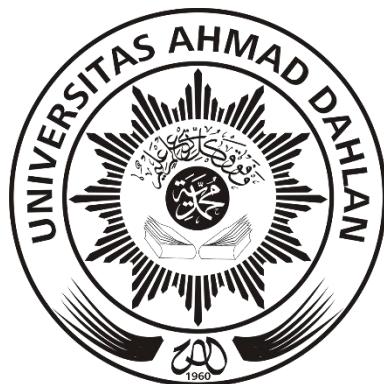


**LAPORAN AKHIR PRAKTIKUM
GRAFIKA KOMPUTER**



DISUSUN OLEH
Dyah Rahma Alifiyah 2300018154
JUMAT 15.15 – KELAS C

**PROGRAM STUDI TEKNIK INFORMATIKA
FAKULTAS TEKNOLOGI INDUSTRI
UNIVERSITAS AHMAD DAHLAN**

JULI 2024

LEMBAR PENGESAHAN ASISTEN

RESPONSI

LAPORAN AKHIR PRAKTIKUM GRAFIKA KOMPUTER

Disusun oleh:

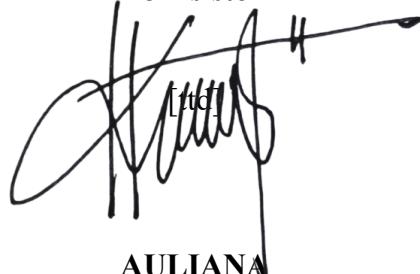
DYAH RAHMA ALIFIYAH

2300018154

**Laboratorium Informatika
Program Studi S1 Informatika
Fakultas Teknologi Industri
Universitas Ahmad Dahlan**

Telah disetujui oleh:

PJ Asisten



A handwritten signature consisting of several loops and strokes, with the text "PJ Asisten" written above it.

AULIANA

2200018029

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Kata Pengantar

Puji syukur kami panjatkan ke hadirat Tuhan Yang Maha Esa atas rahmat-Nya sehingga laporan praktikum Grafika Komputer Bab 1 hingga Bab 10 ini dapat diselesaikan dengan baik dan lancar. Laporan ini berisi rangkuman jawaban dari praktikum yang terdiri dari pretest, langkah praktikum, dan posttest.

Kami mengucapkan terima kasih kepada dosen dan asisten praktikum yang telah membantu selama proses praktikum berlangsung. Semoga laporan ini dapat mendapatkan nilai yang baik dan memuaskan.

Yogyakarta, 9 Juli 2025

Dyah Rahma Alifiyah

BAB I. PENGANTAR OPENGL

Pretest 1

Pertanyaan:

1. Apa saja yang bisa dilakukan dengan library OpenGL?
2. Gambarkan kemudian jelaskan tahapan OpenGL?

Jawaban:

1. Library OpenGL
 - Menggambar sebuah objek dua dimensi dan tiga dimensi
 - Transformasi geometri
 - Rendering teknik pencahayaan
 - Animasi objek
2. Vertex data – vertex shader – tesmilation control shader – tesmilation evaluation shader – geometry shader – primitive setup – clipping – rasterization – fragment shader

Vertex data : data titik mentah

vertex shader : transformasi vertex

tesmilation control shader : atur tingkat subdivisi

tesmilation evaluation shader : hitung hasil subdivisi

geometry shader : buat/modifikasi primitif

primitive setup : siapkan objek

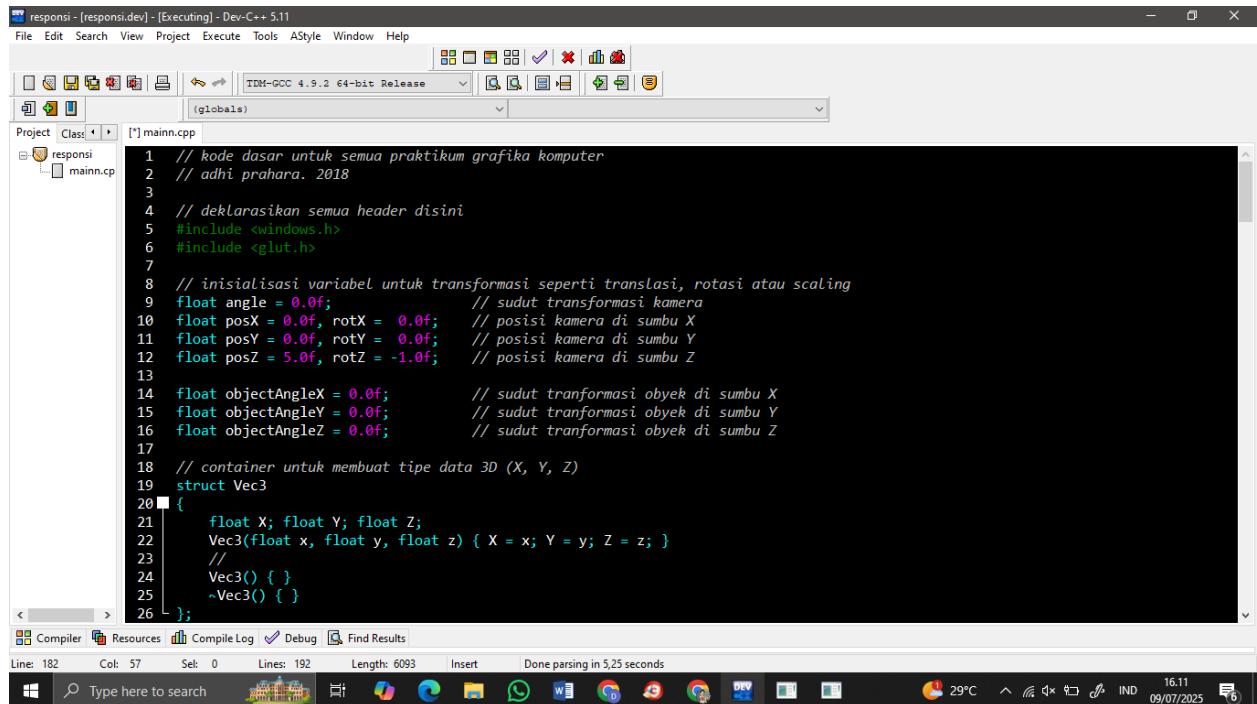
clipping : potong bagian luar kamera

rasterization : ubah objek jadi fragmen

fragment shader : hitung warna piksel

Langkah Praktikum 1

Gambar 1 laprak 1



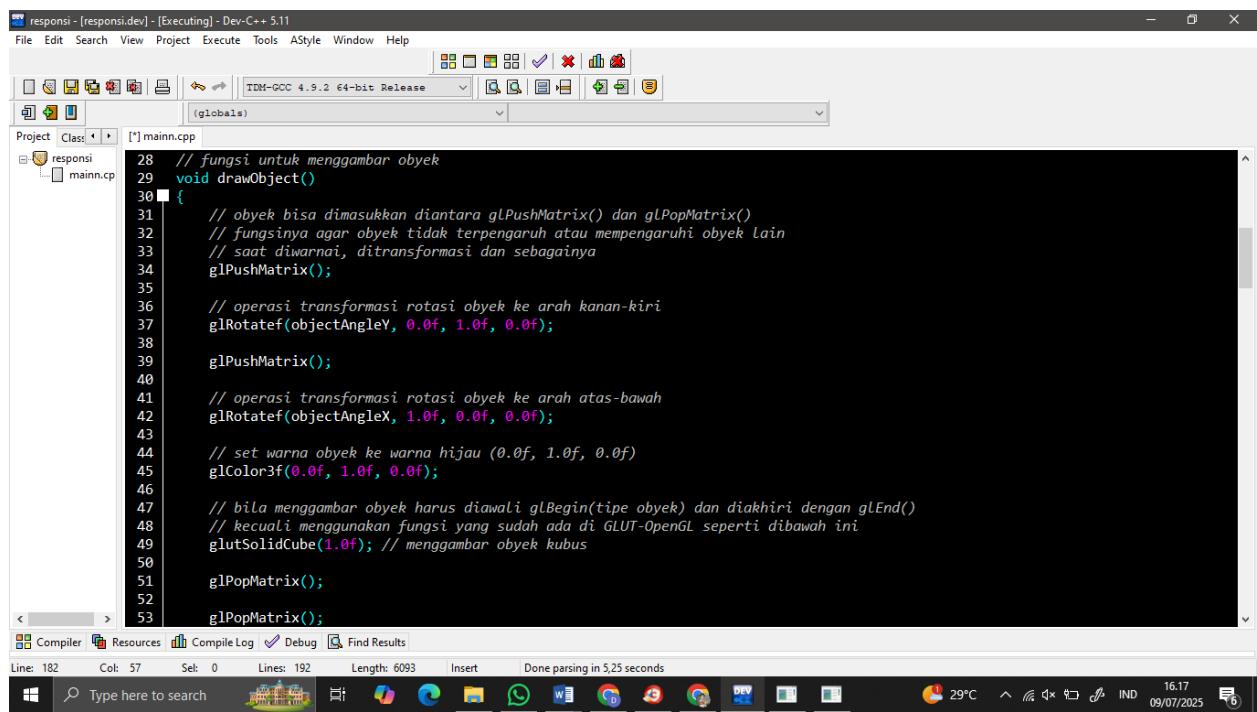
The screenshot shows the Dev-C++ IDE interface with the following details:

- Title Bar:** responsi - [responsi.dev] - [Executing] - Dev-C++ 5.11
- Menu Bar:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help
- Toolbar:** Includes icons for file operations like Open, Save, Print, and Build.
- Project Explorer:** Shows a project named "responsi" with a file "mainn.cpp".
- Code Editor:** Displays the following C++ code:

```
1 // kode dasar untuk semua praktikum grafika komputer
2 // adhi prahara. 2018
3
4 // deklarasikan semua header disini
5 #include <windows.h>
6 #include <glut.h>
7
8 // inisialisasi variabel untuk transformasi seperti translasi, rotasi atau scaling
9 float angle = 0.0f; // sudut transformasi kamera
10 float posX = 0.0f, rotX = 0.0f; // posisi kamera di sumbu X
11 float posY = 0.0f, rotY = 0.0f; // posisi kamera di sumbu Y
12 float posZ = 5.0f, rotZ = -1.0f; // posisi kamera di sumbu Z
13
14 float objectAngleX = 0.0f; // sudut transformasi obyek di sumbu X
15 float objectAngleY = 0.0f; // sudut transformasi obyek di sumbu Y
16 float objectAngleZ = 0.0f; // sudut transformasi obyek di sumbu Z
17
18 // container untuk membuat tipe data 3D (X, Y, Z)
19 struct Vec3
20 {
21     float X; float Y; float Z;
22     Vec3(float x, float y, float z) { X = x; Y = y; Z = z; }
23     //
24     Vec3() { }
25     ~Vec3() { }
26 };
27
28 // fungsi untuk menggambar obyek
29 void drawObject()
30 {
31     // obyek bisa dimasukkan diantara glPushMatrix() dan glPopMatrix()
32     // fungsinya agar obyek tidak terpengaruh atau mempengaruhi obyek lain
33     // saat diwarnai, ditransformasi dan sebagainya
34     glPushMatrix();
35
36     // operasi transformasi rotasi obyek ke arah kanan-kiri
37     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
38
39     glPushMatrix();
40
41     // operasi transformasi rotasi obyek ke arah atas-bawah
42     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
43
44     // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
45     glColor3f(0.0f, 1.0f, 0.0f);
46
47     // bila menggambar obyek harus diawali glBegin(tipe obyek) dan diakhiri dengan glEnd()
48     // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
49     glutSolidCube(1.0f); // menggambar obyek kubus
50
51     glPopMatrix();
52
53     glPopMatrix();
54 }
```

Below the code editor, the status bar shows: Line: 182 Col: 57 Sel: 0 Lines: 192 Length: 6093 Insert Done parsing in 5.25 seconds.

Gambar 2 laprak 1



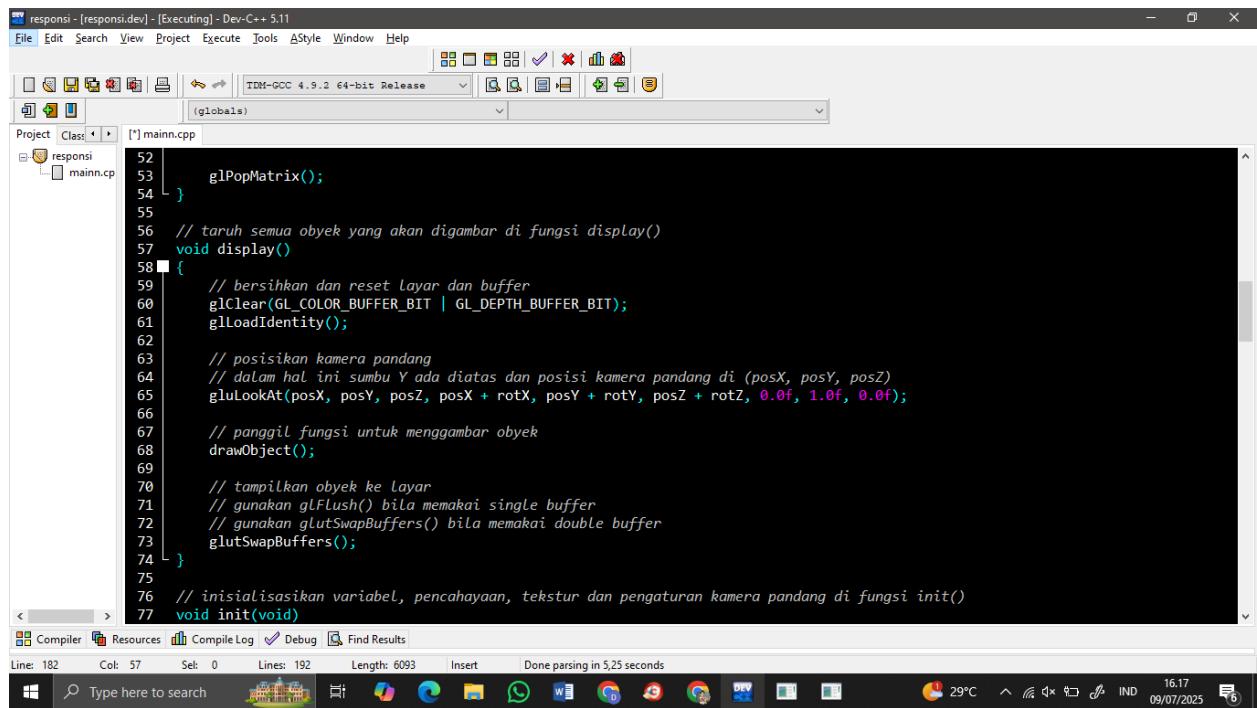
The screenshot shows the Dev-C++ IDE interface with the following details:

- Title Bar:** responsi - [responsi.dev] - [Executing] - Dev-C++ 5.11
- Menu Bar:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help
- Toolbar:** Includes icons for file operations like Open, Save, Print, and Build.
- Project Explorer:** Shows a project named "responsi" with a file "mainn.cpp".
- Code Editor:** Displays the following C++ code, identical to Gambar 1 but with additional drawing logic:

```
1 // kode dasar untuk semua praktikum grafika komputer
2 // adhi prahara. 2018
3
4 // deklarasikan semua header disini
5 #include <windows.h>
6 #include <glut.h>
7
8 // inisialisasi variabel untuk transformasi seperti translasi, rotasi atau scaling
9 float angle = 0.0f; // sudut transformasi kamera
10 float posX = 0.0f, rotX = 0.0f; // posisi kamera di sumbu X
11 float posY = 0.0f, rotY = 0.0f; // posisi kamera di sumbu Y
12 float posZ = 5.0f, rotZ = -1.0f; // posisi kamera di sumbu Z
13
14 float objectAngleX = 0.0f; // sudut transformasi obyek di sumbu X
15 float objectAngleY = 0.0f; // sudut transformasi obyek di sumbu Y
16 float objectAngleZ = 0.0f; // sudut transformasi obyek di sumbu Z
17
18 // container untuk membuat tipe data 3D (X, Y, Z)
19 struct Vec3
20 {
21     float X; float Y; float Z;
22     Vec3(float x, float y, float z) { X = x; Y = y; Z = z; }
23     //
24     Vec3() { }
25     ~Vec3() { }
26 };
27
28 // fungsi untuk menggambar obyek
29 void drawObject()
30 {
31     // obyek bisa dimasukkan diantara glPushMatrix() dan glPopMatrix()
32     // fungsinya agar obyek tidak terpengaruh atau mempengaruhi obyek lain
33     // saat diwarnai, ditransformasi dan sebagainya
34     glPushMatrix();
35
36     // operasi transformasi rotasi obyek ke arah kanan-kiri
37     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
38
39     glPushMatrix();
40
41     // operasi transformasi rotasi obyek ke arah atas-bawah
42     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
43
44     // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
45     glColor3f(0.0f, 1.0f, 0.0f);
46
47     // bila menggambar obyek harus diawali glBegin(tipe obyek) dan diakhiri dengan glEnd()
48     // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
49     glutSolidCube(1.0f); // menggambar obyek kubus
50
51     glPopMatrix();
52
53     glPopMatrix();
54 }
```

Below the code editor, the status bar shows: Line: 182 Col: 57 Sel: 0 Lines: 192 Length: 6093 Insert Done parsing in 5.25 seconds.

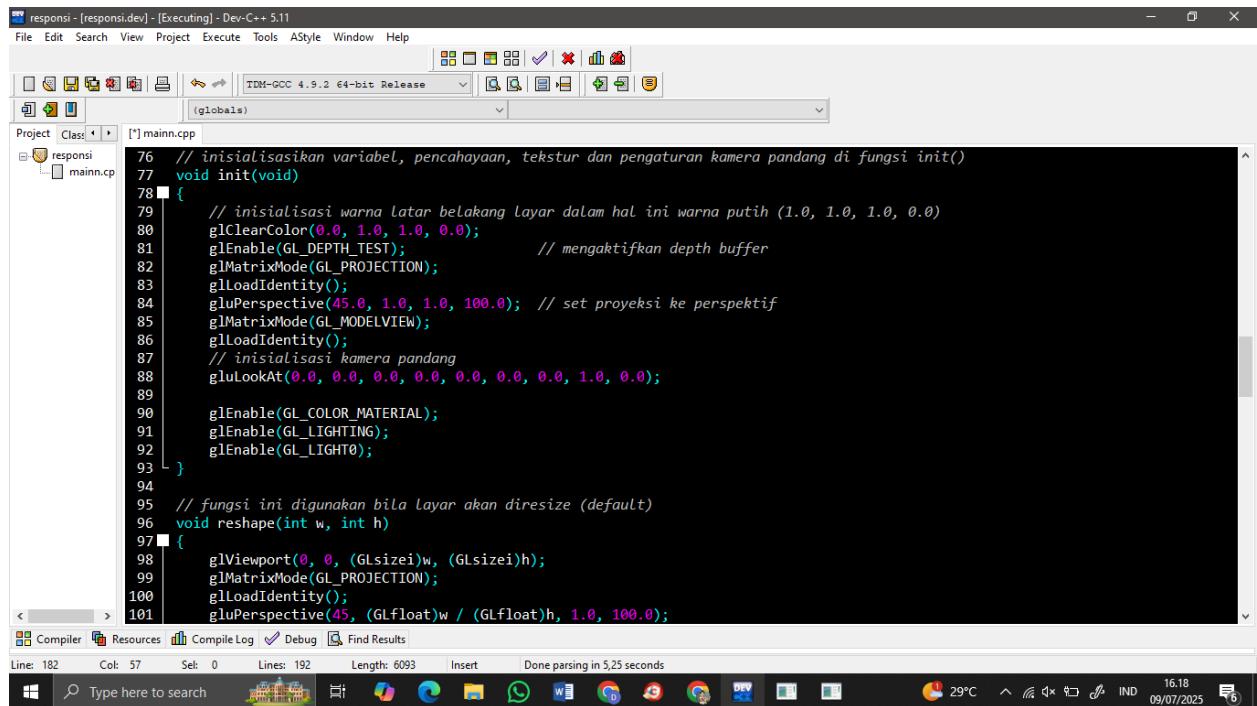
Gambar 3 laprak 1



The screenshot shows the Dev-C++ IDE interface with the title bar "responsi - [responsi.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 182 Col: 57 Sel: 0 Lines: 192 Length: 6093 Insert Done parsing in 5,25 seconds". The bottom taskbar includes icons for Start, Task View, File Explorer, Edge, WhatsApp, Microsoft Word, Microsoft Excel, Microsoft Powerpoint, Microsoft Access, Microsoft OneDrive, Microsoft Edge, and Microsoft Word.

```
52     glPopMatrix();
53 }
55
56 // taruh semua obyek yang akan digambar di fungsi display()
57 void display()
58 {
59     // bersihkan dan reset layar dan buffer
60     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
61     glLoadIdentity();
62
63     // posisikan kamera pandang
64     // dalam hal ini sumbu Y ada diatas dan posisi kamera pandang di (posX, posY, posZ)
65     gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
66
67     // panggil fungsi untuk menggambar obyek
68     drawObject();
69
70     // tampilkan obyek ke layar
71     // gunakan glFlush() bila memakai single buffer
72     // gunakan glutSwapBuffers() bila memakai double buffer
73     glutSwapBuffers();
74 }
75
76 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
77 void init(void)
```

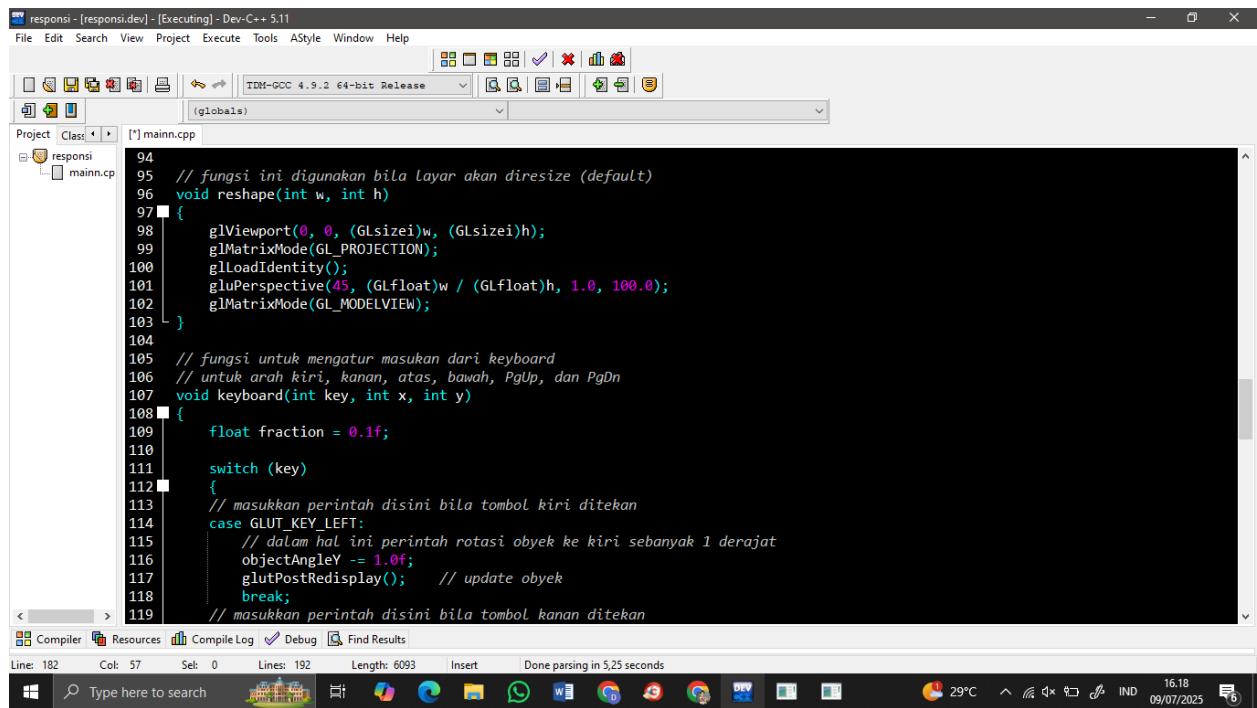
Gambar 4 laprak 1



The screenshot shows the Dev-C++ IDE interface with the title bar "responsi - [responsi.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 182 Col: 57 Sel: 0 Lines: 192 Length: 6093 Insert Done parsing in 5,25 seconds". The bottom taskbar includes icons for Start, Task View, File Explorer, Edge, WhatsApp, Microsoft Word, Microsoft Excel, Microsoft Powerpoint, Microsoft Access, Microsoft OneDrive, Microsoft Edge, and Microsoft Word.

```
76 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
77 void init(void)
78 {
79     // inisialisasi warna latar belakang layar dalam hal ini warna putih (1.0, 1.0, 1.0, 0.0)
80     glClearColor(0.0, 1.0, 1.0, 0.0);
81     glEnable(GL_DEPTH_TEST);           // mengaktifkan depth buffer
82     glMatrixMode(GL_PROJECTION);
83     glLoadIdentity();
84     gluPerspective(45.0, 1.0, 1.0, 100.0); // set proyeksi ke perspektif
85     glMatrixMode(GL_MODELVIEW);
86     glLoadIdentity();
87     // inisialisasi kamera pandang
88     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
89
90     glEnable(GL_COLOR_MATERIAL);
91     glEnable(GL_LIGHTING);
92     glEnable(GL_LIGHT0);
93 }
94
95 // fungsi ini digunakan bila layar akan diresize (default)
96 void reshape(int w, int h)
97 {
98     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
99     glMatrixMode(GL_PROJECTION);
100    glLoadIdentity();
101    gluPerspective(45, (GLfloat)w / (GLfloat)h, 1.0, 100.0);
```

