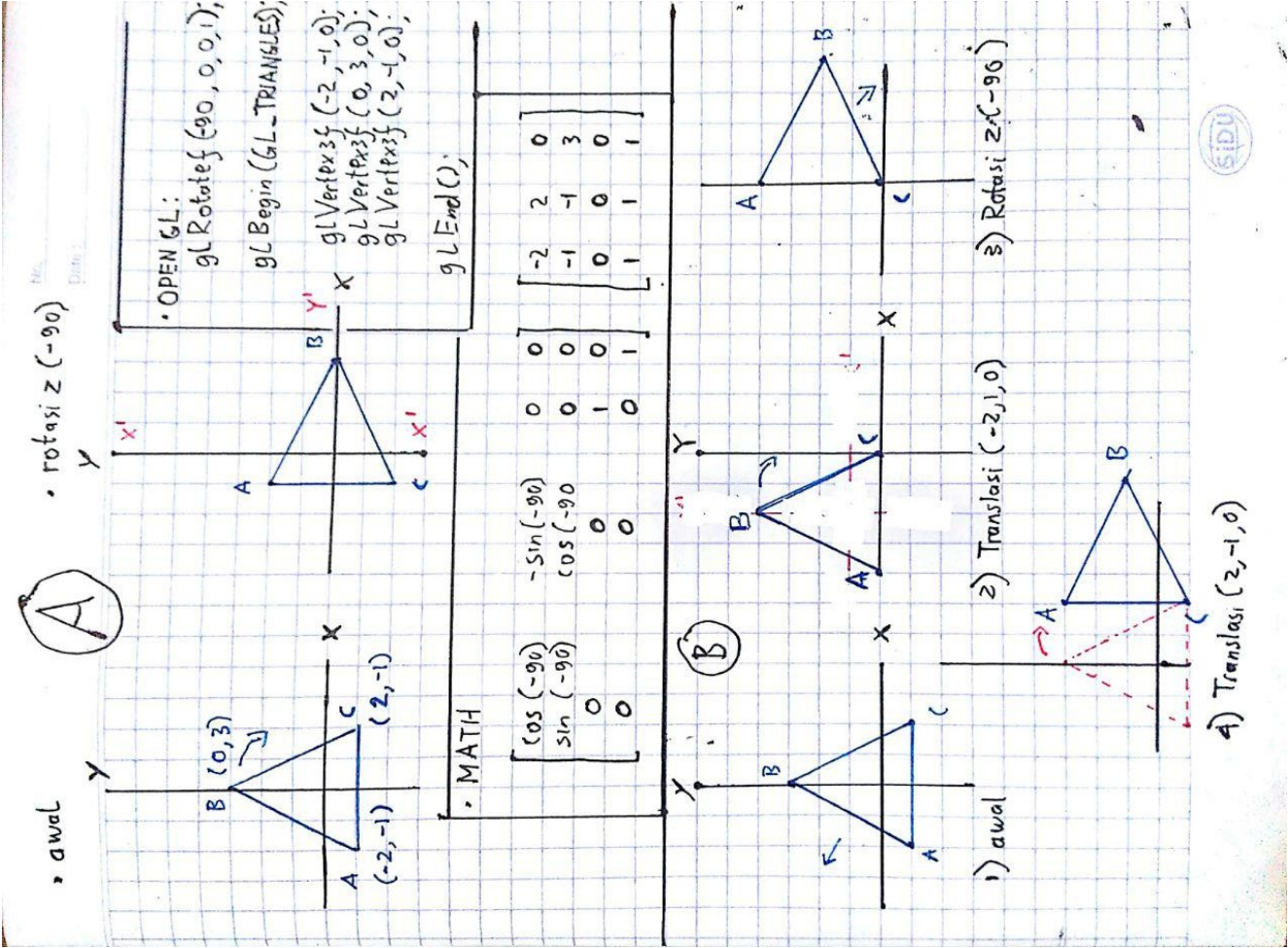
ACTIVITY

- * Determine the differences of `X Rotation`, `Y Rotation`, and `Z Rotation`
- * Find out how `Y Rotation + Translation` works.
- * Read the article in <https://www.mathplanet.com/education/geometry/transformations> to understand about transformation matrix.
- * Suppose the angle is 45° , determine the coordinate of the purple square (relative to bottom-left of the white square) after these operations:
 - * X Rotation
 - * Y Rotation
 - * Z Rotation
 - * Y Rotation + Translation

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1. Try to understand figure A
2. Look at figure B. Calculate the Coordinate of ABC triangle by using matrix multiplication.
3. Look at figure C. Write an OpenGL program to do the rotation.

GRAPHICS PROGRAMMING: 3D Transformation (Flappy bird)

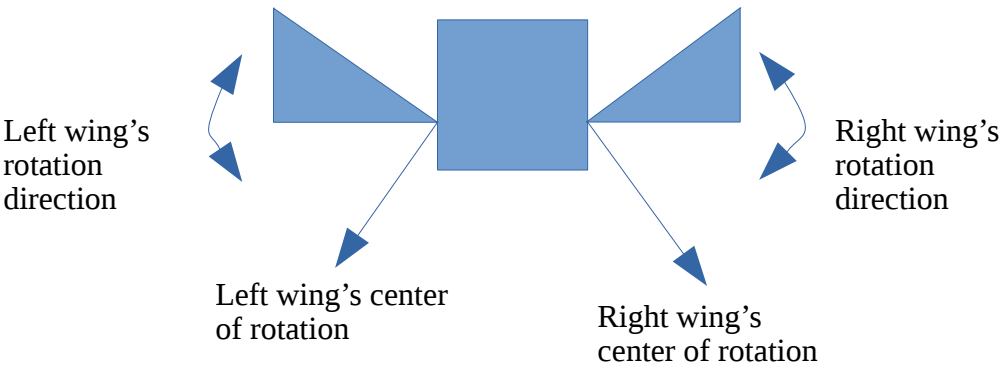
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ACTIVITY

Create an OpenGL program to make a flappy bird like motion. The body of the bird is a square, while it's two wings are triangle



GRAPHICS PROGRAMMING: 3D Transformation (Drone)

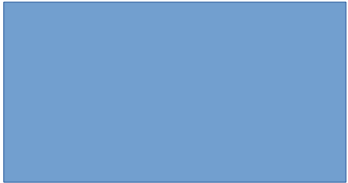
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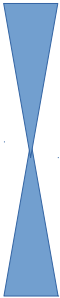
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ACTIVITY

Create an OpenGL program to make a drone like motion. The body of the drone is a square, while it's four copters are composed of two triangles



body



copter

GRAPHICS PROGRAMMING: 3D Gear (Understanding Circle)

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ACTIVITY

Create an OpenGL program to make a 3d gear model like in <https://www.youtube.com/watch?v=PaDbjsxJxv0> (Only one gear, without the motion.