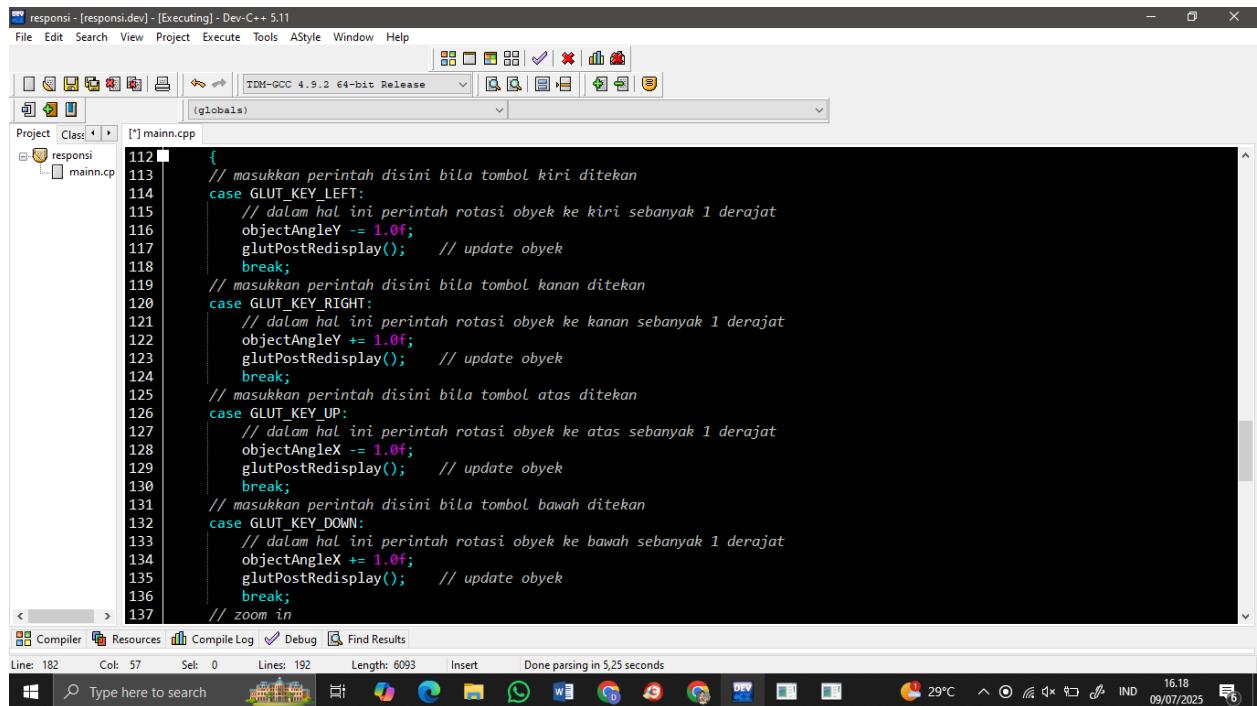
Gambar 5 laprak 1



The screenshot shows the Dev-C++ IDE interface with the title bar "responsi - [responsi.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 182 Col: 57 Sel: 0 Lines: 192 Length: 6093 Insert Done parsing in 5,25 seconds". The bottom taskbar includes icons for Start, Task View, File Explorer, Edge, WhatsApp, File Manager, Google Chrome, and DEV. The date and time are 09/07/2025 16:18. The code editor displays mainn.cpp with the following content:

```
94
95 // fungsi ini digunakan bila Layar akan diresize (default)
96 void reshape(int w, int h)
97 {
98     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
99     glMatrixMode(GL_PROJECTION);
100    glLoadIdentity();
101    gluPerspective(45, (GLfloat)w / (GLfloat)h, 1.0, 100.0);
102    glMatrixMode(GL_MODELVIEW);
103 }
104
105 // fungsi untuk mengatur masukan dari keyboard
106 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
107 void keyboard(int key, int x, int y)
108 {
109     float fraction = 0.1f;
110
111     switch (key)
112     {
113         // masukkan perintah disini bila tombol kiri ditekan
114         case GLUT_KEY_LEFT:
115             // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
116             objectAngleY -= 1.0f;
117             glutPostRedisplay(); // update obyek
118             break;
119         // masukkan perintah disini bila tombol kanan ditekan
```

Gambar 6 laprak 1



The screenshot shows the Dev-C++ IDE interface with the title bar "responsi - [responsi.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 182 Col: 57 Sel: 0 Lines: 192 Length: 6093 Insert Done parsing in 5,25 seconds". The bottom taskbar includes icons for Start, Task View, File Explorer, Edge, WhatsApp, File Manager, Google Chrome, and DEV. The date and time are 09/07/2025 16:18. The code editor displays mainn.cpp with the following content:

```
117 {
118     // masukkan perintah disini bila tombol kiri ditekan
119     case GLUT_KEY_LEFT:
120         // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
121         objectAngleY -= 1.0f;
122         glutPostRedisplay(); // update obyek
123         break;
124     // masukkan perintah disini bila tombol kanan ditekan
125     case GLUT_KEY_RIGHT:
126         // dalam hal ini perintah rotasi obyek ke kanan sebanyak 1 derajat
127         objectAngleY += 1.0f;
128         glutPostRedisplay(); // update obyek
129         break;
130     // masukkan perintah disini bila tombol atas ditekan
131     case GLUT_KEY_UP:
132         // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
133         objectAngleX -= 1.0f;
134         glutPostRedisplay(); // update obyek
135         break;
136     // masukkan perintah disini bila tombol bawah ditekan
137     case GLUT_KEY_DOWN:
138         // dalam hal ini perintah rotasi obyek ke bawah sebanyak 1 derajat
139         objectAngleX += 1.0f;
140         glutPostRedisplay(); // update obyek
141         break;
142     // zoom in
```

Gambar 7 laprak 1

The screenshot shows the Dev-C++ IDE interface with the main window titled "responsi - [responsi.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar contains various icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 140 Col: 41 Sel: 0 Lines: 192 Length: 6093 Insert Done parsing in 5,25 seconds". The code editor displays "mainn.cpp" with the following content:

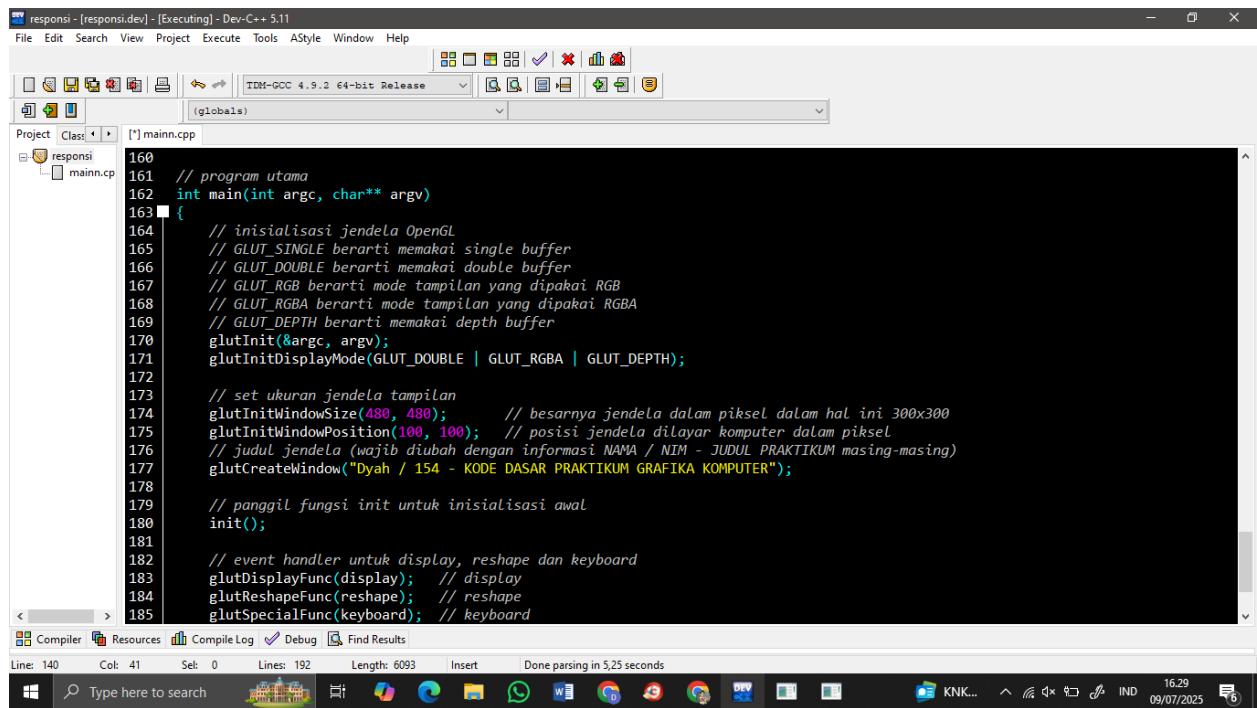
```
127 // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
128 objectAngleX -= 1.0f;
129 glutPostRedisplay(); // update obyek
130 break;
131 // masukkan perintah disini bila tombol bawah ditekan
132 case GLUT_KEY_DOWN:
133 // dalam hal ini perintah rotasi obyek ke bawah sebanyak 1 derajat
134 objectAngleX += 1.0f;
135 glutPostRedisplay(); // update obyek
136 break;
137 // zoom in
138 case GLUT_KEY_PAGE_UP:
139 // masukkan perintah disini bila tombol PgUp ditekan
140 posX += rotX * fraction;
141 posZ += rotZ * fraction;
142 glutPostRedisplay(); // update obyek
143 break;
144 // zoom out
145 case GLUT_KEY_PAGE_DOWN:
146 // masukkan perintah disini bila tombol PgDn ditekan
147 posX -= rotX * fraction;
148 posZ -= rotZ * fraction;
149 glutPostRedisplay(); // update obyek
150 break;
151 }
152 }
```

Gambar 8 laprak 1

The screenshot shows the Dev-C++ IDE interface with the main window titled "responsi - [responsi.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar contains various icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 140 Col: 41 Sel: 0 Lines: 192 Length: 6093 Insert Done parsing in 5,25 seconds". The code editor displays "mainn.cpp" with the following content:

```
154 // timer untuk animasi (gunakan bila perlu)
155 void timer(int value)
156 {
157     glutPostRedisplay();
158     glutTimerFunc(55, timer, 0);
159 }
160
161 // program utama
162 int main(int argc, char** argv)
163 {
164     // inisialisasi jendela OpenGL
165     // GLUT_SINGLE berarti memakai single buffer
166     // GLUT_DOUBLE berarti memakai double buffer
167     // GLUT_RGB berarti mode tampilan yang dipakai RGB
168     // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
169     // GLUT_DEPTH berarti memakai depth buffer
170     glutInit(&argc, argv);
171     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGBA | GLUT_DEPTH);
172
173     // set ukuran jendela tampilan
174     glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
175     glutInitWindowPosition(100, 100); // posisi jendela dilayar komputer dalam piksel
176     // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
177     glutCreateWindow("Dyah / 154 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");
178
179     // panggil fungsi init untuk inisialisasi awal
```

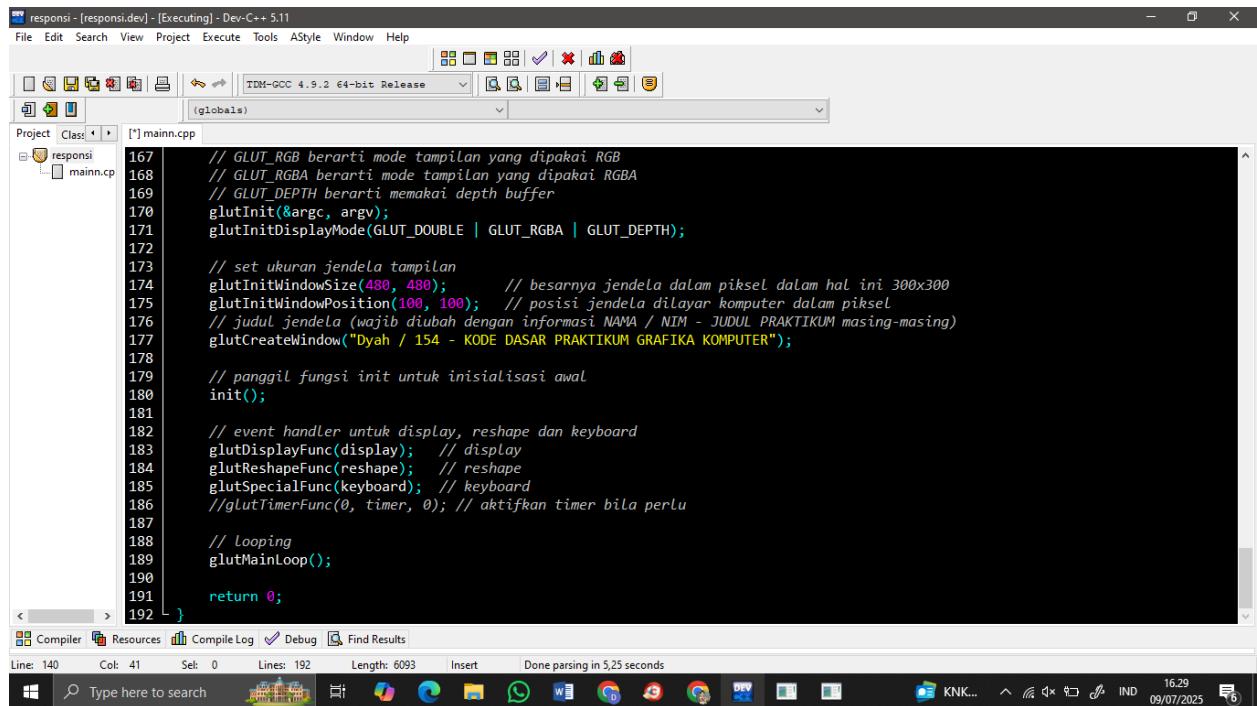
Gambar 9 laprak 1



The screenshot shows the Dev-C++ IDE interface with the title bar "responsi - [responsi.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 140 Col: 41 Sel: 0 Lines: 192 Length: 6093 Insert Done parsing in 5,25 seconds". The code editor displays mainn.cpp with the following content:

```
160
161 // program utama
162 int main(int argc, char** argv)
163 {
164     // inisialisasi jendela OpenGL
165     // GLUT_SINGLE berarti memakai single buffer
166     // GLUT_DOUBLE berarti memakai double buffer
167     // GLUT_RGB berarti mode tampilan yang dipakai RGB
168     // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
169     // GLUT_DEPTH berarti memakai depth buffer
170     glutInit(&argc, argv);
171     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
172
173     // set ukuran jendela tampilan
174     glutInitWindowSize(480, 480);           // besarnya jendela dalam piksel dalam hal ini 300x300
175     glutInitWindowPosition(100, 100);       // posisi jendela dilayar komputer dalam piksel
176     // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
177     glutCreateWindow("Dyah / 154 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");
178
179     // panggil fungsi init untuk inisialisasi awal
180     init();
181
182     // event handler untuk display, reshape dan keyboard
183     glutDisplayFunc(display); // display
184     glutReshapeFunc(reshape); // reshape
185     glutSpecialFunc(keyboard); // keyboard
186
187     //Looping
188     glutMainLoop();
189
190
191     return 0;
192 }
```

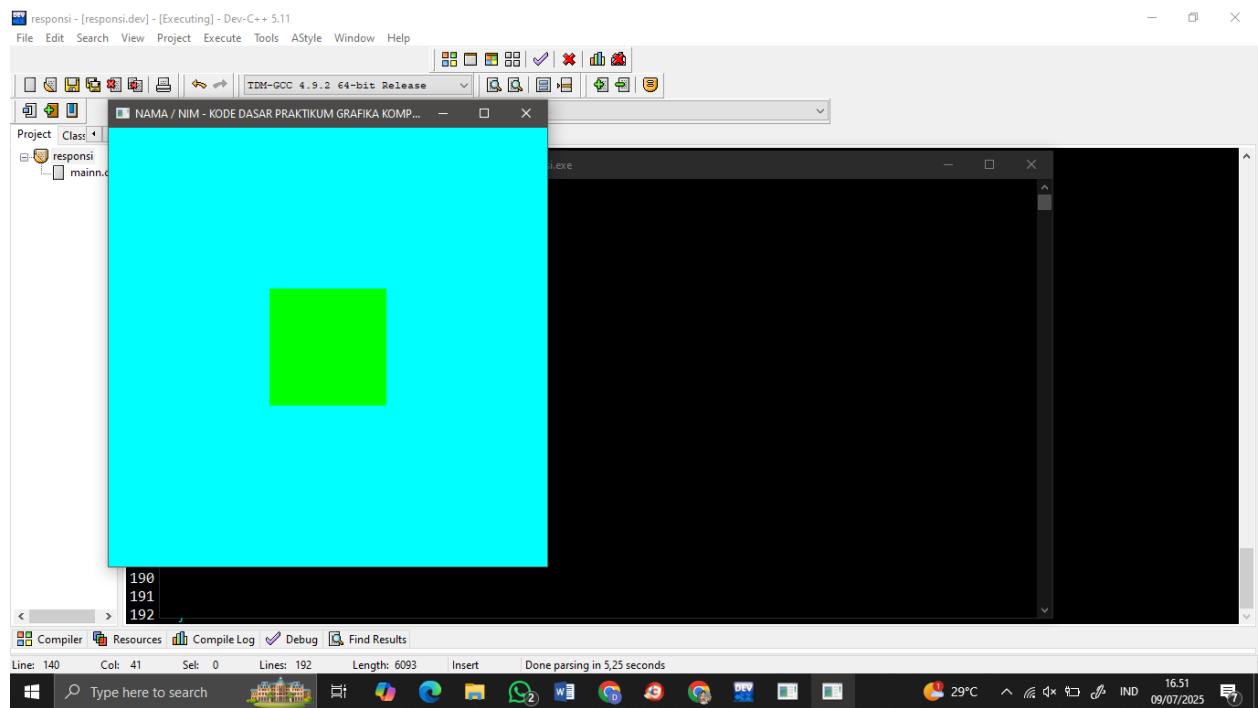
Gambar 10 laprak 1



The screenshot shows the Dev-C++ IDE interface with the title bar "responsi - [responsi.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 140 Col: 41 Sel: 0 Lines: 192 Length: 6093 Insert Done parsing in 5,25 seconds". The code editor displays mainn.cpp with the following content:

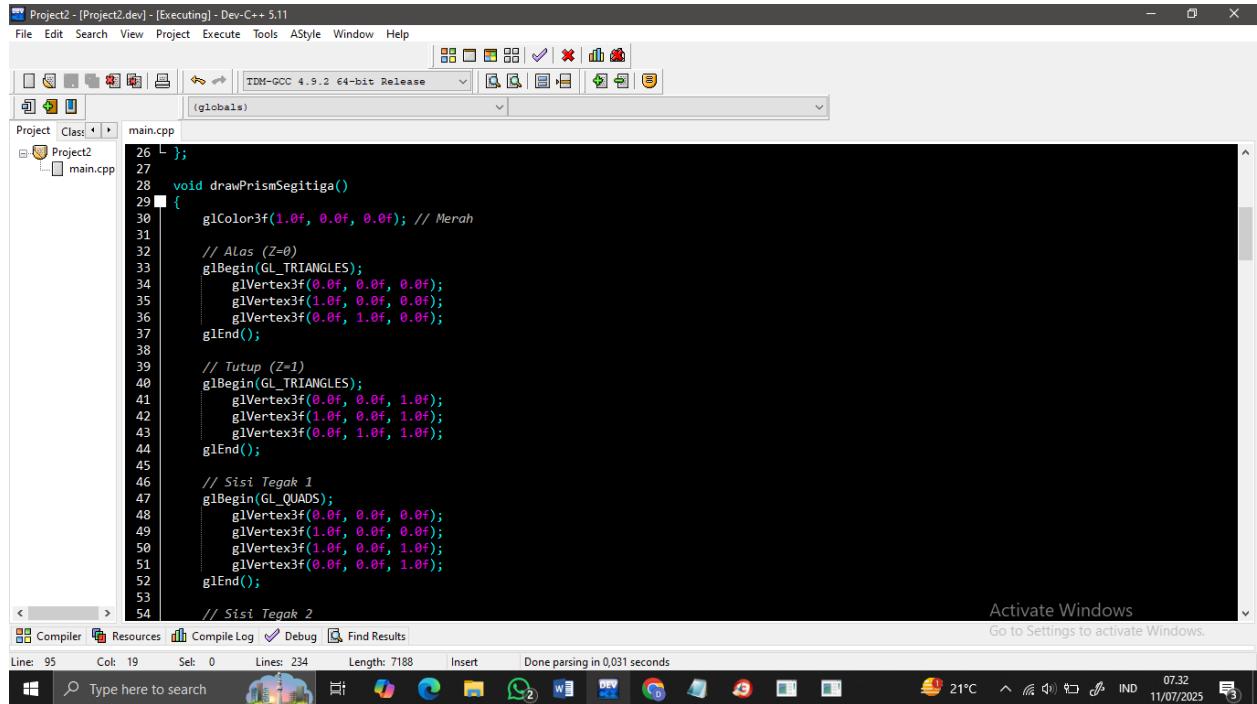
```
167 // GLUT_RGB berarti mode tampilan yang dipakai RGB
168 // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
169 // GLUT_DEPTH berarti memakai depth buffer
170 glutInit(&argc, argv);
171 glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
172
173 // set ukuran jendela tampilan
174 glutInitWindowSize(480, 480);           // besarnya jendela dalam piksel dalam hal ini 300x300
175 glutInitWindowPosition(100, 100);       // posisi jendela dilayar komputer dalam piksel
176 // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
177 glutCreateWindow("Dyah / 154 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");
178
179 // panggil fungsi init untuk inisialisasi awal
180 init();
181
182 // event handler untuk display, reshape dan keyboard
183 glutDisplayFunc(display); // display
184 glutReshapeFunc(reshape); // reshape
185 glutSpecialFunc(keyboard); // keyboard
186 //glutTimerFunc(0, timer, 0); // aktifkan timer bila perlu
187
188 // Looping
189 glutMainLoop();
190
191
192 }
```

Output



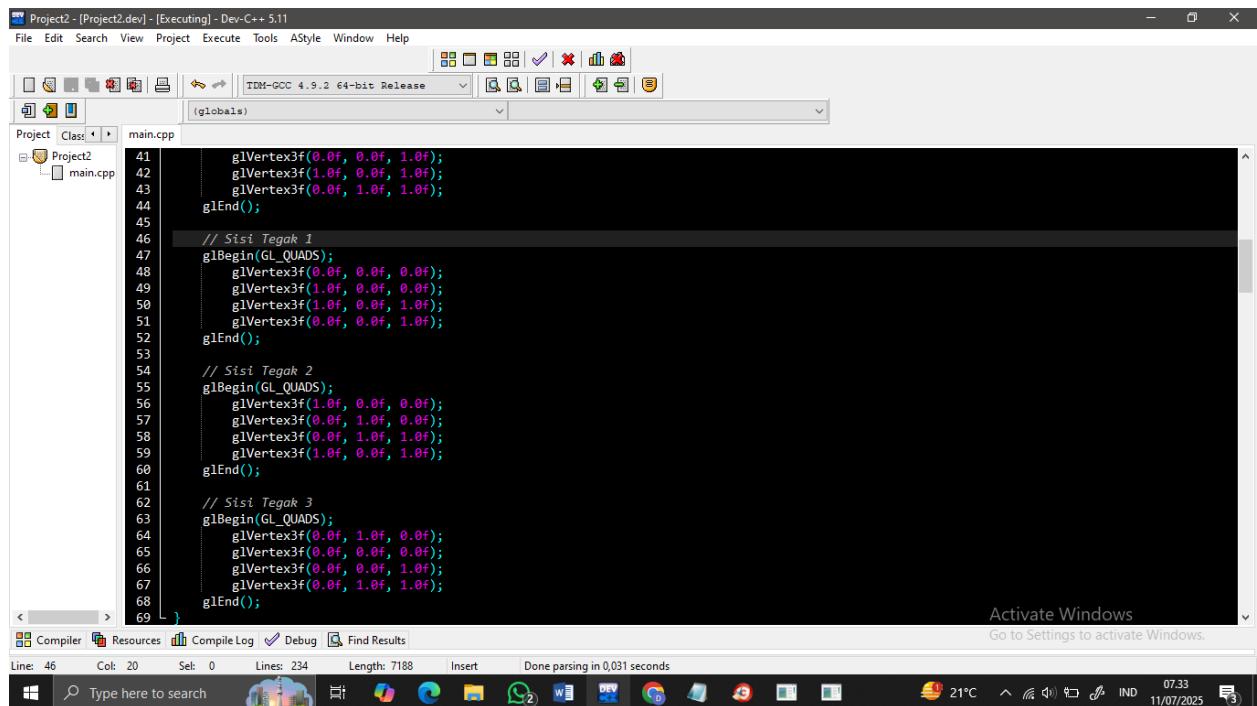
Posttest 1

Gambar 1 posttest 1



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has various icons for file operations. The main window displays the code for "main.cpp" under the "Project2" project. The code uses OpenGL functions to draw a prism. It starts with a closing brace for a class definition at line 26. Lines 27-37 handle the first triangular face ("drawPrismSegitiga") with glBegin(GL_TRIANGLES) and glVertex3f calls. Lines 38-45 handle the second triangular face ("Tutup (Z=1)") with similar code. Lines 46-53 handle the quadrilateral faces ("Sisi Tegak 1") with glBegin(GL_QUADS) and glVertex3f calls. The code ends with a closing brace for the class definition at line 54. The status bar at the bottom shows "Line: 95 Col: 19 Sel: 0 Lines: 234 Length: 7188 Insert Done parsing in 0,031 seconds". The taskbar at the bottom right shows the Windows Start button, a search bar, and various pinned application icons.

Gambar 2 posttest 1



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has various icons for file operations. The main window displays the code for "main.cpp" under the "Project2" project. The code is identical to the one in Gambar 1, showing the drawing of a prism using OpenGL functions. It includes the same class definition, drawing methods, and quadrilateral faces. The status bar at the bottom shows "Line: 46 Col: 20 Sel: 0 Lines: 234 Length: 7188 Insert Done parsing in 0,031 seconds". The taskbar at the bottom right shows the Windows Start button, a search bar, and various pinned application icons.

Gambar 3 postest 1

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 46 Col: 20 Sel: 0 Lines: 234 Length: 7188 Insert Done parsing in 0,031 seconds". The code editor window displays "main.cpp" with the following content:

```
1 // fungsi untuk menggambar obyek
2 void drawObject()
3 {
4     // obyek bisa dimasukkan diantara glPushMatrix() dan glPopMatrix()
5     // fungsinya agar obyek tidak terpengaruh atau mempengaruhi obyek lain
6     // saat diawali, ditransformasi dan sebagainya
7     glPushMatrix();
8
9     // operasi transformasi rotasi obyek ke arah kanan-kiri
10    glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
11
12    glPushMatrix();
13
14    // operasi transformasi rotasi obyek ke arah atas-bawah
15    glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
16
17    // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
18    glColor3f(1.0f, 0.0f, 0.0f);
19
20    // bila menggambar obyek harus diawali glBegin(tipe obyek) dan diakhiri dengan glEnd()
21    // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
22    glPushMatrix();
23    glTranslatef(-3.0f, 0.0f, 0.0f);
24    drawPrismSegitiga();
25    glPopMatrix();
26 }
27
28 void drawPrismJajarGenjang()
29 {
30     glColor3f(1.0f, 0.0f, 1.0f); // Magenta
31
32     // Alas (Z=0)
33     glBegin(GL_QUADS);
34     glVertex3f(0.0f, 0.0f, 0.0f);
35     glVertex3f(1.0f, 0.0f, 0.0f);
36     glVertex3f(1.5f, 1.0f, 0.0f);
37     glVertex3f(0.5f, 1.0f, 0.0f);
38     glEnd();
39
40     // Tutup (Z=1)
41     glBegin(GL_QUADS);
42     glVertex3f(0.0f, 0.0f, 1.0f);
43     glVertex3f(1.0f, 0.0f, 1.0f);
44     glVertex3f(1.5f, 1.0f, 1.0f);
45     glVertex3f(0.5f, 1.0f, 1.0f);
46     glEnd();
47
48     // Sisi Tegak 1
49     glBegin(GL_QUADS);
50     glVertex3f(0.0f, 0.0f, 0.0f);
51     glVertex3f(1.0f, 0.0f, 0.0f);
52     glVertex3f(1.0f, 0.0f, 1.0f);
53     glVertex3f(0.0f, 0.0f, 1.0f);
54     glEnd();
55 }
```

The status bar at the bottom shows "Line: 46 Col: 20 Sel: 0 Lines: 234 Length: 7188 Insert Done parsing in 0,031 seconds". The taskbar at the bottom includes icons for File Explorer, Task View, Start, Taskbar settings, and system notifications.

Gambar 4 postest 1

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 103 Col: 20 Sel: 0 Lines: 244 Length: 7452 Insert Done parsing in 0,032 seconds". The code editor window displays "main.cpp" with the following content:

```
26 L };
27
28 void drawPrismJajarGenjang()
29 {
30     glColor3f(1.0f, 0.0f, 1.0f); // Magenta
31
32     // Alas (Z=0)
33     glBegin(GL_QUADS);
34     glVertex3f(0.0f, 0.0f, 0.0f);
35     glVertex3f(1.0f, 0.0f, 0.0f);
36     glVertex3f(1.5f, 1.0f, 0.0f);
37     glVertex3f(0.5f, 1.0f, 0.0f);
38     glEnd();
39
40     // Tutup (Z=1)
41     glBegin(GL_QUADS);
42     glVertex3f(0.0f, 0.0f, 1.0f);
43     glVertex3f(1.0f, 0.0f, 1.0f);
44     glVertex3f(1.5f, 1.0f, 1.0f);
45     glVertex3f(0.5f, 1.0f, 1.0f);
46     glEnd();
47
48     // Sisi Tegak 1
49     glBegin(GL_QUADS);
50     glVertex3f(0.0f, 0.0f, 0.0f);
51     glVertex3f(1.0f, 0.0f, 0.0f);
52     glVertex3f(1.0f, 0.0f, 1.0f);
53     glVertex3f(0.0f, 0.0f, 1.0f);
54     glEnd();
55 }
```

The status bar at the bottom shows "Line: 103 Col: 20 Sel: 0 Lines: 244 Length: 7452 Insert Done parsing in 0,032 seconds". The taskbar at the bottom includes icons for File Explorer, Task View, Start, Taskbar settings, and system notifications.

Gambar 5 postest 1

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 103 Col: 20 Sel: 0 Lines: 244 Length: 7452 Insert Done parsing in 0,032 seconds". The main window displays the code for "main.cpp" which contains OpenGL vertex definitions for a cube. The code is as follows:

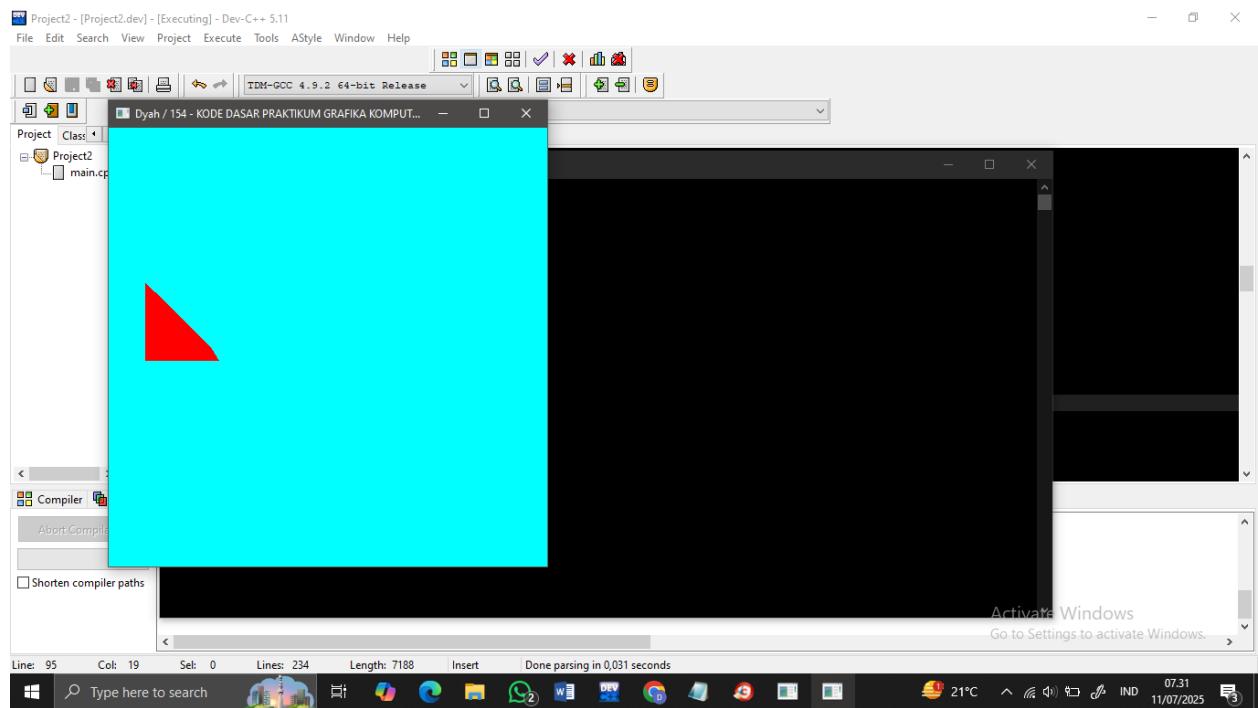
```
53     glVertex3f(0.0f, 0.0f, 1.0f);
54     glEnd();
55
56     // Sisi Tegak 2
57     glBegin(GL_QUADS);
58     glVertex3f(1.0f, 0.0f, 0.0f);
59     glVertex3f(1.5f, 1.0f, 0.0f);
60     glVertex3f(1.5f, 1.0f, 1.0f);
61     glVertex3f(1.0f, 0.0f, 1.0f);
62     glEnd();
63
64     // Sisi Tegak 3
65     glBegin(GL_QUADS);
66     glVertex3f(1.5f, 1.0f, 0.0f);
67     glVertex3f(0.5f, 1.0f, 0.0f);
68     glVertex3f(0.5f, 1.0f, 1.0f);
69     glVertex3f(1.5f, 1.0f, 1.0f);
70     glEnd();
71
72     // Sisi Tegak 4
73     glBegin(GL_QUADS);
74     glVertex3f(0.5f, 1.0f, 0.0f);
75     glVertex3f(0.0f, 0.0f, 0.0f);
76     glVertex3f(0.0f, 0.0f, 1.0f);
77     glVertex3f(0.5f, 1.0f, 1.0f);
78     glEnd();
79 }
80
81
82 // fungsi untuk menggambar obyek
83 void drawObject()
84 {
85     // obyek bisa dimasukkan diantara glPushMatrix() dan glPopMatrix()
86     // fungsinya agar obyek tidak terpengaruh atau mempengaruhi obyek lain
87     // saat diwarnai, ditransformasi dan sebagainya
88     glPushMatrix();
89
90     // operasi transformasi rotasi obyek ke arah kanan-kiri
91     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
92
93     glPushMatrix();
94
95     // operasi transformasi rotasi obyek ke arah atas-bawah
96     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
97
98     // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
99     glColor3f(1.0f, 0.0f, 0.0f);
100
101    // bila menggambar obyek harus diawali glBegin(tipe obyek) dan diakhiri dengan glEnd()
102    // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
103    glPushMatrix();
104    drawPrismajarGenjang();
105    glPopMatrix();
106 }
107
108 // taruh semua obyek yang akan digambar di fungsi display()
```

Gambar 6 postest 1

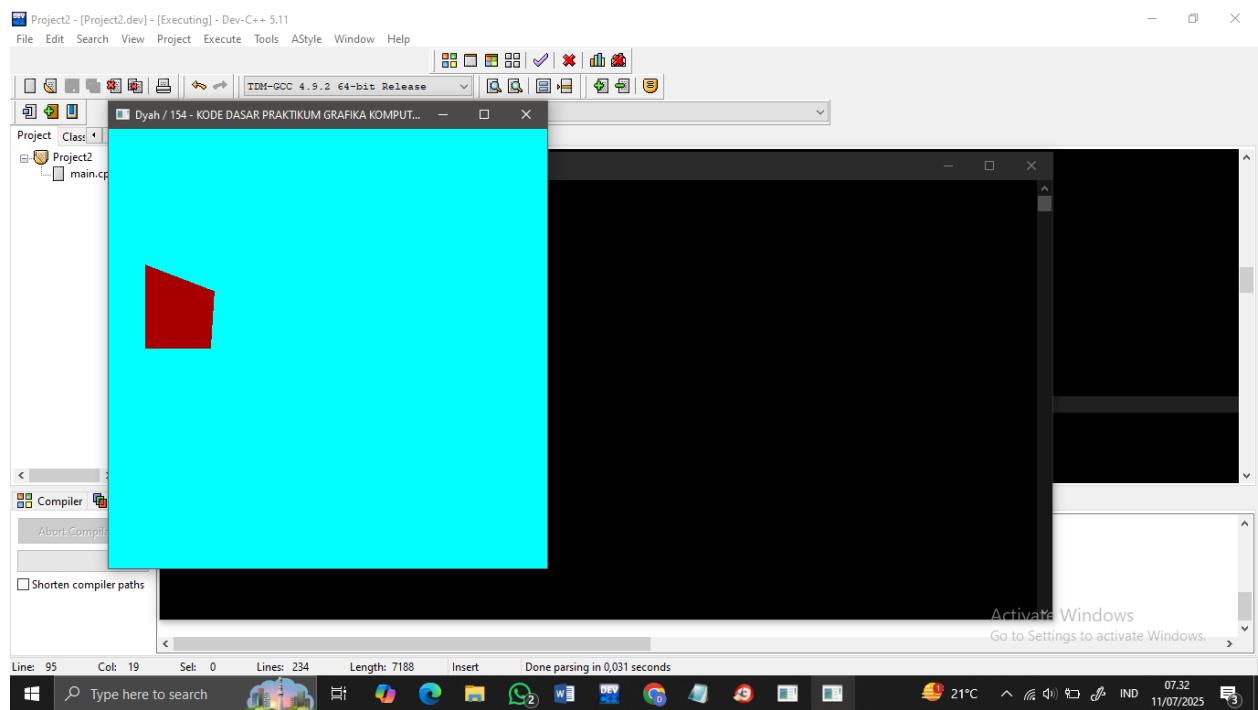
The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 103 Col: 20 Sel: 0 Lines: 244 Length: 7452 Insert Done parsing in 0,032 seconds". The main window displays the code for "main.cpp" which contains OpenGL code for drawing a prism. The code is as follows:

```
80
81
82 // fungsi untuk menggambar obyek
83 void drawObject()
84 {
85     // obyek bisa dimasukkan diantara glPushMatrix() dan glPopMatrix()
86     // fungsinya agar obyek tidak terpengaruh atau mempengaruhi obyek lain
87     // saat diwarnai, ditransformasi dan sebagainya
88     glPushMatrix();
89
90     // operasi transformasi rotasi obyek ke arah kanan-kiri
91     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
92
93     glPushMatrix();
94
95     // operasi transformasi rotasi obyek ke arah atas-bawah
96     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
97
98     // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
99     glColor3f(1.0f, 0.0f, 0.0f);
100
101    // bila menggambar obyek harus diawali glBegin(tipe obyek) dan diakhiri dengan glEnd()
102    // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
103    glPushMatrix();
104    drawPrismajarGenjang();
105    glPopMatrix();
106 }
107
108 // taruh semua obyek yang akan digambar di fungsi display()
```

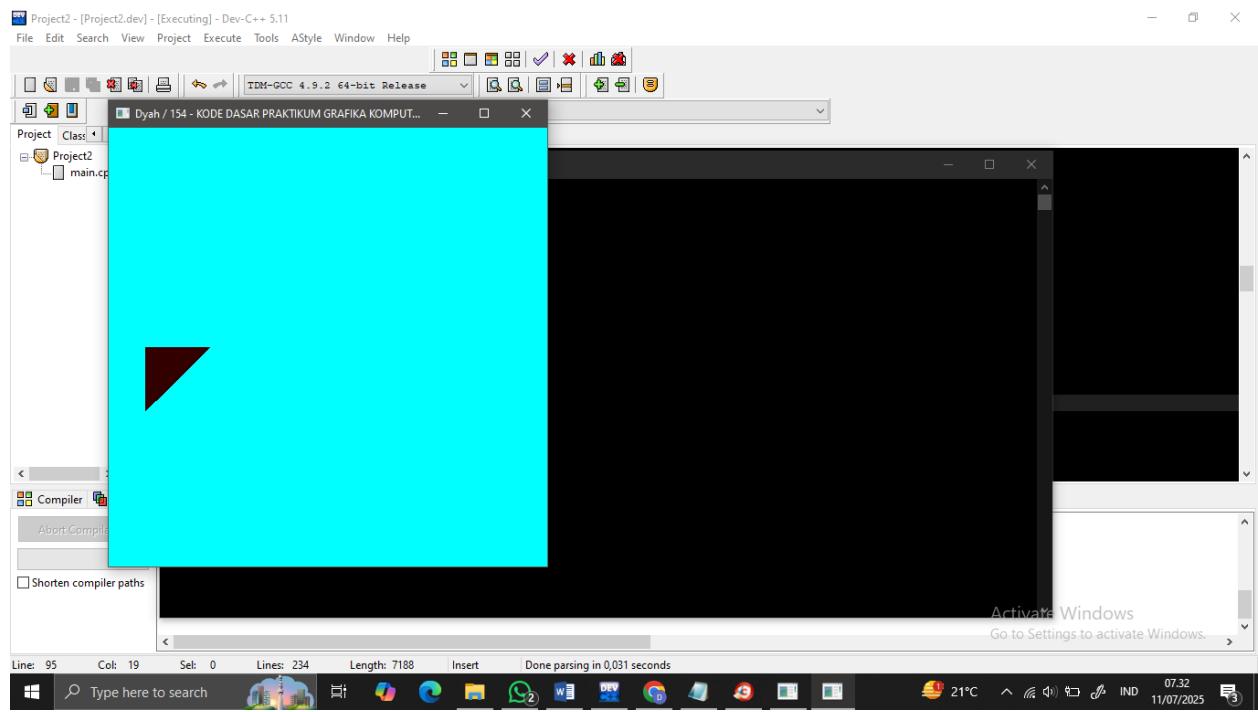
Output 1 posttest 1



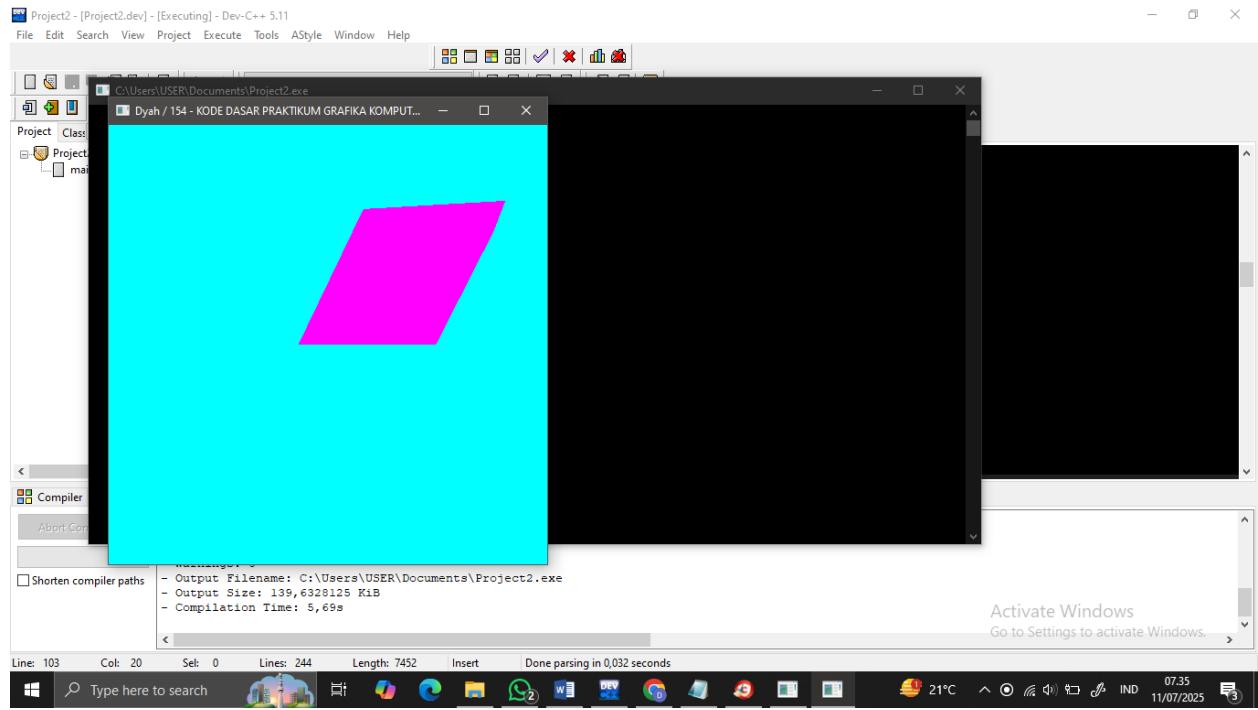
Output 2 posttest 1



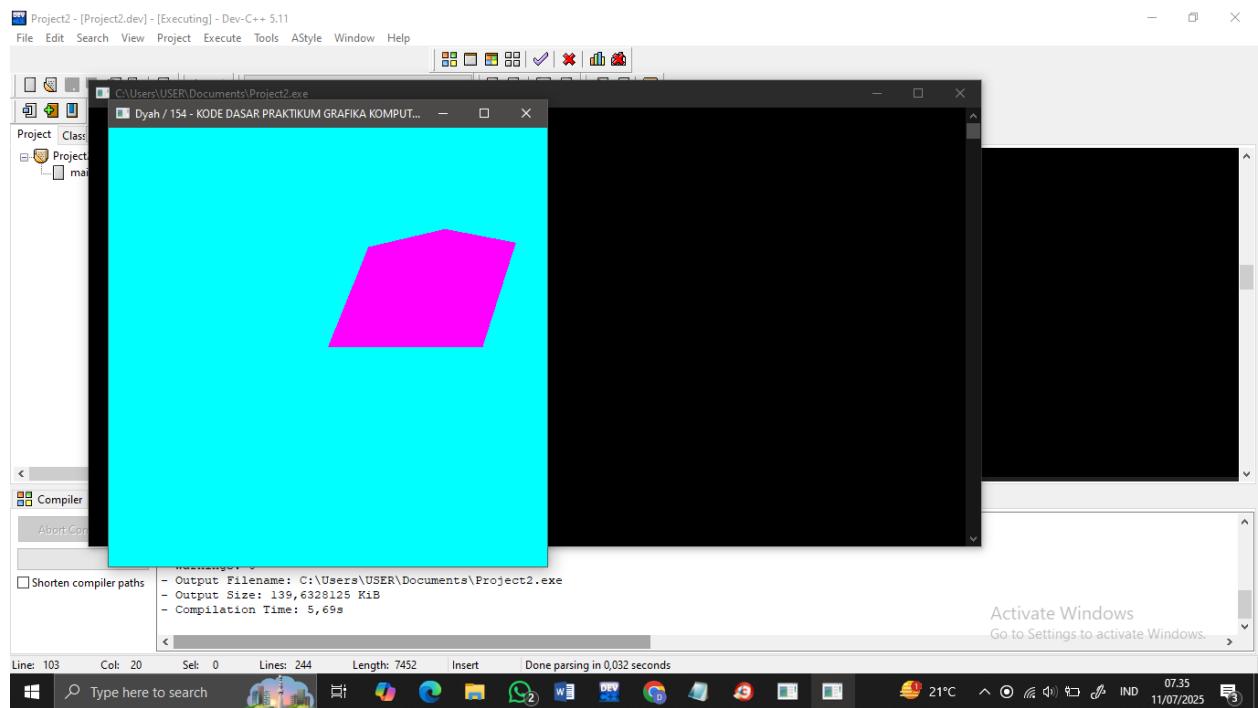
Output 3 posttest 1



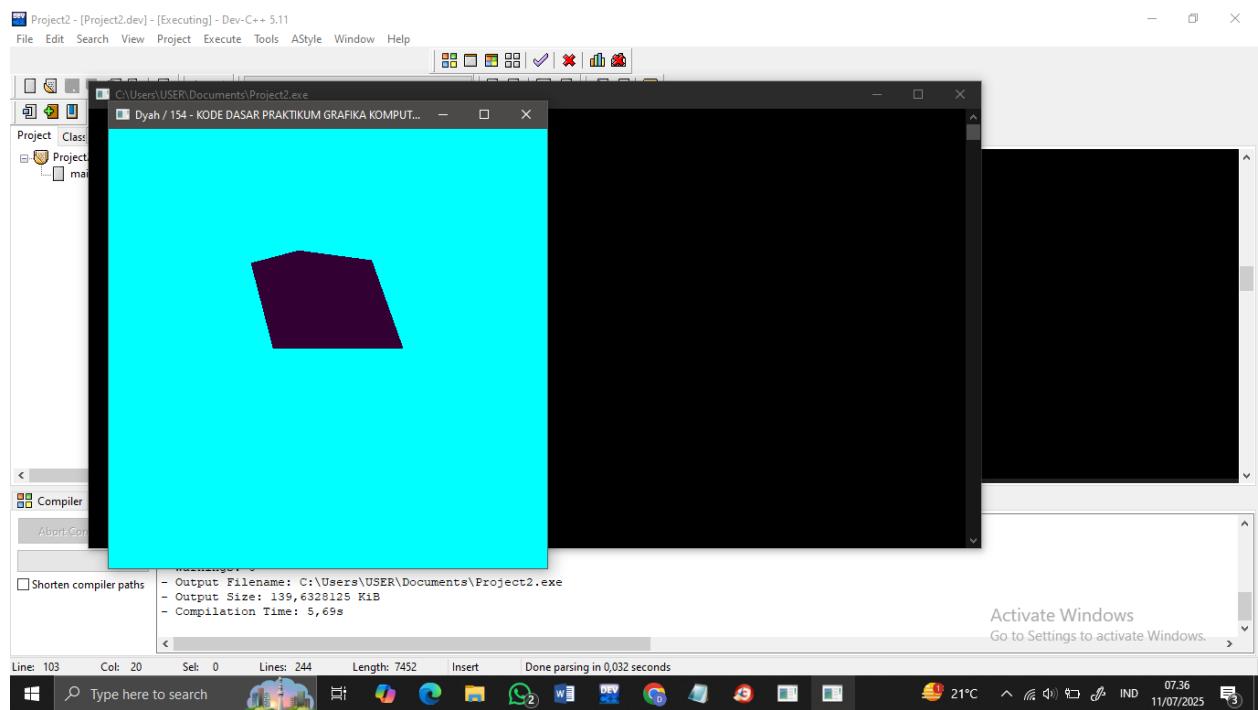
Output 4 posttest 1



Output 5 posttest 1



Output 6 posttest 1



BAB II. ALGORITMA GARIS

Pretest 2

Pertanyaan:

1. Jelaskan tahapan pembangkitan garis dengan algoritma DDA
2. Jelaskan tahapan pembangkitan garis dengan algoritma Bresenham

Jawaban:

1. Tahapan DDA

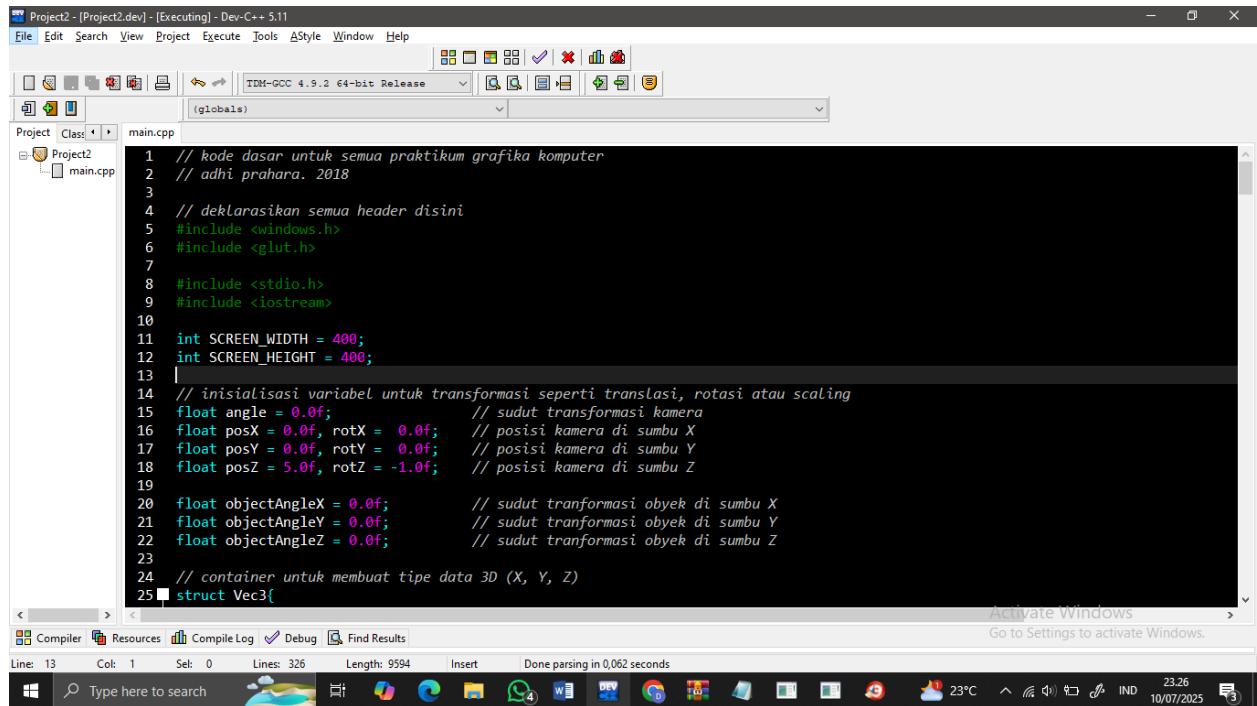
- Ketika slope berada pada nilai $-1 < m < 1$ maka koordinat x naik satu demi satu dan koordinat y naik berdasarkan slope dari garis
- Dengan menaikkan koordinat x dengan 1 maka y dapat dihitung: $y_{k+1} = y_k + m$
- Bila m diluar nilai tersebut maka lakukan sebaliknya
- Dengan menaikkan koordinat y dengan 1 maka x dapat dihitung: $x_{k+1} = x_k + 1/m$
- Selanjutnya nilai hasil perhitungan harus dibulatkan agar cocok dengan nilai piksel

2. Tahapan Bresenham

- Bila titik awal garis (x_1, y_1) dan akhir garis (x_2, y_2) , untuk inisialisasi awal, hitung;
 - a. Selisih lebar = $\Delta x = x_2 - x_1$
 - b. Selisih tinggi = $\Delta y = y_2 - y_1$
 - c. $2\Delta y = 2(y_2 - y_1)$
- Inisial parameter keputusan = $p_0 = 2\Delta y - \Delta x$
- Setiap x_k di sepanjang garis, mulai dari $k = 0$, cek kondisi berikut:
 - a. Jika $p_k < 0$ maka titik selanjutnya untuk digambar di : $(x_k + 1, y_k)$ $p_{k+1} = p_k + 2\Delta y$
 - b. Selain itu maka titik selanjutnya untuk digambar di : $(x_k + 1, y_k + 1)$ $p_{k+1} = p_k + 2\Delta y - 2\Delta x$
- Ulangi langkah diatas sebanyak Δx

Langkah Praktikum 2

Gambar 1 laprak 2



The screenshot shows the Dev-C++ IDE interface with the following details:

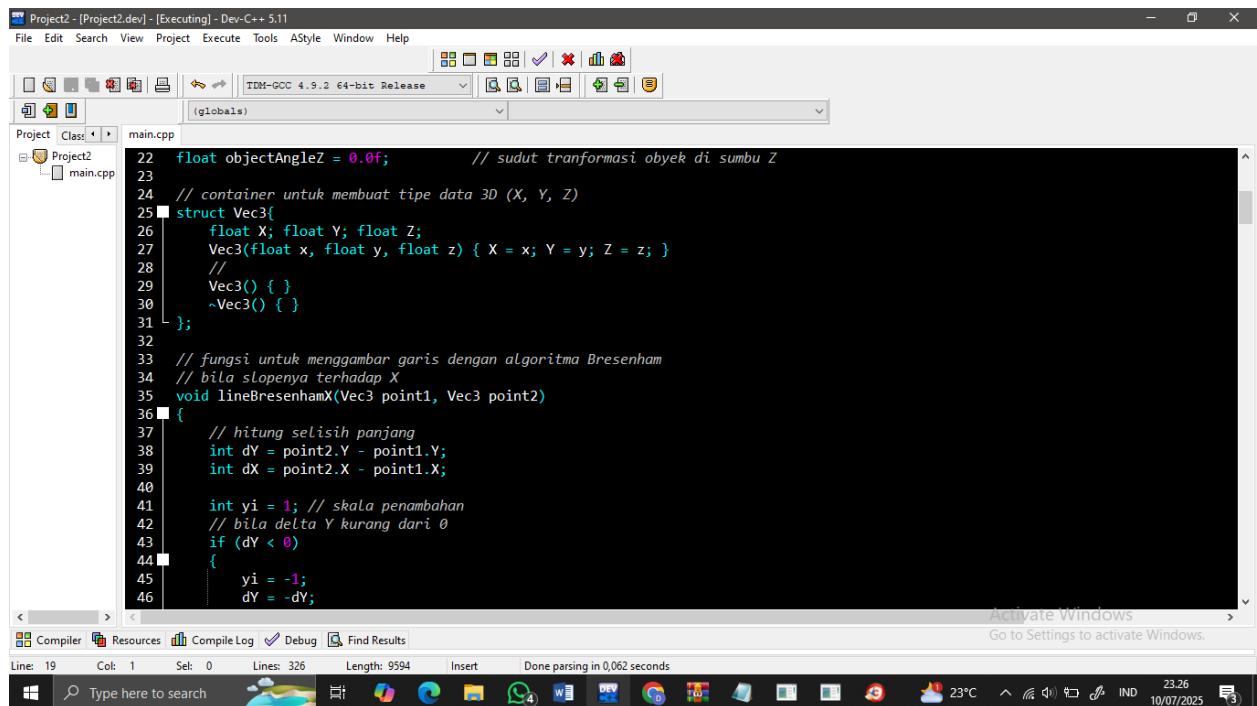
- Title Bar:** Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11
- Menu Bar:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help
- Toolbar:** Includes icons for New, Open, Save, Build, Run, Stop, and others.
- Project Explorer:** Shows "Project2" and "main.cpp".
- Code Editor:** Displays the following C++ code:

```
1 // kode dasar untuk semua praktikum grafika komputer
2 // adhi prahara. 2018
3
4 // deklarasikan semua header disini
5 #include <windows.h>
6 #include <glut.h>
7
8 #include <stdio.h>
9 #include <iostream>
10
11 int SCREEN_WIDTH = 400;
12 int SCREEN_HEIGHT = 400;
13
14 // inisialisasi variabel untuk transformasi seperti translasi, rotasi atau scaling
15 float angle = 0.0f; // sudut transformasi kamera
16 float posX = 0.0f, rotX = 0.0f; // posisi kamera di sumbu X
17 float posY = 0.0f, rotY = 0.0f; // posisi kamera di sumbu Y
18 float posZ = 5.0f, rotZ = -1.0f; // posisi kamera di sumbu Z
19
20 float objectAngleX = 0.0f; // sudut transformasi objek di sumbu X
21 float objectAngleY = 0.0f; // sudut transformasi objek di sumbu Y
22 float objectAngleZ = 0.0f; // sudut transformasi objek di sumbu Z
23
24 // container untuk membuat tipe data 3D (X, Y, Z)
25 struct Vec3{
```

Below the code editor, status bar information includes: Line: 13, Col: 1, Sel: 0, Lines: 326, Length: 9594, Insert, Done parsing in 0.062 seconds.

The taskbar at the bottom shows various application icons and the system clock indicating 23:26 on 10/07/2025.

Gambar 2 laprak 2



The screenshot shows the Dev-C++ IDE interface with the following details:

- Title Bar:** Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11
- Menu Bar:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help
- Toolbar:** Includes icons for New, Open, Save, Build, Run, Stop, and others.
- Project Explorer:** Shows "Project2" and "main.cpp".
- Code Editor:** Displays the following C++ code, which is identical to Gambar 1 but includes a new class definition starting at line 25:

```
22 float objectAngleZ = 0.0f; // sudut transformasi objek di sumbu Z
23
24 // container untuk membuat tipe data 3D (X, Y, Z)
25 struct Vec3{
26     float X; float Y; float Z;
27     Vec3(float x, float y, float z) { X = x; Y = y; Z = z; }
28     //
29     Vec3() { }
30     ~Vec3() { }
31 };
32
33 // fungsi untuk menggambar garis dengan algoritma Bresenham
34 // bila slopenya terhadap X
35 void lineBresenhamX(Vec3 point1, Vec3 point2)
36 {
37     // hitung selisih panjang
38     int dY = point2.Y - point1.Y;
39     int dX = point2.X - point1.X;
40
41     int yi = 1; // skala penambahan
42     // bila delta Y kurang dari 0
43     if (dY < 0)
44     {
45         yi = -1;
46         dY = -dY;
```

Below the code editor, status bar information includes: Line: 19, Col: 1, Sel: 0, Lines: 326, Length: 9594, Insert, Done parsing in 0.062 seconds.

The taskbar at the bottom shows various application icons and the system clock indicating 23:26 on 10/07/2025.

Gambar 3 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The main window displays the code for "main.cpp". The code implements the Bresenham line drawing algorithm. It starts by calculating differences (dY and dX) between the two points. It then initializes variables for the first point and begins a loop to calculate intermediate points. The code uses global OpenGL functions like `glBegin(GL_POINTS)` and `glVertex3f` to draw the line.

```
34 // bila slopenya terhadap X
35 void lineBresenhamX(Vec3 point1, Vec3 point2)
36 {
37     // hitung selisih panjang
38     int dY = point2.Y - point1.Y;
39     int dX = point2.X - point1.X;
40
41     int yi = 1; // skala penambahan
42     // bila delta Y kurang dari 0
43     if (dY < 0)
44     {
45         yi = -1;
46         dY = -dY;
47     }
48
49     // mulai menggambar titik-titik
50     glBegin(GL_POINTS);
51     // koordinat titik awal
52     glVertex3f(point1.X, point1.Y, point1.Z);
53
54     int pX = point1.X, pY = point1.Y, pZ = point1.Z;
55     int dY2 = 2*dY;           // hitung 2*deltaY
56     int dX2 = 2*dX;           // hitung 2*deltaX
57     int pk = dY2 - dX;        // hitung p0
58     // kenaikan terhadap X
```

Gambar 4 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The main window displays the code for "main.cpp", which continues from the previous screenshot. The loop iterates through the points, updating the error term (pk) and the coordinates (pX, pY) based on whether the error is less than or greater than zero. The code uses OpenGL functions to draw each point in sequence, resulting in a straight line segment between the two specified points.

```
55     int dY2 = 2*dY;           // hitung 2*deltaY
56     int dX2 = 2*dX;           // hitung 2*deltaX
57     int pk = dY2 - dX;        // hitung p0
58     // kenaikan terhadap X
59     for (int i = point1.X; i < point2.X; i++)
60     {
61         if (pk < 0)           // bila p < 0
62         {
63             pk = pk + dY2;    // update pk+1 = pk + 2dY
64             pX = pX + 1;       // Xn+1 = Xn + 1
65             pY = pY;           // Yn+1 = Yn
66         }
67         else // bila p >= 0
68         {
69             pk = pk + dY2 - dX2; // update pk+1 = pk + 2dY - 2dX
70             pX = pX + 1;       // Xn+1 = Xn + 1
71             pY = pY + yi;      // Yn+1 = Yn + yi
72         }
73         glVertex3f(pX, pY, pZ);
74     }
75     // koordinat titik akhir
76     glVertex3f(point2.X, point2.Y, point2.Z);
77     glEnd();
78 }
```

Gambar 5 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 99 Col: 46 Sel: 0 Lines: 326 Length: 9594 Insert Done parsing in 0,062 seconds". The code editor window displays main.cpp with the following code:

```
79 // fungsi untuk menggambar garis dengan algoritma Bresenham
80 // bila slopenya terhadap Y
81 void lineBresenham(Vec3 point1, Vec3 point2)
82 {
83     // hitung selisih panjang
84     int dY = point2.Y - point1.Y;
85     int dX = point2.X - point1.X;
86
87     int xi = 1; // skala penambahan
88     // bila delta X kurang dari 0
89     if (dX < 0)
90     {
91         xi = -1;
92         dX = -dX;
93     }
94
95     // mulai menggambar titik-titik
96     glBegin(GL_POINTS);
97     // koordinat titik awal
98     glVertex3f(point1.X, point1.Y, point1.Z);
99
100    int pX = point1.X, pY = point1.Y, pZ = point1.Z;
101    int dY2 = 2*dY; // hitung 2*deltaY
102    int dX2 = 2*dX; // hitung 2*deltaX
```

Gambar 6 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 148 Col: 2 Sel: 0 Lines: 326 Length: 9594 Insert Done parsing in 0,062 seconds". The code editor window displays main.cpp with the following code:

```
100    int pX = point1.X, pY = point1.Y, pZ = point1.Z;
101    int dY2 = 2*dY; // hitung 2*deltaY
102    int dX2 = 2*dX; // hitung 2*deltaX
103    int pk = dX2 - dY; // hitung p0
104    // kenaikan terhadap Y
105    for (int i = point1.Y; i < point2.Y; i++)
106    {
107        if (pk < 0) // bila p < 0
108        {
109            pk = pk + dX2; // update pk+1 = pk + 2dX
110            pX = pX; // Xn+1 = Xn
111            pY = pY + 1; // Yn+1 = Yn + 1
112        }
113        else // bila p >= 0
114        {
115            pk = pk + dX2 - dY2; // update pk+1 = pk + 2dX - 2dY
116            pX = pX + xi; // Xn+1 = Xn + xi
117            pY = pY + 1; // Yn+1 = Yn + 1
118        }
119        glVertex3f(pX, pY, pZ);
120    }
121    // koordinat titik akhir
122    glVertex3f(point2.X, point2.Y, point2.Z);
123    glEnd();
```

Gambar 7 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 119 Col: 10 Sel: 0 Lines: 326 Length: 9594 Insert Done parsing in 0,062 seconds". The code editor displays the following C++ code:

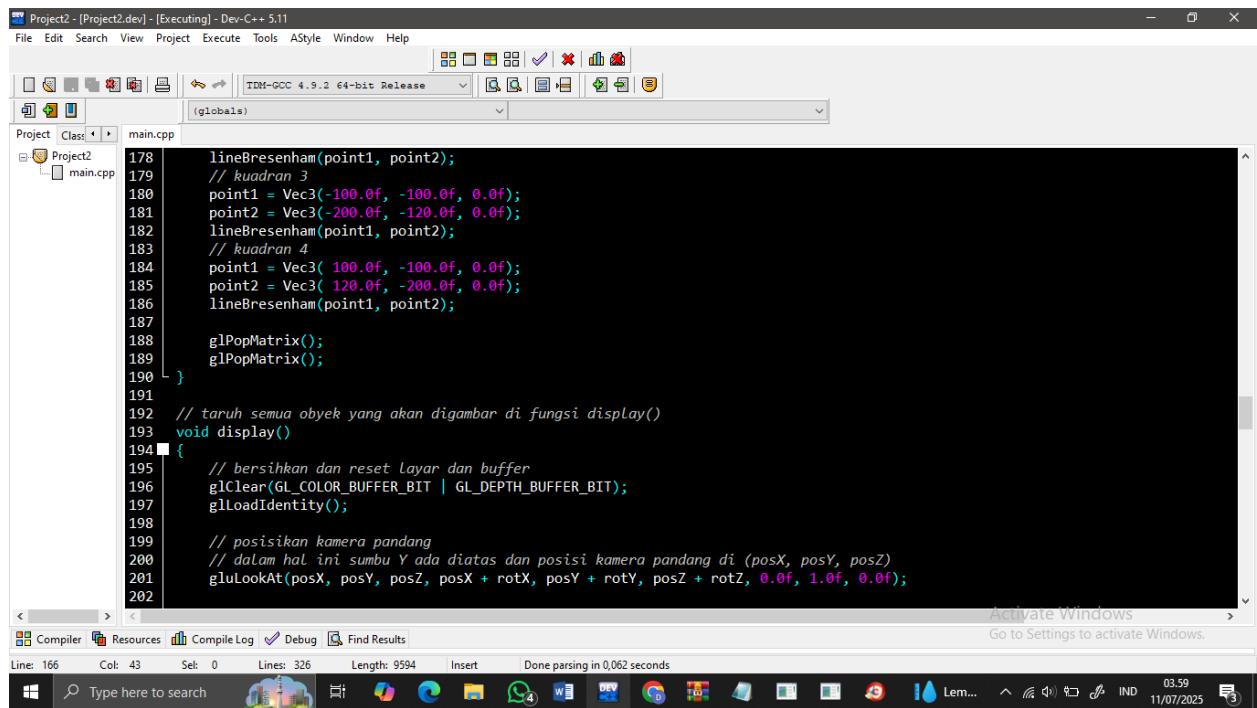
```
127 // fungsi untuk menggambar garis dengan algoritma Bresenham
128 void lineBresenham(Vec3 point1, Vec3 point2)
129 {
130     // hitung selisih panjang
131     int dY = point2.Y - point1.Y;
132     int dX = point2.X - point1.X;
133     if (abs(dY) < abs(dX)) // bila deltaY lebih pendek dari deltaX
134     {
135         if (point1.X < point2.X) // bila X1 < X2
136             lineBresenhamX(point1, point2);
137         else // bila X1 > X2 maka dibalik
138             lineBresenhamX(point2, point1);
139     }
140     else // bila deltaY lebih panjang dari deltaX
141     {
142         if (point1.Y < point2.Y) // bila Y1 < Y2
143             lineBresenhamY(point1, point2);
144         else // bila Y1 > Y2 maka dibalik
145             lineBresenhamY(point2, point1);
146     }
147 }
148
149
150
151 // fungsi untuk menggambar objek
```

Gambar 8 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 146 Col: 37 Sel: 0 Lines: 326 Length: 9594 Insert Done parsing in 0,062 seconds". The code editor displays the following C++ code:

```
151 // fungsi untuk menggambar objek
152 void drawObject()
153 {
154     glPushMatrix();
155     // operasi transformasi rotasi objek ke arah kanan-kiri
156     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
157     glPushMatrix();
158     // operasi transformasi rotasi objek ke arah atas-bawah
159     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
160
161     // set warna objek ke warna hijau (0.0f, 1.0f, 0.0f)
162     glColor3f(0.0f, 1.0f, 0.0f);
163
164     // gambar sumbu
165     Vec3 sbY1 = Vec3( 0.0f, -300.0f, 0.0f);
166     Vec3 sbY2 = Vec3( 0.0f, 300.0f, 0.0f);
167     Vec3 sbX1 = Vec3(-300.0f, 0.0f, 0.0f);
168     Vec3 sbX2 = Vec3( 300.0f, 0.0f, 0.0f);
169     lineBresenham(sbX1, sbX2);
170     lineBresenham(sbY1, sbY2);
171     // kuadran 1
172     Vec3 point1 = Vec3( 100.0f, 100.0f, 0.0f);
173     Vec3 point2 = Vec3( 200.0f, 120.0f, 0.0f);
174     lineBresenham(point1, point2);
175     // kuadran 2
```

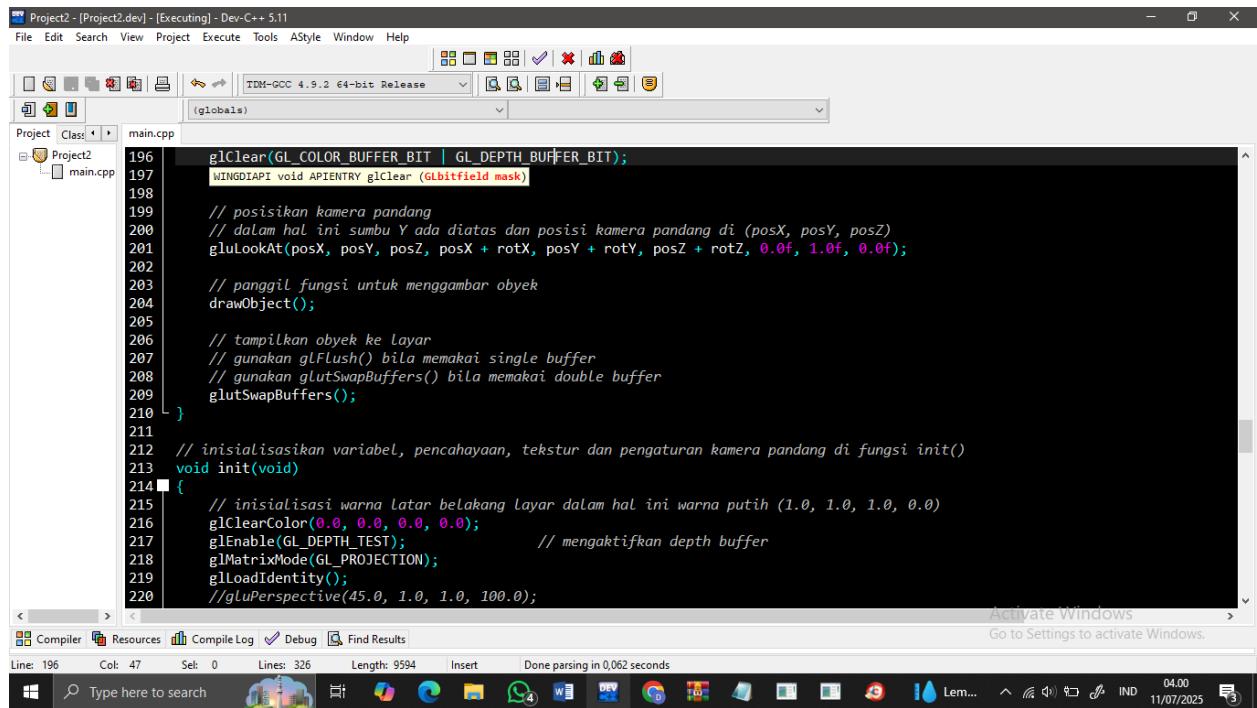
Gambar 9 laprak 2



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 166 Col: 43 Sel: 0 Lines: 326 Length: 9594 Insert Done parsing in 0,062 seconds". The code editor displays the main.cpp file with the following content:

```
178     lineBresenham(point1, point2);
179     // kuadran 3
180     point1 = Vec3(-100.0f, -100.0f, 0.0f);
181     point2 = Vec3(-200.0f, -120.0f, 0.0f);
182     lineBresenham(point1, point2);
183     // kuadran 4
184     point1 = Vec3( 100.0f, -100.0f, 0.0f);
185     point2 = Vec3( 120.0f, -200.0f, 0.0f);
186     lineBresenham(point1, point2);
187
188     glPopMatrix();
189     glPopMatrix();
190 }
191
192 // taruh semua obyek yang akan digambar di fungsi display()
193 void display()
194 {
195     // bersihkan dan reset layar dan buffer
196     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
197     glLoadIdentity();
198
199     // posisikan kamera pandang
200     // dalam hal ini sumbu Y ada diatas dan posisi kamera pandang di (posX, posY, posZ)
201     gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
202 }
```

Gambar 10 laprak 2



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 196 Col: 47 Sel: 0 Lines: 326 Length: 9594 Insert Done parsing in 0,062 seconds". The code editor displays the main.cpp file with the following content:

```
196     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
197     WINGDIAPI void APIENTRY glClear (GLbitfield mask);
198
199     // posisikan kamera pandang
200     // dalam hal ini sumbu Y ada diatas dan posisi kamera pandang di (posX, posY, posZ)
201     gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
202
203     // panggil fungsi untuk menggambar obyek
204     drawObject();
205
206     // tampilkan obyek ke layar
207     // gunakan glFlush() bila memakai single buffer
208     // gunakan glutSwapBuffers() bila memakai double buffer
209     glutSwapBuffers();
210 }
211
212 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
213 void init(void)
214 {
215     // inisialisasi warna latar belakang layar dalam hal ini warna putih (1.0, 1.0, 1.0, 0.0)
216     glClearColor(0.0, 0.0, 0.0, 0.0);
217     glEnable(GL_DEPTH_TEST);           // mengaktifkan depth buffer
218     glMatrixMode(GL_PROJECTION);
219     glLoadIdentity();
220     //gluPerspective(45.0, 1.0, 1.0, 100.0);
```

Gambar 11 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 210 Col: 2 Sel: 0 Lines: 326 Length: 9594 Insert Done parsing in 0,062 seconds". The code editor displays the following C++ code:

```
211 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
212 void init(void)
213 {
214     // inisialisasi warna latar belakang Layar dalam hal ini warna putih (1.0, 1.0, 1.0, 0.0)
215     glClearColor(0.0, 0.0, 0.0, 0.0);
216     glEnable(GL_DEPTH_TEST); // mengaktifkan depth buffer
217     glMatrixMode(GL_PROJECTION);
218     glLoadIdentity();
219     //gluPerspective(45.0, 1.0, 1.0, 100.0);
220     glOrtho((GLfloat)SCREEN_WIDTH/2, (GLfloat)SCREEN_WIDTH/2, (GLfloat)SCREEN_HEIGHT/2, (GLfloat)SCREEN_HEIGHT/2, 1.0, 100.0);
221     glMatrixMode(GL_MODELVIEW);
222     glLoadIdentity();
223     // inisialisasi kamera pandang
224     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
225 }
226
227
228 // fungsi ini digunakan bila layar akan diresize (default)
229 void reshape(int w, int h)
230 {
231     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
232     glMatrixMode(GL_PROJECTION);
233     glLoadIdentity();
234     //gluPerspective(45, (GLfloat)w / (GLfloat)h, 1.0, 100.0);
235     glOrtho((GLfloat)-w/2, (GLfloat)w/2, (GLfloat)-h/2, (GLfloat)h/2, 1.0, 100.0);
236 }
```

Gambar 12 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 228 Col: 41 Sel: 0 Lines: 326 Length: 9594 Insert Done parsing in 0,062 seconds". The code editor displays the following C++ code:

```
229 void reshape(int w, int h)
230 {
231     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
232     glMatrixMode(GL_PROJECTION);
233     glLoadIdentity();
234     //gluPerspective(45, (GLfloat)w / (GLfloat)h, 1.0, 100.0);
235     glOrtho((GLfloat)-w/2, (GLfloat)w/2, (GLfloat)-h/2, (GLfloat)h/2, 1.0, 100.0);
236     glMatrixMode(GL_MODELVIEW);
237 }
238
239 // fungsi untuk mengatur masukan dari keyboard
240 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
241 void keyboard(int key, int x, int y)
242 {
243     float fraction = 0.1f;
244
245     switch (key)
246     {
247         // masukkan perintah disini bila tombol kiri ditekan
248         case GLUT_KEY_LEFT:
249             // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
250             objectAngleY -= 1.0f;
251             glutPostRedisplay(); // update obyek
252             break;
253         // masukkan perintah disini bila tombol kanan ditekan
```

Gambar 13 laprak 2

The screenshot shows the Dev-C++ IDE interface with the main.cpp file open. The code handles keyboard input for rotation and zooming:

```
250     objectAngleY -= 1.0f; // update obyek
251     glutPostRedisplay(); // update obyek
252     break;
253     // masukkan perintah disini bila tombol kanan ditekan
254     case GLUT_KEY_RIGHT:
255         // dalam hal ini perintah rotasi obyek ke kanan sebanyak 1 derajat
256         objectAngleY += 1.0f;
257         glutPostRedisplay(); // update obyek
258         break;
259     // masukkan perintah disini bila tombol atas ditekan
260     case GLUT_KEY_UP:
261         // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
262         objectAngleX -= 1.0f;
263         glutPostRedisplay(); // update obyek
264         break;
265     // masukkan perintah disini bila tombol bawah ditekan
266     case GLUT_KEY_DOWN:
267         // dalam hal ini perintah rotasi obyek ke bawah sebanyak 1 derajat
268         objectAngleX += 1.0f;
269         glutPostRedisplay(); // update obyek
270         break;
271     // zoom in
272     case GLUT_KEY_PAGE_UP:
273         // masukkan perintah disini bila tombol PgUp ditekan
274         posX += rotX * fraction;
275
276         // zoom out
277     case GLUT_KEY_PAGE_DOWN:
278         // masukkan perintah disini bila tombol PgDn ditekan
279         posX -= rotX * fraction;
280         posZ -= rotZ * fraction;
281         glutPostRedisplay(); // update obyek
282         break;
283     }
284
285     // timer untuk animasi (gunakan bila perlu)
286     void timer(int value)
287     {
288         glutPostRedisplay();
289         glutTimerFunc(55, timer, 0);
290     }
291
292     // program utama
293 }
```

The code includes comments explaining the purpose of each section: rotation around the Y-axis for right and up keys, rotation around the X-axis for down key, and zooming in/out along the X and Z axes for page up/down keys. It also defines a timer function for animation.

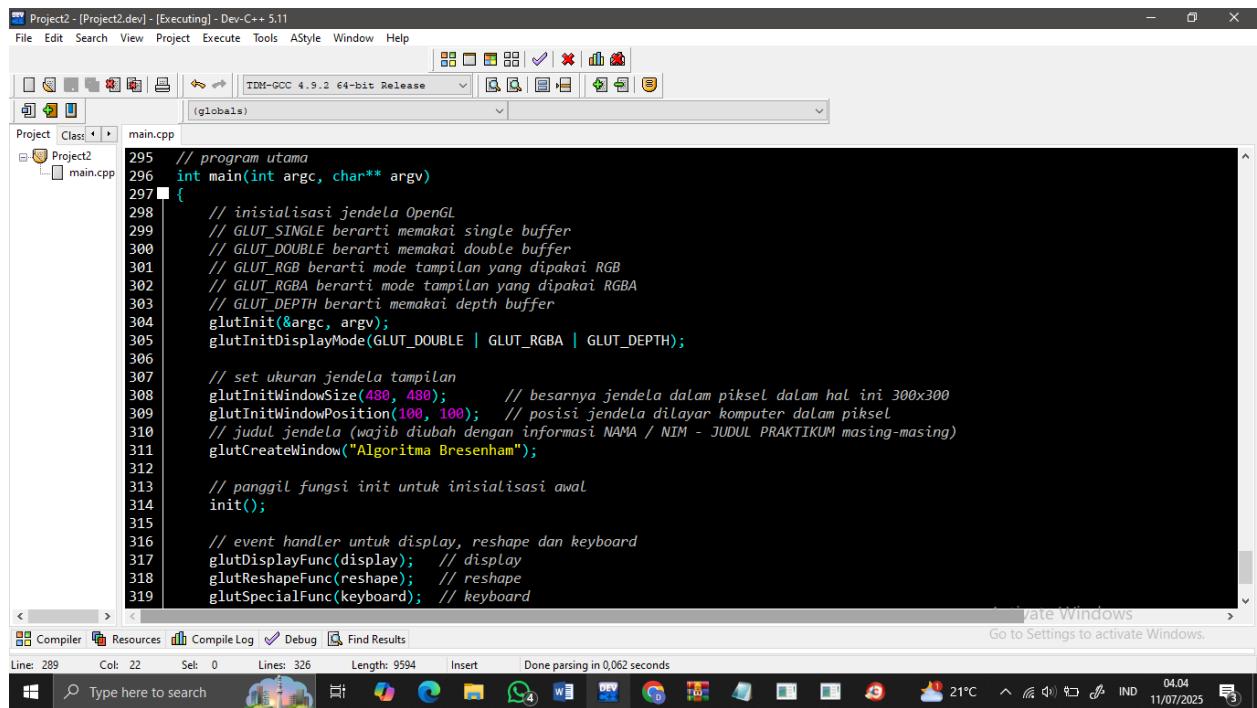
Gambar 14 laprak 2

The screenshot shows the Dev-C++ IDE interface with the main.cpp file open. The code handles keyboard input for zooming and defines a timer function:

```
271     // zoom in
272     case GLUT_KEY_PAGE_UP:
273         // masukkan perintah disini bila tombol PgUp ditekan
274         posX += rotX * fraction;
275         posZ += rotZ * fraction;
276         glutPostRedisplay(); // update obyek
277         break;
278     // zoom out
279     case GLUT_KEY_PAGE_DOWN:
280         // masukkan perintah disini bila tombol PgDn ditekan
281         posX -= rotX * fraction;
282         posZ -= rotZ * fraction;
283         glutPostRedisplay(); // update obyek
284         break;
285     }
286
287     // timer untuk animasi (gunakan bila perlu)
288     void timer(int value)
289     {
290         glutPostRedisplay();
291         glutTimerFunc(55, timer, 0);
292     }
293
294     // program utama
295 }
```

The code continues from the previous screenshot, adding logic for zooming and defining a timer function. The zoom logic is similar to the rotation logic, using the same fraction variable for scaling. The timer function is defined with a period of 55 milliseconds.

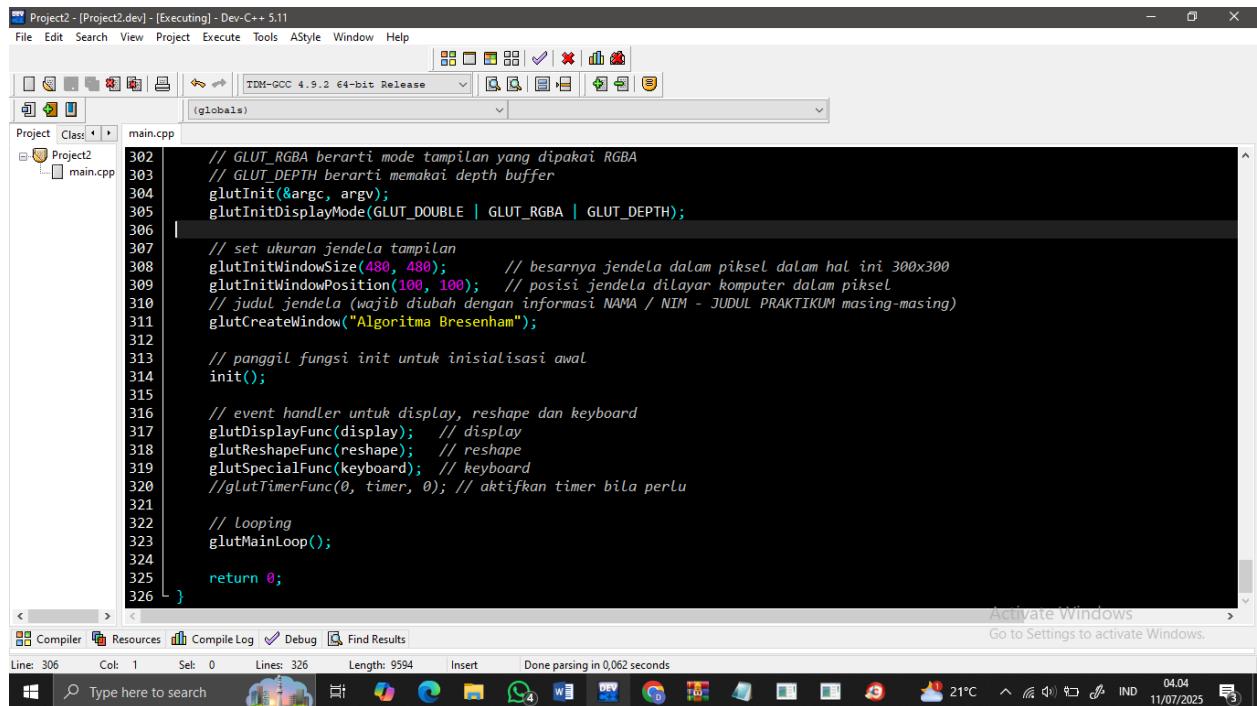
Gambar 15 laprak 2



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 289 Col: 22 Sel: 0 Lines: 326 Length: 9594 Insert Done parsing in 0,062 seconds". The code editor displays the main.cpp file with the following content:

```
295 // program utama
296 int main(int argc, char** argv)
297 {
298     // inisialisasi jendela OpenGL
299     // GLUT_SINGLE berarti memakai single buffer
300     // GLUT_DOUBLE berarti memakai double buffer
301     // GLUT_RGB berarti mode tampilan yang dipakai RGB
302     // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
303     // GLUT_DEPTH berarti memakai depth buffer
304     glutInit(&argc, argv);
305     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
306
307     // set ukuran jendela tampilan
308     glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
309     glutInitWindowPosition(100, 100); // posisi jendela di layar komputer dalam piksel
310     // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
311     glutCreateWindow("Algoritma Bresenham");
312
313     // panggil fungsi init untuk inisialisasi awal
314     init();
315
316     // event handler untuk display, reshape dan keyboard
317     glutDisplayFunc(display); // display
318     glutReshapeFunc(reshape); // reshape
319     glutSpecialFunc(keyboard); // keyboard
320
321     // Looping
322     glutMainLoop();
323
324     return 0;
325 }
```

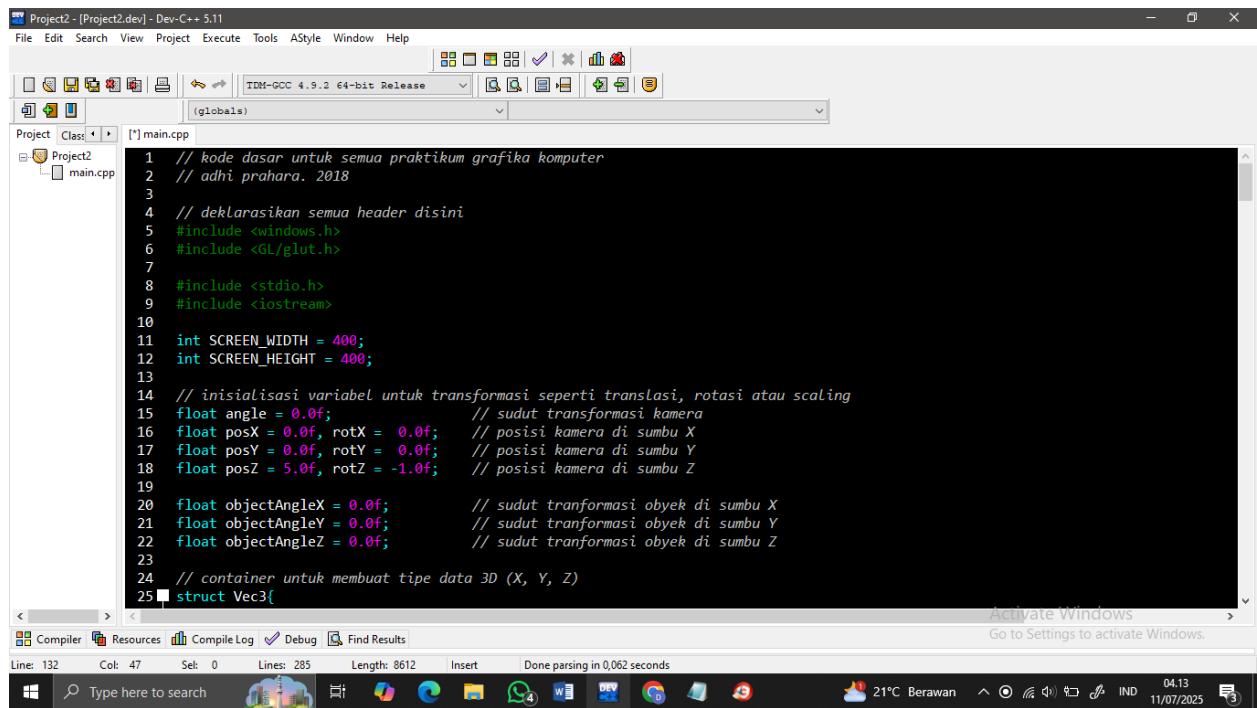
Gambar 16 laprak 2



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 306 Col: 1 Sel: 0 Lines: 326 Length: 9594 Insert Done parsing in 0,062 seconds". The code editor displays the main.cpp file with the following content:

```
302 // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
303 // GLUT_DEPTH berarti memakai depth buffer
304 glutInit(&argc, argv);
305 glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
306
307 // set ukuran jendela tampilan
308 glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
309 glutInitWindowPosition(100, 100); // posisi jendela di layar komputer dalam piksel
310 // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
311 glutCreateWindow("Algoritma Bresenham");
312
313 // panggil fungsi init untuk inisialisasi awal
314 init();
315
316 // event handler untuk display, reshape dan keyboard
317 glutDisplayFunc(display); // display
318 glutReshapeFunc(reshape); // reshape
319 glutSpecialFunc(keyboard); // keyboard
320 // glutTimerFunc(0, timer, 0); // aktifkan timer bila perlu
321
322 // Looping
323 glutMainLoop();
324
325
326 }
```

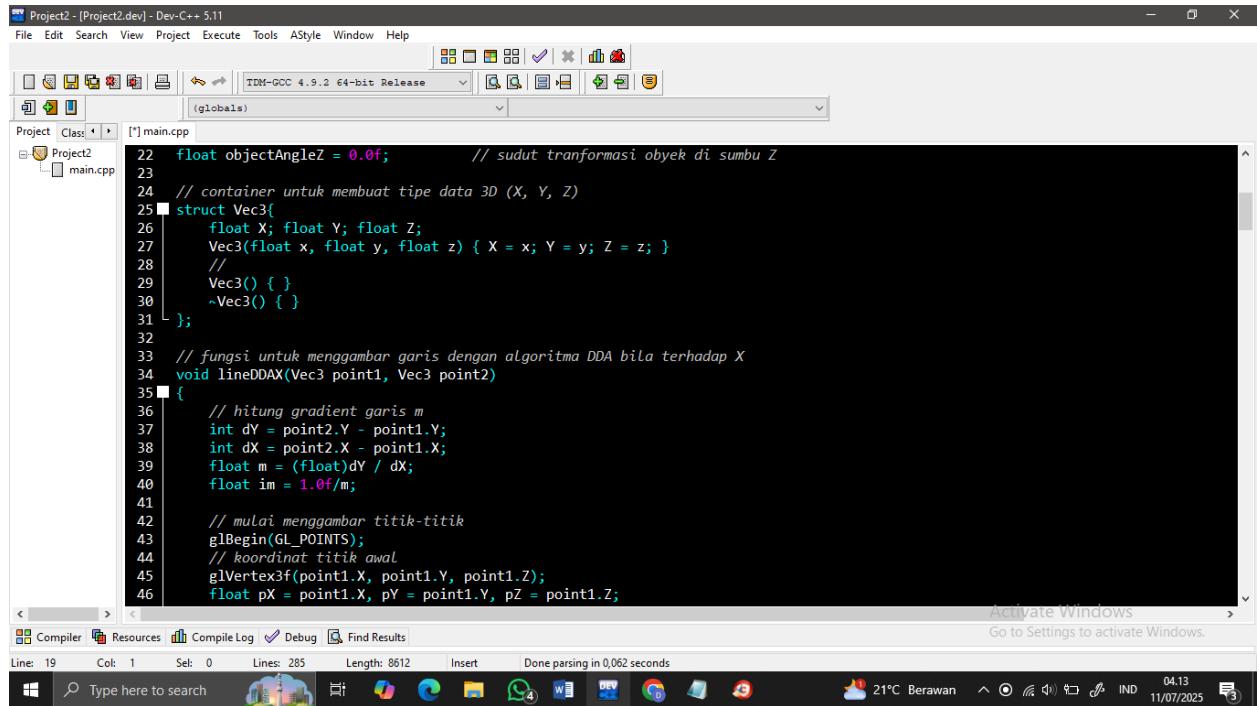
Gambar 17 laprak 2



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 132 Col: 47 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The code editor displays the following C++ code:

```
1 // kode dasar untuk semua praktikum grafika komputer
2 // adhi prahara. 2018
3
4 // deklarasikan semua header disini
5 #include <windows.h>
6 #include <GL/glut.h>
7
8 #include <stdio.h>
9 #include <iostream>
10
11 int SCREEN_WIDTH = 400;
12 int SCREEN_HEIGHT = 400;
13
14 // inisialisasi variabel untuk transformasi seperti translasi, rotasi atau scaling
15 float angle = 0.0f; // sudut transformasi kamera
16 float posX = 0.0f, rotX = 0.0f; // posisi kamera di sumbu X
17 float posY = 0.0f, rotY = 0.0f; // posisi kamera di sumbu Y
18 float posZ = 5.0f, rotZ = -1.0f; // posisi kamera di sumbu Z
19
20 float objectAngleX = 0.0f; // sudut transformasi obyek di sumbu X
21 float objectAngleY = 0.0f; // sudut transformasi obyek di sumbu Y
22 float objectAngleZ = 0.0f; // sudut transformasi obyek di sumbu Z
23
24 // container untuk membuat tipe data 3D (X, Y, Z)
25 struct Vec3{
```

Gambar 18 laprak 2



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 19 Col: 1 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The code editor displays the following C++ code:

```
22 float objectAngleZ = 0.0f; // sudut transformasi obyek di sumbu Z
23
24 // container untuk membuat tipe data 3D (X, Y, Z)
25 struct Vec3{
26     float X; float Y; float Z;
27     Vec3(float x, float y, float z) { X = x; Y = y; Z = z; }
28     //
29     Vec3() { }
30     ~Vec3() { }
31 };
32
33 // fungsi untuk menggambar garis dengan algoritma DDA bila terhadap X
34 void lineDDAX(Vec3 point1, Vec3 point2)
35 {
36     // hitung gradient garis m
37     int dy = point2.Y - point1.Y;
38     int dx = point2.X - point1.X;
39     float m = (float)dy / dx;
40     float im = 1.0f/m;
41
42     // mulai menggambar titik-titik
43     glBegin(GL_POINTS);
44     // koordinat titik awal
45     glVertex3f(point1.X, point1.Y, point1.Z);
46     float px = point1.X, py = point1.Y, pz = point1.Z;
```

Gambar 19 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 43 Col: 24 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The code editor displays the following C++ code:

```
34 void lineDDAX(Vec3 point1, Vec3 point2)
35 {
36     // hitung gradient garis m
37     int dY = point2.Y - point1.Y;
38     int dX = point2.X - point1.X;
39     float m = (float)dY / dX;
40     float im = 1.0f/m;
41
42     // mulai menggambar titik-titik
43     glBegin(GL_POINTS);
44     // koordinat titik awal
45     glVertex3f(point1.X, point1.Y, point1.Z);
46     float pX = point1.X, pY = point1.Y, pZ = point1.Z;
47
48     // kenaikan terhadap X
49     for (int i = point1.X; i < point2.X; i++)
50     {
51         pX = pX + 1; // Xn+1 = Xn + 1
52         pY = pY + m; // Yn+1 = Yn + m
53         glVertex3f(pX, pY, pZ);
54     }
55     // koordinat titik akhir
56     glVertex3f(point2.X, point2.Y, point2.Z);
57     glEnd();
58 }
```

Gambar 20 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 49 Col: 44 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The code editor displays the following C++ code:

```
61 void lineDDAY(Vec3 point1, Vec3 point2)
62 {
63     // hitung gradient garis m
64     int dY = point2.Y - point1.Y;
65     int dX = point2.X - point1.X;
66     float m = (float)dY / dX;
67     float im = 1.0f/m;
68
69     // mulai menggambar titik-titik
70     glBegin(GL_POINTS);
71     // koordinat titik awal
72     glVertex3f(point1.X, point1.Y, point1.Z);
73     float pX = point1.X, pY = point1.Y, pZ = point1.Z;
74
75     // kenaikan terhadap Y
76     for (int i = point1.Y; i < point2.Y; i++)
77     {
78         pX = pX + im; // Xn+1 = Xn + 1/m
79         pY = pY + 1; // Yn+1 = Yn + 1
80         glVertex3f(pX, pY, pZ);
81     }
82     // koordinat titik akhir
83     glVertex3f(point2.X, point2.Y, point2.Z);
84     glEnd();
85 }
```

Gambar 21 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 81 Col: 6 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The code editor displays the main.cpp file with the following content:

```
85 }
86
87 // fungsi untuk menggambar garis dengan algoritma DDA
88 void lineDDA(Vec3 point1, Vec3 point2)
89 {
90     // hitung selisih panjang
91     int dY = point2.Y - point1.Y;
92     int dX = point2.X - point1.X;
93     // bila deltaY lebih pendek dari deltaX
94     if (abs(dY) < abs(dX))
95     {
96         if (point1.X < point2.X) // bila X1 < X2
97             lineDDAX(point1, point2);
98         else // bila X1 > X2 maka dibalik
99             lineDDAX(point2, point1);
100    }
101   else // bila deltaY lebih panjang dari deltaX
102    {
103        if (point1.Y < point2.Y) // bila Y1 < Y2
104            lineDDAY(point1, point2);
105        else // bila Y1 > Y2 maka dibalik
106            lineDDAY(point2, point1);
107    }
108 }
109
```

The status bar also indicates "Activate Windows Go to Settings to activate Windows." and the system tray shows the date and time as 11/07/2025 04:13.

Gambar 22 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 103 Col: 34 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The code editor displays the main.cpp file with the following content:

```
109
110 // fungsi untuk menggambar obyek
111 void drawObject()
112 {
113     glPushMatrix();
114     // operasi transformasi rotasi obyek ke arah kanan-kiri
115     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
116     glPushMatrix();
117     // operasi transformasi rotasi obyek ke arah atas-bawah
118     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
119
120     // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
121     glColor3f(0.0f, 1.0f, 0.0f);
122
123     // gambar sumbu
124     Vec3 sbY1 = Vec3( 0.0f, -300.0f, 0.0f);
125     Vec3 sbY2 = Vec3( 0.0f, 300.0f, 0.0f);
126     Vec3 sbX1 = Vec3(-300.0f, 0.0f, 0.0f);
127     Vec3 sbX2 = Vec3( 300.0f, 0.0f, 0.0f);
128     lineDDA(sbX1, sbX2);
129     lineDDA(sbY1, sbY2);
130     // kuadran 1
131     Vec3 point1 = Vec3( 100.0f, 100.0f, 0.0f);
132     Vec3 point2 = Vec3( 200.0f, 120.0f, 0.0f);
133     lineDDA(point1, point2);
```

The status bar also indicates "Activate Windows Go to Settings to activate Windows." and the system tray shows the date and time as 11/07/2025 04:14.

Gambar 23 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 123 Col: 21 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The code editor displays the following C++ code:

```
130 // kuadran 1
131 Vec3 point1 = Vec3( 100.0f, 100.0f, 0.0f);
132 Vec3 point2 = Vec3( 200.0f, 120.0f, 0.0f);
133 lineDDA(point1, point2);
134 // kuadran 2
135 point1 = Vec3(-100.0f, 100.0f, 0.0f);
136 point2 = Vec3(-120.0f, 200.0f, 0.0f);
137 lineDDA(point1, point2);
138 // kuadran 3
139 point1 = Vec3(-100.0f, -100.0f, 0.0f);
140 point2 = Vec3(-200.0f, -120.0f, 0.0f);
141 lineDDA(point1, point2);
142 // kuadran 4
143 point1 = Vec3( 100.0f, -100.0f, 0.0f);
144 point2 = Vec3( 120.0f, -200.0f, 0.0f);
145 lineDDA(point1, point2);
146
147 glPopMatrix();
148 glPopMatrix();
149 }
150
151 // taruh semua obyek yang akan digambar di fungsi display()
152 void display()
153 {
154     // bersihkan dan reset Layar dan buffer
```

Gambar 24 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 185 Col: 2 Sel: 0 Lines: 285 Length: 8612 Overwrite Done parsing in 0,062 seconds". The code editor displays the following C++ code:

```
148     glPopMatrix();
149 }
150
151 // taruh semua obyek yang akan digambar di fungsi display()
152 void display()
153 {
154     // bersihkan dan reset layar dan buffer
155     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
156     glLoadIdentity();
157
158     // posisikan kamera pandang
159     // dalam hal ini sumbu Y ada diatas dan posisi kamera pandang di (posX, posY, posZ)
160     gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
161
162     // panggil fungsi untuk menggambar obyek
163     drawObject();
164
165     // tampilkan obyek ke layar
166     // gunakan glFlush() bila memakai single buffer
167     // gunakan glutSwapBuffers() bila memakai double buffer
168     glutSwapBuffers();
169 }
170
171 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
172 void init(void)
```

Gambar 25 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 160 Col: 37 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The main code editor window displays the following C++ code:

```
172 void init(void)
173 {
174     // initialisasi warna latar belakang layar dalam hal ini warna putih (1.0, 1.0, 1.0, 0.0)
175     glClearColor(0.0, 0.0, 0.0, 0.0);
176     glEnable(GL_DEPTH_TEST);           // mengaktifkan depth buffer
177     glMatrixMode(GL_PROJECTION);
178     glLoadIdentity();
179     //glOrtho((GLfloat)SCREEN_WIDTH/2, (GLfloat)SCREEN_WIDTH/2, (GLfloat)SCREEN_HEIGHT/2, (GLfloat)SCREEN_HEIGHT/2, 1.0, 100.0);
180     glOrtho((GLfloat)-SCREEN_WIDTH/2, (GLfloat)SCREEN_WIDTH/2, (GLfloat)-SCREEN_HEIGHT/2, (GLfloat)SCREEN_HEIGHT/2, 1.0, 100.0);
181     glMatrixMode(GL_MODELVIEW);
182     glLoadIdentity();
183     // initialisasi kamera pandang
184     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
185 }
186
187 // fungsi ini digunakan bila layar akan diresize (default)
188 void reshape(int w, int h)
189 {
190     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
191     glMatrixMode(GL_PROJECTION);
192     glLoadIdentity();
193     //gluPerspective(45, (GLfloat)w / (GLfloat)h, 1.0, 100.0);
194     glOrtho((GLfloat)-w/2, (GLfloat)w/2, (GLfloat)-h/2, (GLfloat)h/2, 1.0, 100.0);
195     glMatrixMode(GL_MODELVIEW);
196 }
```

Gambar 26 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 191 Col: 26 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The main code editor window displays the following C++ code:

```
196 L }
197
198 // fungsi untuk mengatur masukan dari keyboard
199 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
200 void keyboard(int key, int x, int y)
201 {
202     float fraction = 0.1f;
203
204     switch (key)
205     {
206         // masukkan perintah disini bila tombol kiri ditekan
207         case GLUT_KEY_LEFT:
208             // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
209             objectAngleY -= 1.0f;
210             glutPostRedisplay(); // update obyek
211             break;
212         // masukkan perintah disini bila tombol kanan ditekan
213         case GLUT_KEY_RIGHT:
214             // dalam hal ini perintah rotasi obyek ke kanan sebanyak 1 derajat
215             objectAngleY += 1.0f;
216             glutPostRedisplay(); // update obyek
217             break;
218         // masukkan perintah disini bila tombol atas ditekan
219         case GLUT_KEY_UP:
220             // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
```

Gambar 27 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 218 Col: 36 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The code editor window displays the main.cpp file with the following code:

```
217     break;
218     // masukkan perintah disini bila tombol atas ditekan
219     case GLUT_KEY_UP:
220         // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
221         objectAngleX -= 1.0f;
222         glutPostRedisplay(); // update obyek
223         break;
224     // masukkan perintah disini bila tombol bawah ditekan
225     case GLUT_KEY_DOWN:
226         // dalam hal ini perintah rotasi obyek ke bawah sebanyak 1 derajat
227         objectAngleX += 1.0f;
228         glutPostRedisplay(); // update obyek
229         break;
230     // zoom in
231     case GLUT_KEY_PAGE_UP:
232         // masukkan perintah disini bila tombol PgUp ditekan
233         posX += rotX * fraction;
234         posZ += rotZ * fraction;
235         glutPostRedisplay(); // update obyek
236         break;
237     // zoom out
238     case GLUT_KEY_PAGE_DOWN:
239         // masukkan perintah disini bila tombol PgDn ditekan
240         posX -= rotX * fraction;
241         posZ -= rotZ * fraction;
```

Gambar 28 laprak 2

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 233 Col: 12 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The code editor window displays the main.cpp file with the following code:

```
247 // timer untuk animasi (gunakan bila perlu)
248 void timer(int value)
249 {
250     glutPostRedisplay();
251     glutTimerFunc(55, timer, 0);
252 }
253
254 // program utama
255 int main(int argc, char** argv)
256 {
257     // inisialisasi jendela OpenGL
258     // GLUT_SINGLE berarti memakai single buffer
259     // GLUT_DOUBLE berarti memakai double buffer
260     // GLUT_RGB berarti mode tampilan yang dipakai RGB
261     // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
262     // GLUT_DEPTH berarti memakai depth buffer
263     glutInit(&argc, argv);
264     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGBA | GLUT_DEPTH);
265
266     // set ukuran jendela tampilan
267     glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
268     glutInitWindowPosition(100, 100); // posisi jendela dilayar komputer dalam piksel
269     // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
270     glutCreateWindow("Algoritma DDA");
271 }
```

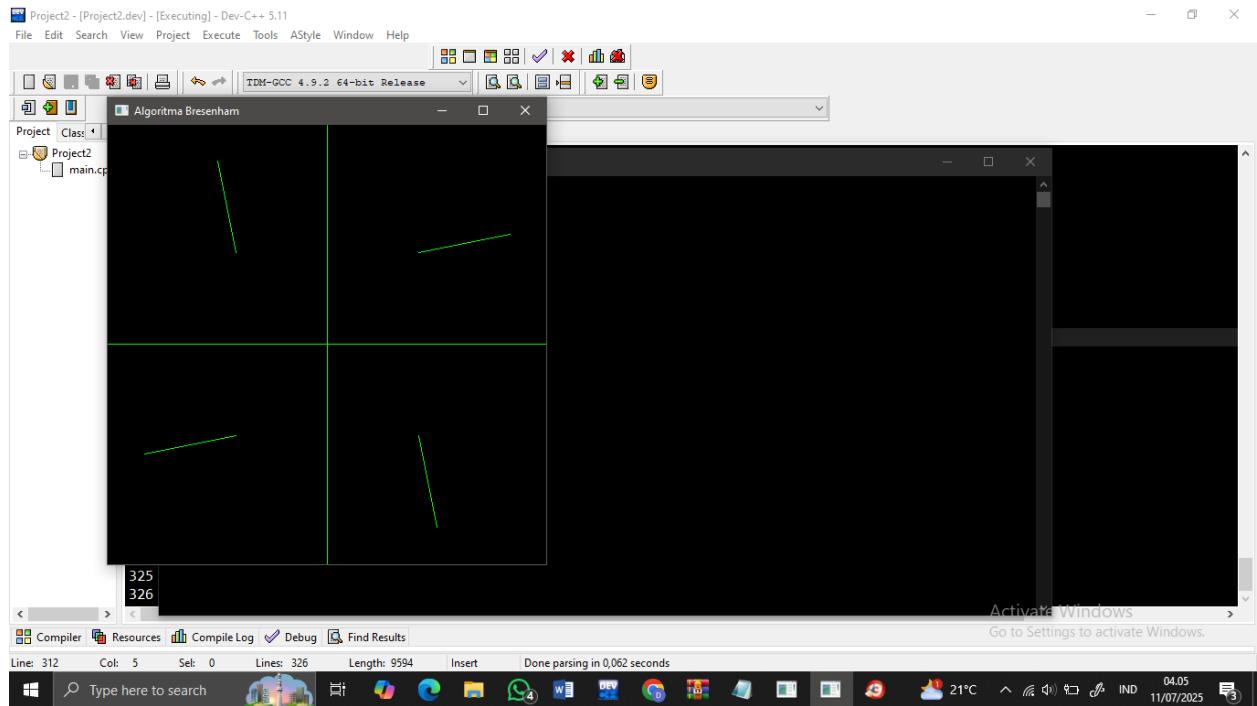
Gambar 29 laprak 2

The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar contains various icons for file operations. The central workspace shows the code for "main.cpp". The code is written in C++ and uses OpenGL functions to set up a window and handle events. The code is as follows:

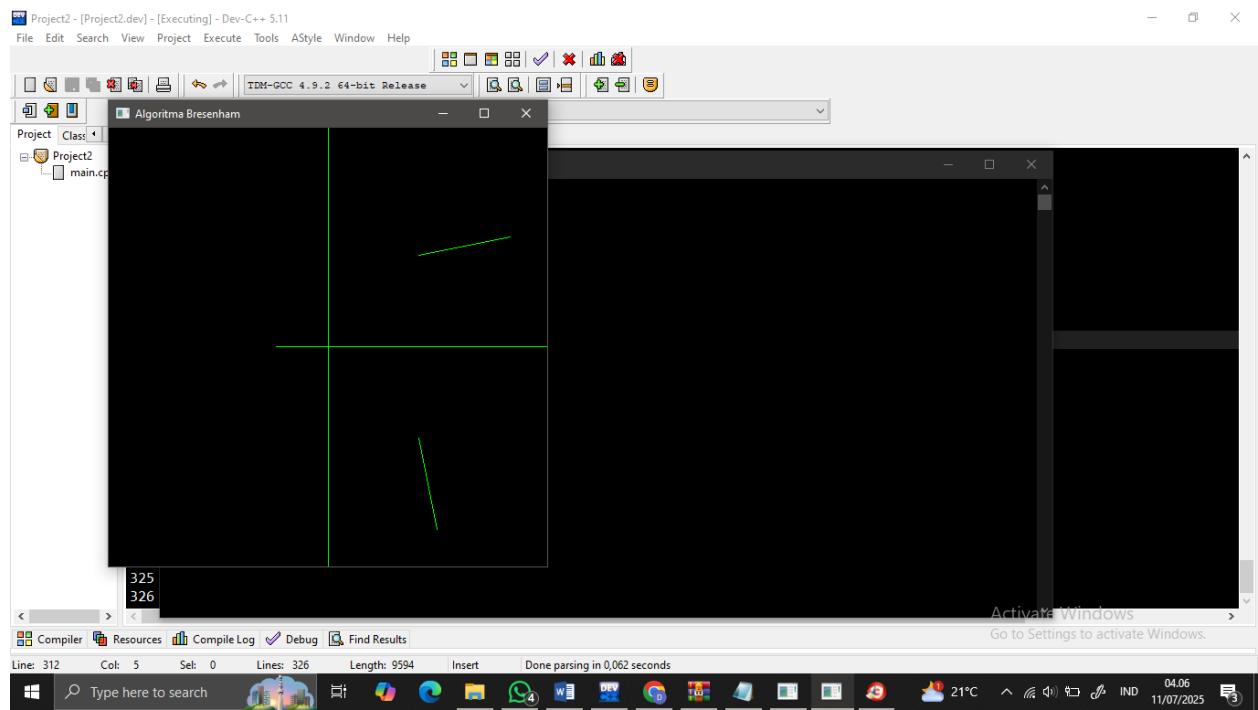
```
261 // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
262 // GLUT_DEPTH berarti memakai depth buffer
263 glutInit(&argc, argv);
264 glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGBA | GLUT_DEPTH);
265
266 // set ukuran jendela tampilan
267 glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
268 glutInitWindowPosition(100, 100); // posisi jendela dilayar komputer dalam piksel
269 // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
270 glutCreateWindow("Algoritma DDA");
271
272 // panggil fungsi init untuk inisialisasi awal
273 init();
274
275 // event handler untuk display, reshape dan keyboard
276 glutDisplayFunc(display); // display
277 glutReshapeFunc(reshape); // reshape
278 glutSpecialFunc(keyboard); // keyboard
279 //glutTimerFunc(0, timer, 0); // aktifkan timer bila perlu
280
281 // Looping
282 glutMainLoop();
283
284 return 0;
285 }
```

The status bar at the bottom shows "Line: 267 Col: 50 Sel: 0 Lines: 285 Length: 8612 Insert Done parsing in 0,062 seconds". The taskbar at the bottom right shows the date and time as 04.16 11/07/2025.

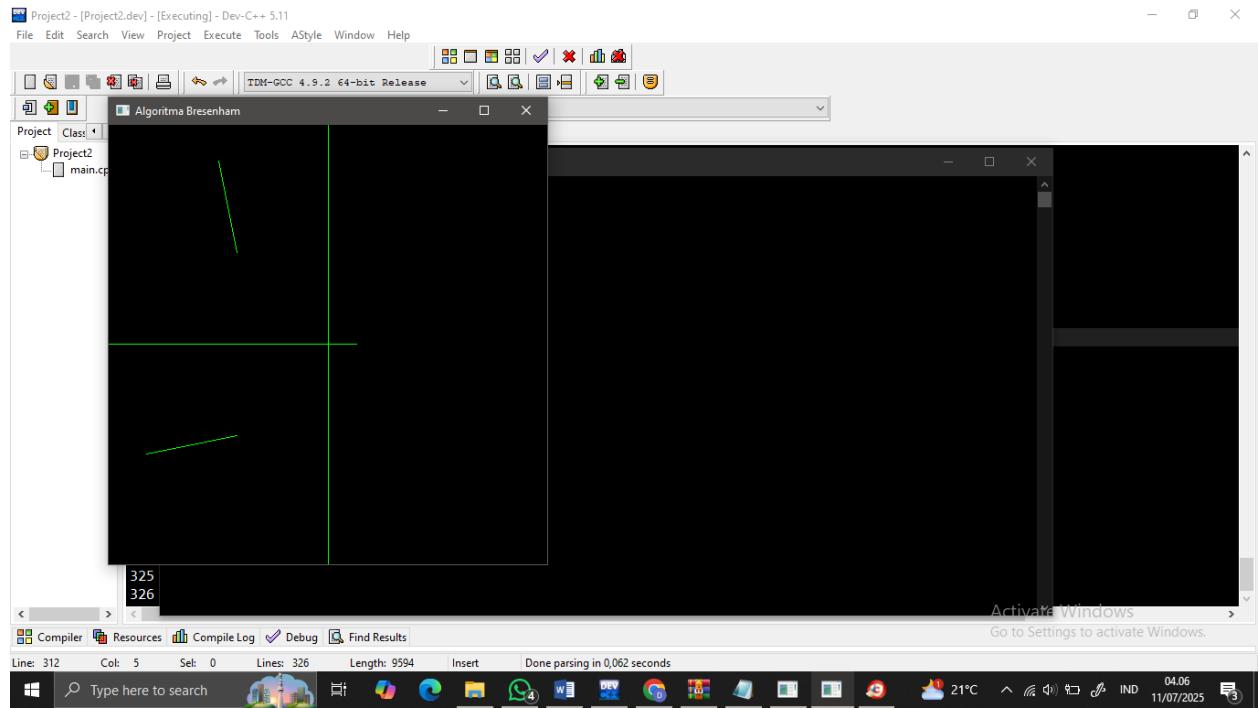
Output 1 laprak 2



Output 2 laprak 2

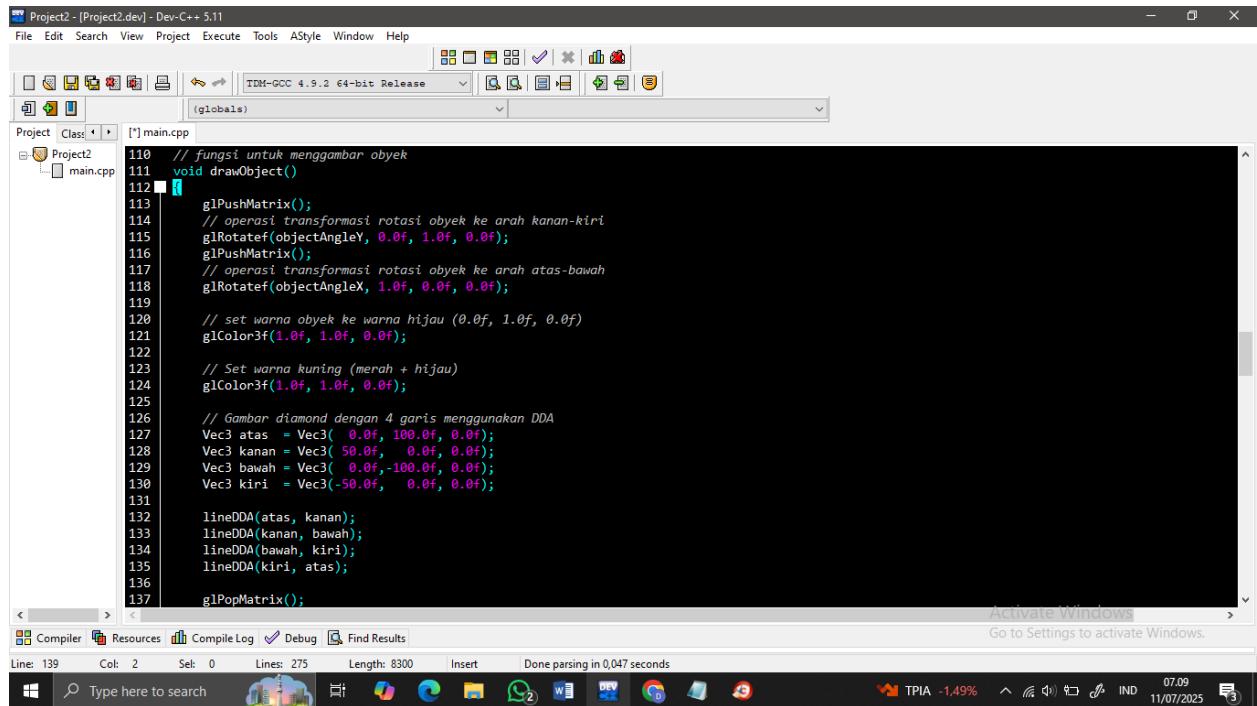


Output 3 laprak 2



Posttest 2

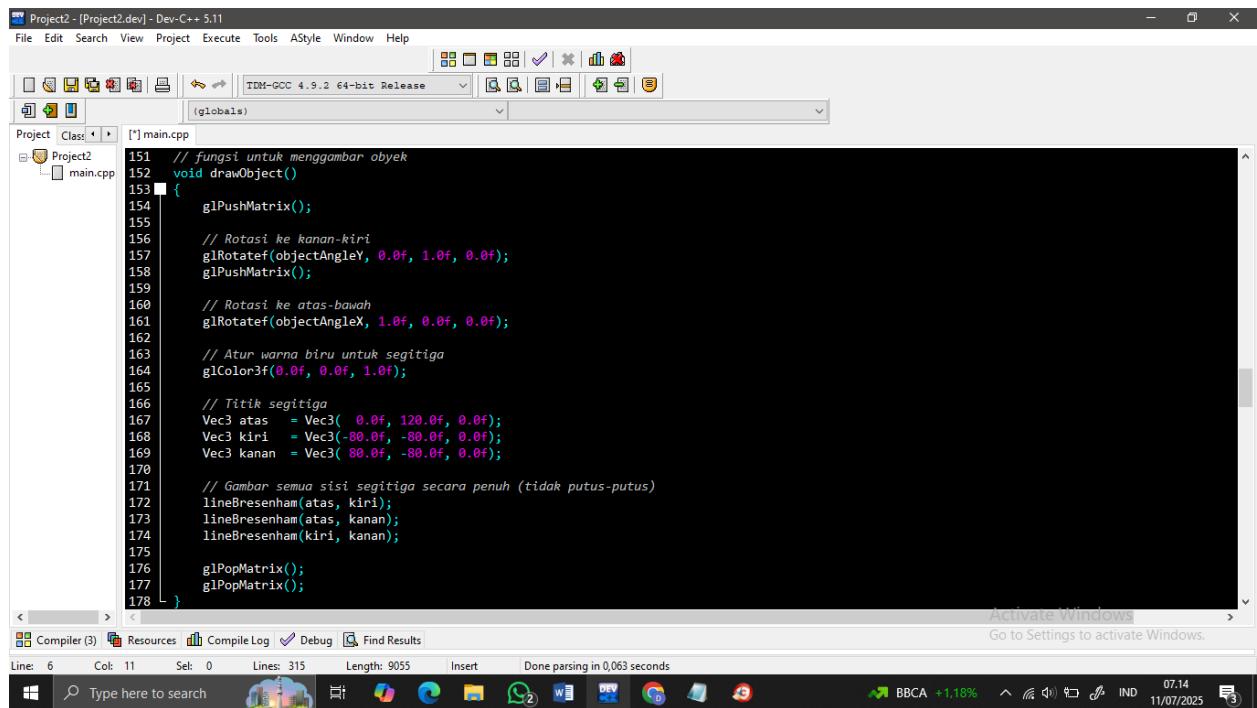
Gambar 2 posttest 2



The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has various icons for file operations. The main window displays the code for "main.cpp" under the "Project2" project. The code uses OpenGL functions like glPushMatrix, glRotatef, glColor3f, and lineDDA to draw a diamond shape. The code editor has syntax highlighting for C++ and OpenGL. Below the code editor is a status bar showing "Line: 139 Col: 2 Sel: 0 Lines: 275 Length: 8300 Insert Done parsing in 0,047 seconds". The taskbar at the bottom shows the Windows Start button, a search bar, and several pinned application icons. The system tray shows battery level (TPIA -1.49%), signal strength, and the date/time (07.09 11/07/2025).

```
110 // fungsi untuk menggambar objek
111 void drawObject()
112 {
113     glPushMatrix();
114     // operasi transformasi rotasi objek ke arah kanan-kiri
115     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
116     glPushMatrix();
117     // operasi transformasi rotasi objek ke arah atas-bawah
118     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
119
120     // set warna objek ke warna hijau (0.0f, 1.0f, 0.0f)
121     glColor3f(1.0f, 1.0f, 0.0f);
122
123     // Set warna kuning (merah + hijau)
124     glColor3f(1.0f, 1.0f, 0.0f);
125
126     // Gambar diamond dengan 4 garis menggunakan DDA
127     Vec3 atas = Vec3( 0.0f, 100.0f, 0.0f);
128     Vec3 kanan = Vec3( 50.0f, 0.0f, 0.0f);
129     Vec3 bawah = Vec3( 0.0f,-100.0f, 0.0f);
130     Vec3 kiri = Vec3(-50.0f, 0.0f, 0.0f);
131
132     lineDDA(atas, kanan);
133     lineDDA(kanan, bawah);
134     lineDDA(bawah, kiri);
135     lineDDA(kiri, atas);
136
137     glPopMatrix();
138 }
```

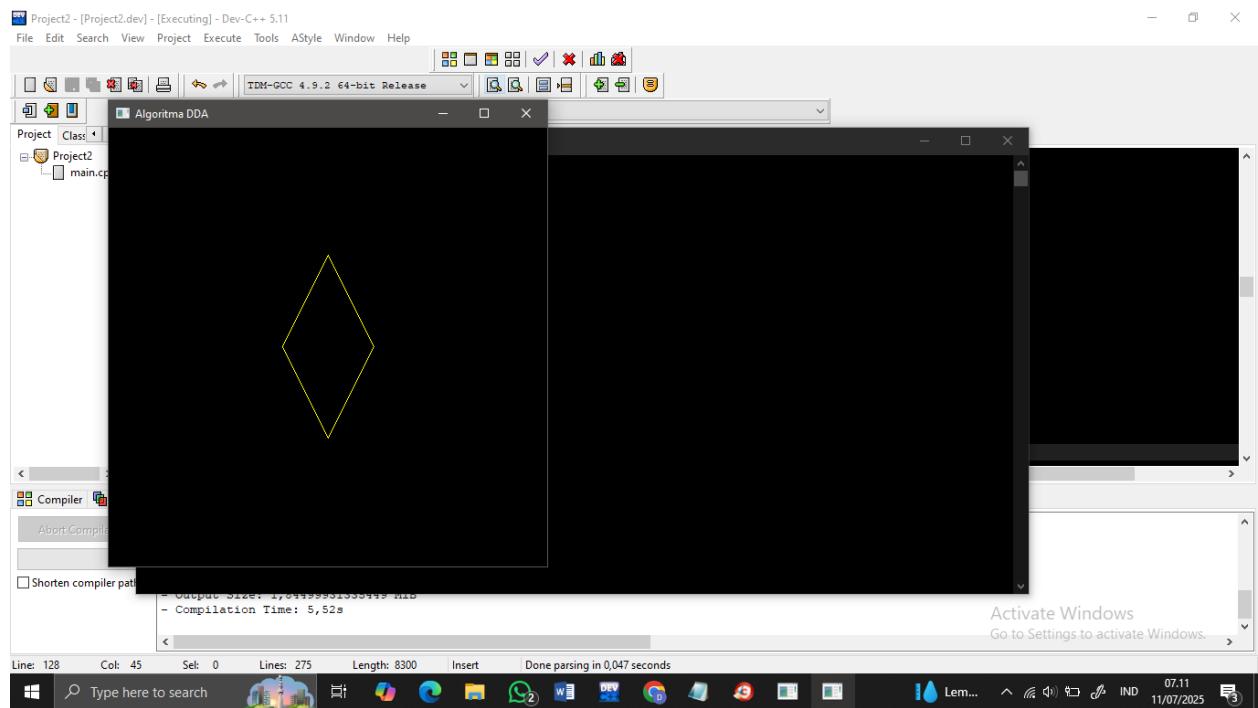
Gambar 2 posttest 2



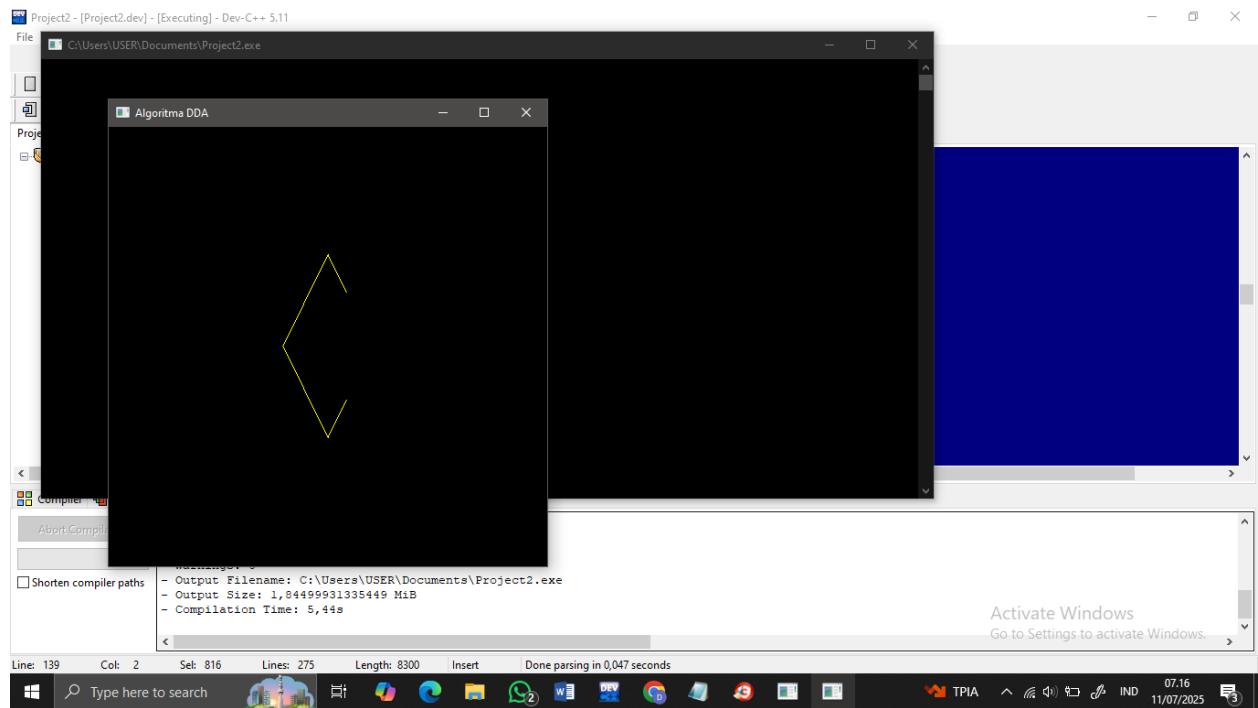
The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has various icons for file operations. The main window displays the code for "main.cpp" under the "Project2" project. The code uses OpenGL functions like glPushMatrix, glRotatef, glColor3f, and lineBresenham to draw a triangle. The code editor has syntax highlighting for C++ and OpenGL. Below the code editor is a status bar showing "Line: 6 Col: 11 Sel: 0 Lines: 315 Length: 9055 Insert Done parsing in 0,063 seconds". The taskbar at the bottom shows the Windows Start button, a search bar, and several pinned application icons. The system tray shows battery level (BBCA +1.18%), signal strength, and the date/time (07.14 11/07/2025).

```
151 // fungsi untuk menggambar objek
152 void drawObject()
153 {
154     glPushMatrix();
155
156     // Rotasi ke kanan-kiri
157     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
158     glPushMatrix();
159
160     // Rotasi ke atas-bawah
161     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
162
163     // Atur warna biru untuk segitiga
164     glColor3f(0.0f, 0.0f, 1.0f);
165
166     // Titik segitiga
167     Vec3 atas = Vec3( 0.0f, 120.0f, 0.0f);
168     Vec3 kiri = Vec3(-80.0f, -80.0f, 0.0f);
169     Vec3 kanan = Vec3( 80.0f, -80.0f, 0.0f);
170
171     // Gambar semua sisi segitiga secara penuh (tidak putus-putus)
172     lineBresenham(atas, kiri);
173     lineBresenham(atas, kanan);
174     lineBresenham(kiri, kanan);
175
176     glPopMatrix();
177     glPopMatrix();
178 }
```

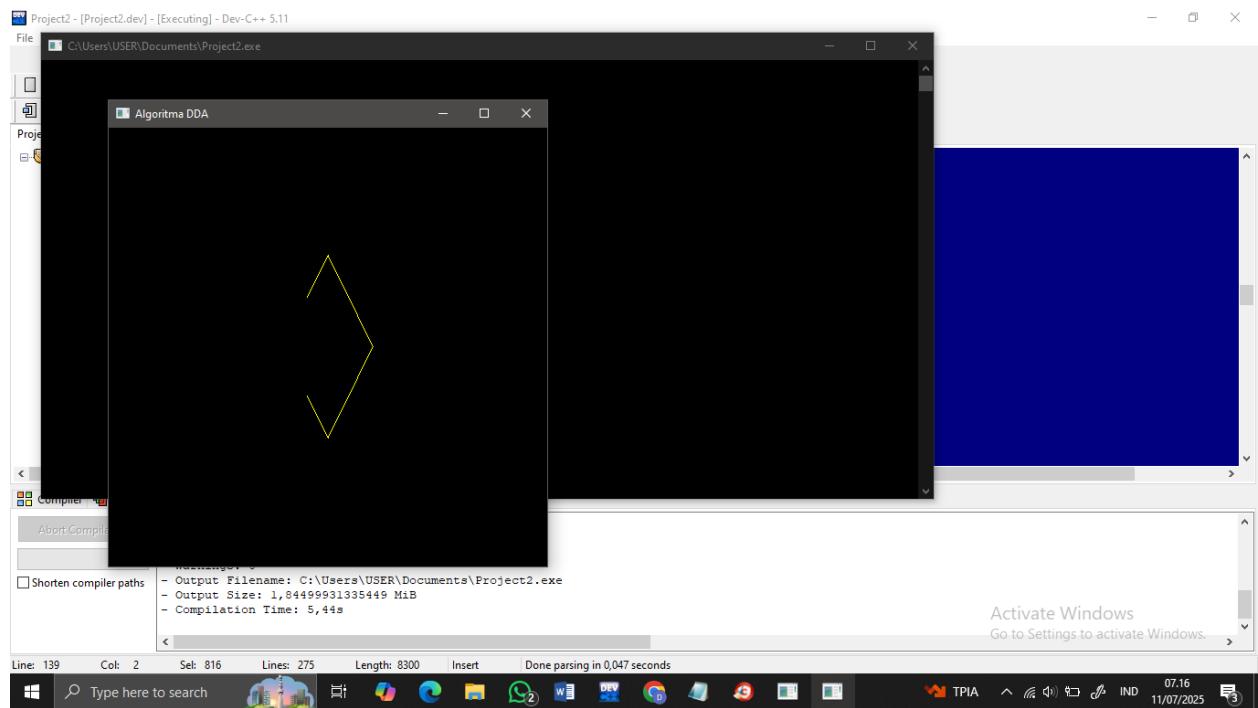
Output 1 postest 2



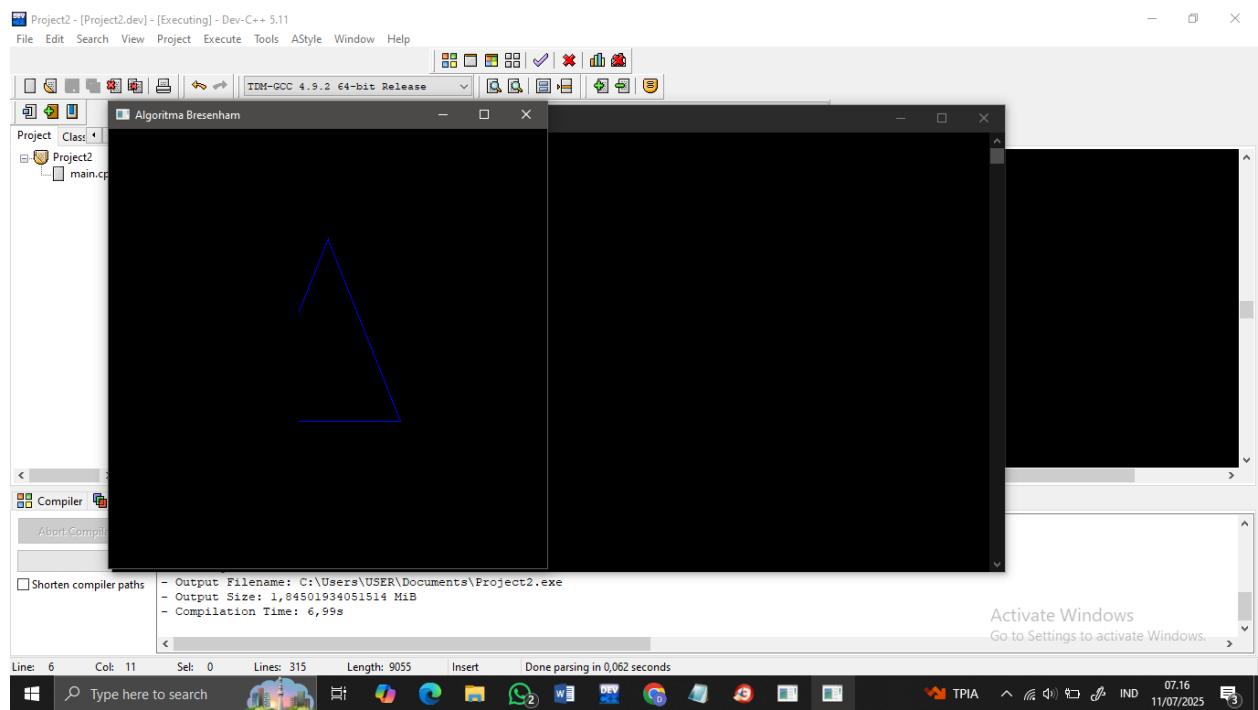
Output 2 postest 2



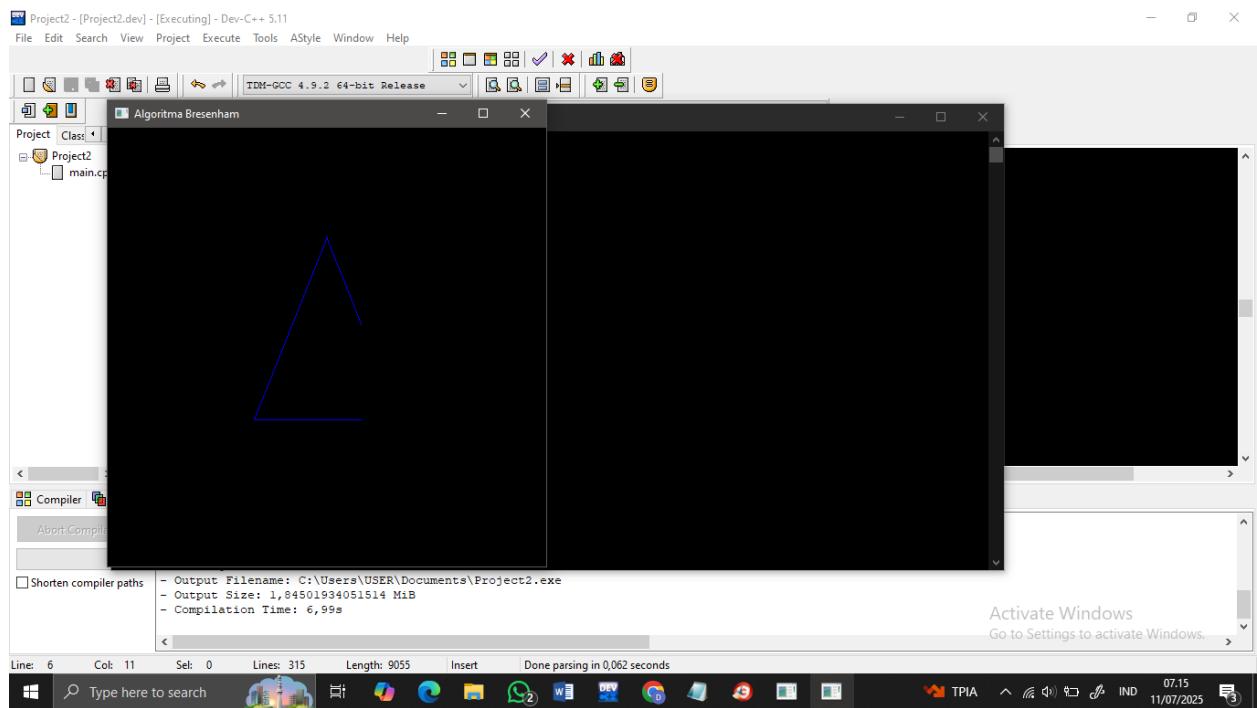
Ouput 3 postest 2



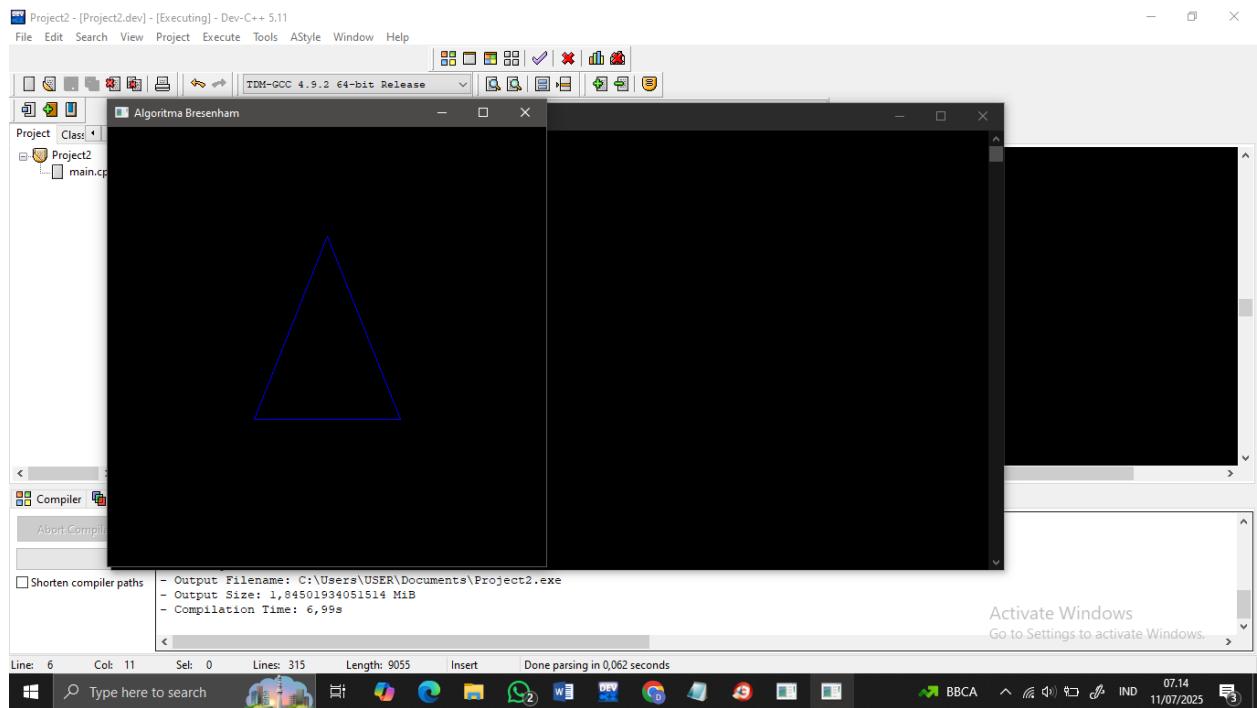
Ouput 4 postest 2



Ouput 5 postest 2



Ouput 6 postest 2



BAB III. INTERPOLASI DAN KURVA

Pretest 3

Pertanyaan:

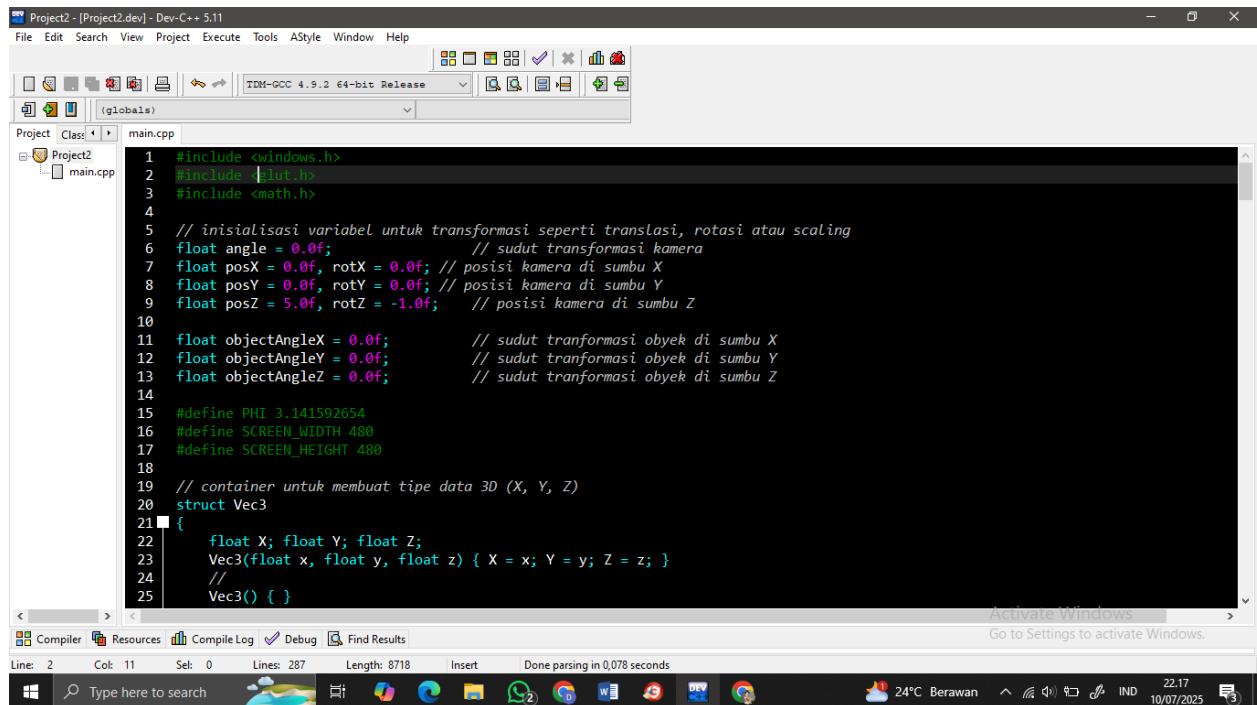
1. Jelaskan tahapan interpolasi linear
2. Jelaskan tahapan interpolasi kubik

Jawaban:

1. Menggunakan fungsi linear untuk melakukan interpolasi. Bila terdapat dua titik yang akan diinterpolasi yaitu (x_0, y_0) sampai (x_1, y_1) . Bila jarak (x_0, y_0) sampai (x_1, y_1) dimisalkan 1(dinormalisasi) dan diketahui jarak awal (x_0, y_0) sampai titik sela (x, y) adalah u maka: $y = y_0 \cdot (1 - u) + y_1 \cdot u$
2. Menggunakan fungsi pangkat tiga / kubik untuk melakukan interpolasi. Interpolasi kubik memerlukan 2 titik tambahan di ujung 2 titik utama untuk interpolasi. Bila terdapat 4 titik yang akan diinterpolasi yaitu $(x_0, y_0), (x_1, y_1), (x_2, y_2)$ sampai (x_3, y_3) dan jarak tersebut dinormalisasi menjadi 1 sedangkan jarak titik awal (x_0, y_0) sampai titik sela (x, y) adalah u dari dua titik tersebut makapersamaannya : $y = au^3 + bu^2 + cu + d$

Langkah Praktikum 3

Gambar 1 laprak 3



The screenshot shows the Dev-C++ IDE interface with the following details:

- File Menu:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help.
- Toolbar:** Standard Dev-C++ toolbar with icons for file operations.
- Project Explorer:** Shows "Project2" with "main.cpp" selected.
- Code Editor:** Displays the following C++ code in "main.cpp":

```
#include <windows.h>
#include <glut.h>
#include <math.h>

// inisialisasi variabel untuk transformasi seperti translasi, rotasi atau scaling
float angle = 0.0f; // sudut transformasi kamera
float posX = 0.0f, rotX = 0.0f; // posisi kamera di sumbu X
float posY = 0.0f, rotY = 0.0f; // posisi kamera di sumbu Y
float posZ = 5.0f, rotZ = -1.0f; // posisi kamera di sumbu Z

float objectAngleX = 0.0f; // sudut transformasi obyek di sumbu X
float objectAngleY = 0.0f; // sudut transformasi obyek di sumbu Y
float objectAngleZ = 0.0f; // sudut transformasi obyek di sumbu Z

#define PHI 3.141592654
#define SCREEN_WIDTH 480
#define SCREEN_HEIGHT 480

// container untuk membuat tipe data 3D (X, Y, Z)
struct Vec3
{
    float X; float Y; float Z;
    Vec3(float x, float y, float z) { X = x; Y = y; Z = z; }
    Vec3() {}
};

// Function prototypes
void display();
void keyboard(unsigned char key, int x, int y);
void mouse(int button, int state, int x, int y);
void motion(int x, int y);

int main()
{
    glutInit(&argc, &argv);
    glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB);
    glutInitWindowSize(SCREEN_WIDTH, SCREEN_HEIGHT);
    glutCreateWindow("3D OpenGL Application");
    glutDisplayFunc(display);
    glutKeyboardFunc(keyboard);
    glutMouseFunc(mouse);
    glutMotionFunc(motion);
    glutMainLoop();
}
```

Bottom Status Bar: Line: 2 Col: 11 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0.078 seconds

Taskbar: Shows the Windows Start button, search bar, and various pinned application icons (File Explorer, Edge, Google Chrome, etc.).

System Tray: Shows battery level (24%), temperature (24°C), and date/time (10/07/2025).

Gambar 2 laprak 3

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 14 Col: 1 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor displays main.cpp with the following content:

```
25     Vec3() { }
26     ~Vec3() { }
27 };
28
29 //Langkah 5
30 // enumerate untuk tipe interpolation
31 enum INTERP_TYPE
32 {
33     INTERP_POINTS = 0,
34     INTERP_LINES = 1,
35     INTERP_LINEAR = 2,
36     INTERP_COSINE = 3,
37     INTERP_CUBIC = 4
38 };
39
40 //Langkah 6
41 // fungsi untuk melakukan interpolasi linear dari dua titik
42 float linearInterpolate(float y0, float y1, float u)
43 {
44     return (y0 * (1 - u) + y1 * u);
45 }
46
47 //Langkah 7
48 // fungsi untuk melakukan interpolasi cosine dari dua titik
49 float cosineInterpolate(float y0, float y1, float u)
```

Gambar 3 laprak 3

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 40 Col: 12 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor displays main.cpp with the following content:

```
46
47 //Langkah 7
48 // fungsi untuk melakukan interpolasi cosine dari dua titik
49 float cosineInterpolate(float y0, float y1, float u)
50 {
51     float cosineU = (1 - cos(u * PHI)) / 2;
52     return (y0 * (1 - cosineU) + y1 * cosineU);
53 }
54
55 //Langkah 8
56 // fungsi untuk melakukan interpolasi cubic dari dua titik
57 float cubicInterpolate(float y0, float y1, float y2, float y3, float u)
58 {
59     float a = y3 - y2 - y0 + y1;
60     float b = 2 * y0 - 2 * y1 - y3 + y2;
61     float c = y2 - y0;
62     float d = y1;
63     return(a * u * u * u + b * u * u + c * u + d);
64 }
65
66 //Langkah 9
67 // gambar garis hasil interpolasi
68 // n adalah jumlah titik yang dibuat
69 // type adalah tipe interpolasi yang digunakan
70 void drawInterpolation()
```

Gambar 4 laprak 3

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 62 Col: 18 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor window displays the following C++ code:

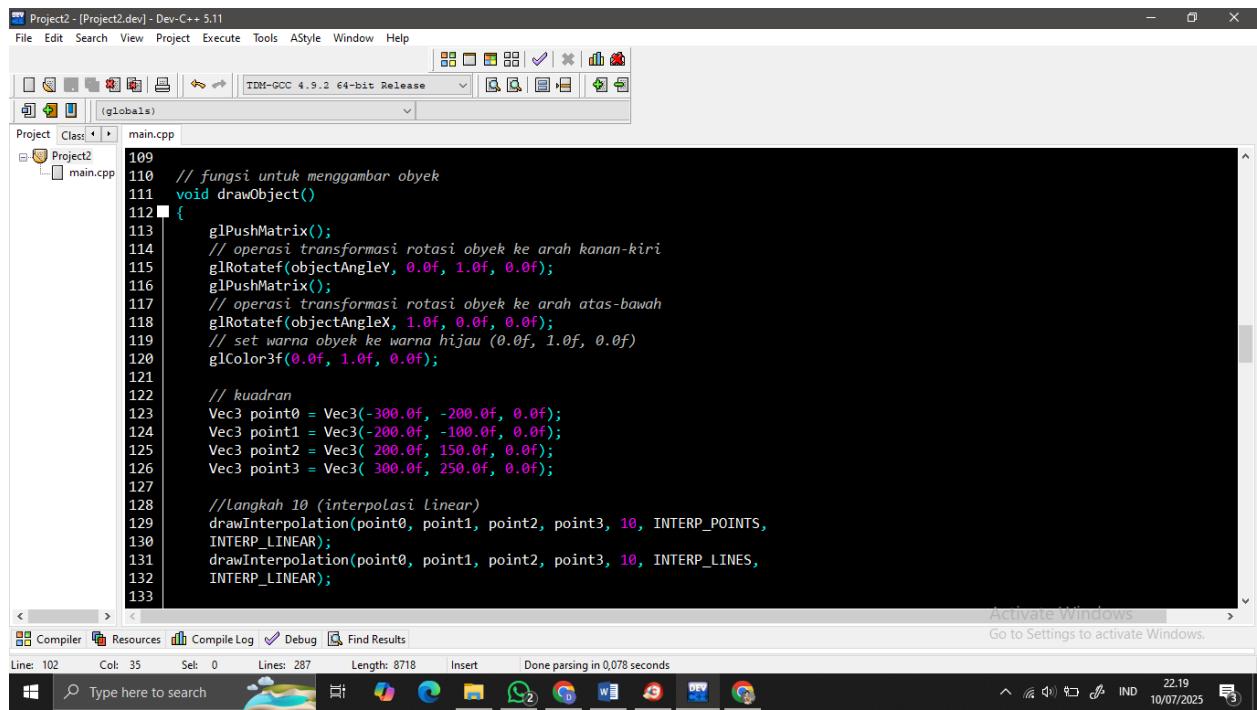
```
67 // gambar garis hasil interpolasi
68 // n adalah jumlah titik yang dibuat
69 // type adalah tipe interpolasi yang digunakan
70 void drawInterpolation(
71     Vec3 point0,
72     Vec3 point1, // point1 adalah titik awal
73     Vec3 point2, // point2 adalah titik akhir
74     Vec3 point3,
75     int n,
76     INTERP_TYPE type1,
77     INTERP_TYPE type2)
78 {
79     float u = 0;
80     float stepU = 1.0f / n; // kenaikan u
81     float stepX = fabs(point2.X - point1.X) / n; // kenaikan x
82     float px = point1.X, py = point1.Y, pz = point1.Z; // titik awal
83     // mulai menggambar titik-titik
84     glPointSize(5);
85     // kondisi menggambar titik
86     if (type1 == INTERP_POINTS)
87         glBegin(GL_POINTS);
88     // kondisi menggambar garis
89     else if (type1 == INTERP_LINES)
90         glBegin(GL_LINES);
91     for (int i = 0; i < n; i++)
92     {
93         glVertex3f(px, py, pz);
94         px = px + stepX;
95         u = u + stepU;
96         // bila interpolasi linear
97         if (type2 == INTERP_LINEAR)
98             py = linearInterpolate(point1.Y, point2.Y, u);
99         // bila interpolasi cosine
100        else if (type2 == INTERP_COSINE)
101            py = cosineInterpolate(point1.Y, point2.Y, u);
102        // bila interpolasi cubic
103        else if (type2 == INTERP_CURIC)
104            py = cubicInterpolate(point0.Y, point1.Y, point2.Y, point3.Y, u);
105        glVertex3f(px, py, pz);
106    }
107 }
108 }
```

Gambar 5 laprak 3

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 84 Col: 20 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor window displays the following C++ code:

```
85 // kondisi menggambar titik
86 if (type1 == INTERP_POINTS)
87     glBegin(GL_POINTS);
88 // kondisi menggambar garis
89 else if (type1 == INTERP_LINES)
90     glBegin(GL_LINES);
91 for (int i = 0; i < n; i++)
92 {
93     glVertex3f(px, py, pz);
94     px = px + stepX;
95     u = u + stepU;
96     // bila interpolasi linear
97     if (type2 == INTERP_LINEAR)
98         py = linearInterpolate(point1.Y, point2.Y, u);
99     // bila interpolasi cosine
100    else if (type2 == INTERP_COSINE)
101        py = cosineInterpolate(point1.Y, point2.Y, u);
102    // bila interpolasi cubic
103    else if (type2 == INTERP_CURIC)
104        py = cubicInterpolate(point0.Y, point1.Y, point2.Y, point3.Y, u);
105    glVertex3f(px, py, pz);
106 }
107 glEnd();
108 }
```

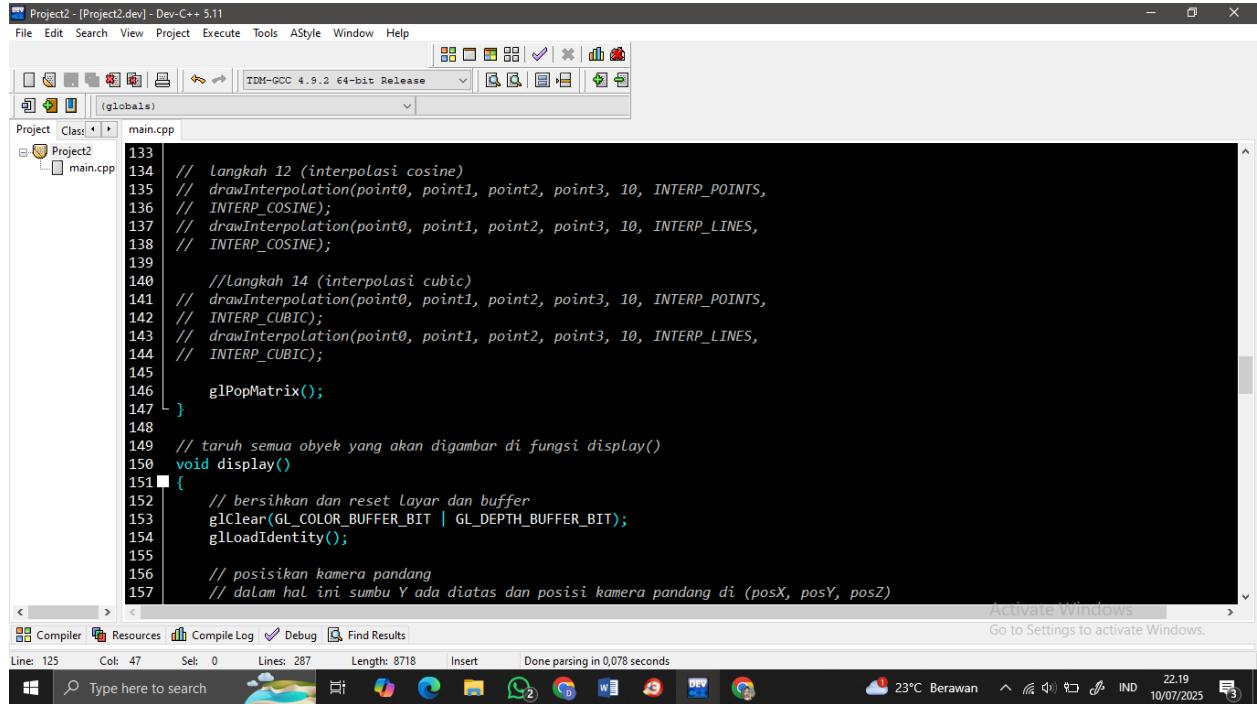
Gambar 6 laprak 3



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 102 Col: 35 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor displays main.cpp with the following content:

```
109 // fungsi untuk menggambar objek
110 void drawObject()
111 {
112     glPushMatrix();
113     // operasi transformasi rotasi objek ke arah kanan-kiri
114     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
115     glPushMatrix();
116     // operasi transformasi rotasi objek ke arah atas-bawah
117     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
118     // set warna objek ke warna hijau (0.0f, 1.0f, 0.0f)
119     glColor3f(0.0f, 1.0f, 0.0f);
120
121     // kuadran
122     Vec3 point0 = Vec3(-300.0f, -200.0f, 0.0f);
123     Vec3 point1 = Vec3(-200.0f, -100.0f, 0.0f);
124     Vec3 point2 = Vec3( 200.0f, 150.0f, 0.0f);
125     Vec3 point3 = Vec3( 300.0f, 250.0f, 0.0f);
126
127     //langkah 10 (interpolasi linear)
128     drawInterpolation(point0, point1, point2, point3, 10, INTERP_POINTS,
129     INTERP_LINEAR);
130     drawInterpolation(point0, point1, point2, point3, 10, INTERP_LINES,
131     INTERP_LINEAR);
132
133 }
```

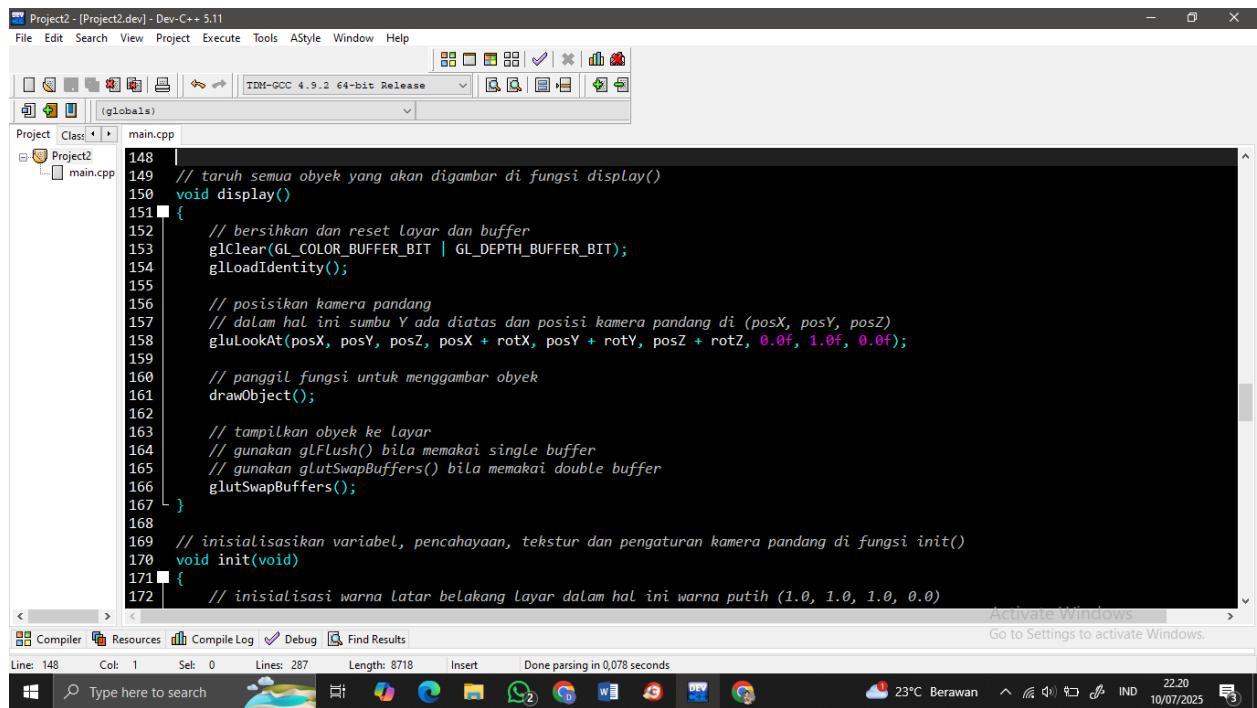
Gambar 7 laprak 3



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 125 Col: 47 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor displays main.cpp with the following content:

```
133 // Langkah 12 (interpolasi cosine)
134 // drawInterpolation(point0, point1, point2, point3, 10, INTERP_POINTS,
135 // INTERP_COSINE);
136 // drawInterpolation(point0, point1, point2, point3, 10, INTERP_LINES,
137 // INTERP_COSINE);
138 // drawInterpolation(point0, point1, point2, point3, 10, INTERP_LINES,
139 // INTERP_COSINE);
140
141 //Langkah 14 (interpolasi cubic)
142 // drawInterpolation(point0, point1, point2, point3, 10, INTERP_POINTS,
143 // INTERP_CUBIC);
144 // drawInterpolation(point0, point1, point2, point3, 10, INTERP_LINES,
145 // INTERP_CUBIC);
146
147 }
148
149 // taruh semua objek yang akan digambar di fungsi display()
150 void display()
151 {
152     // bersihkan dan reset layar dan buffer
153     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
154     glLoadIdentity();
155
156     // posisikan kamera pandang
157     // dalam hal ini sumbu Y ada diatas dan posisi kamera pandang di (posX, posY, posZ)
```

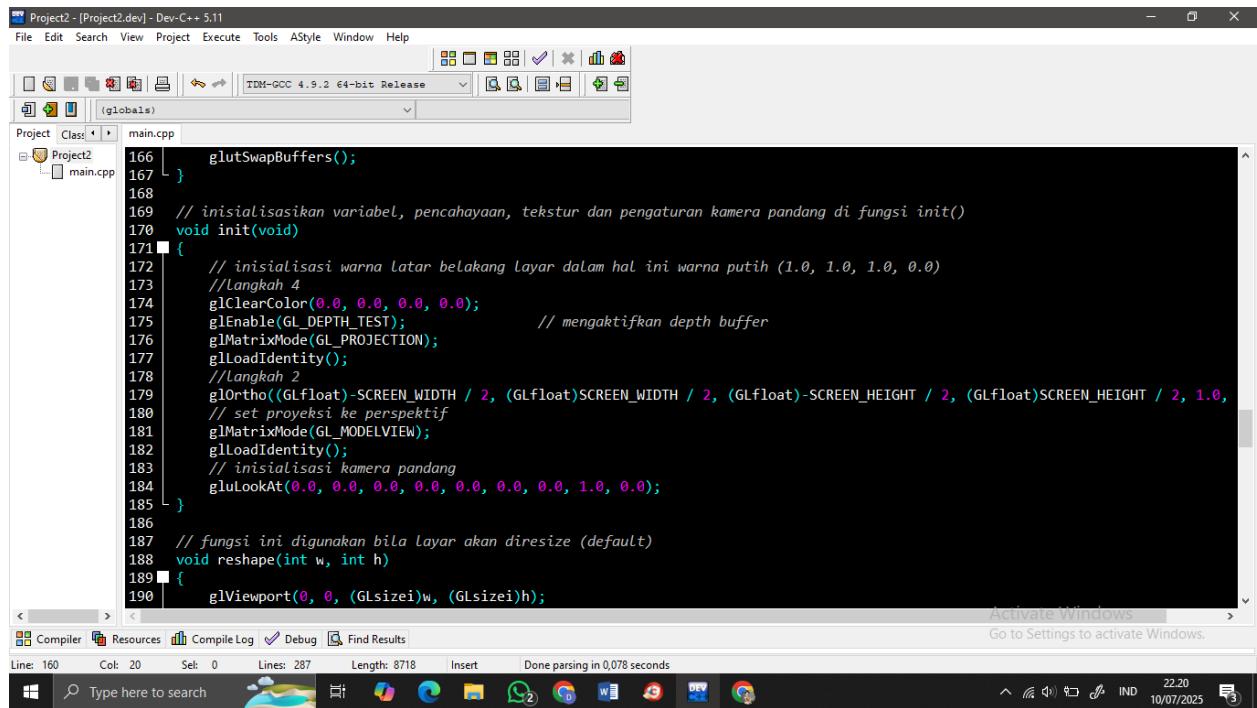
Gambar 8 laprak 3



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 148 Col: 1 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor displays the following C++ code:

```
148 // taruh semua obyek yang akan digambar di fungsi display()
149 void display()
150 {
151     // bersihkan dan reset Layar dan buffer
152     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
153     glLoadIdentity();
154
155     // posisikan kamera pandang
156     // dalam hal ini sumbu Y ada diatas dan posisi kamera pandang di (posX, posY, posZ)
157     gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
158
159     // panggil fungsi untuk menggambar obyek
160     drawObject();
161
162     // tampilkan obyek ke layar
163     // gunakan glFlush() bila memakai single buffer
164     // gunakan glutSwapBuffers() bila memakai double buffer
165     glutSwapBuffers();
166 }
167
168 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
169 void init(void)
170 {
171     // inisialisasi warna Latar belakang Layar dalam hal ini warna putih (1.0, 1.0, 1.0, 0.0)
```

Gambar 9 laprak 3



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 160 Col: 20 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor displays the following C++ code:

```
166     glutSwapBuffers();
167 }
168
169 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
170 void init(void)
171 {
172     // inisialisasi warna Latar belakang Layar dalam hal ini warna putih (1.0, 1.0, 1.0, 0.0)
173     //Langkah 4
174     glColor3f(0.0, 0.0, 0.0); // set warna awal
175     glEnable(GL_DEPTH_TEST); // mengaktifkan depth buffer
176     glMatrixMode(GL_PROJECTION);
177     glLoadIdentity();
178     //Langkah 2
179     glOrtho((GLfloat)-SCREEN_WIDTH / 2, (GLfloat)SCREEN_WIDTH / 2, (GLfloat)-SCREEN_HEIGHT / 2, (GLfloat)SCREEN_HEIGHT / 2, 1.0,
180     // set proyeksi ke perspektif
181     glMatrixMode(GL_MODELVIEW);
182     glLoadIdentity();
183     // inisialisasi kamera pandang
184     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
185 }
186
187 // fungsi ini digunakan bila Layar akan diresize (default)
188 void reshape(int w, int h)
189 {
190     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
```

Gambar 10 laprak 3

The screenshot shows the Dev-C++ IDE interface with the main.cpp file open. The code handles camera setup and keyboard input. It includes functions for reshape and keyboard events, specifically for rotating an object.

```
184     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
185 }
186 // fungsi ini digunakan bila layar akan diresize (default)
187 void reshape(int w, int h)
188 {
189     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
190     glMatrixMode(GL_PROJECTION);
191     glLoadIdentity();
192     //Langkah 3
193     glOrtho((GLfloat)-w / 2, (GLfloat)w / 2, (GLfloat)-h / 2, (GLfloat)h / 2, 1.0, 100.0);
194     glMatrixMode(GL_MODELVIEW);
195 }
196
197 // fungsi untuk mengatur masukan dari keyboard
198 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
199 void keyboard(int key, int x, int y)
200 {
201     float fraction = 0.1f;
202
203     switch (key)
204     {
205         // masukkan perintah disini bila tombol kiri ditekan
206         case GLUT_KEY_LEFT:
207             // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
208             break;
209     }
210 }
```

Below the code editor, the status bar shows: Line: 184, Col: 35, Sel: 0, Lines: 287, Length: 8718, Insert, Done parsing in 0,078 seconds. The taskbar at the bottom shows various application icons.

Gambar 11 laprak 3

The screenshot shows the Dev-C++ IDE interface with the main.cpp file open. The code handles keyboard input for rotation, including cases for GLUT_KEY_LEFT, GLUT_KEY_RIGHT, and GLUT_KEY_UP.

```
199 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
200 void keyboard(int key, int x, int y)
201 {
202     float fraction = 0.1f;
203
204     switch (key)
205     {
206         // masukkan perintah disini bila tombol kiri ditekan
207         case GLUT_KEY_LEFT:
208             // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
209             objectAngleY -= 1.0f;
210             glutPostRedisplay(); // update obyek
211             break;
212         // masukkan perintah disini bila tombol kanan ditekan
213         case GLUT_KEY_RIGHT:
214             // dalam hal ini perintah rotasi obyek ke kanan sebanyak 1 derajat
215             objectAngleY += 1.0f;
216             glutPostRedisplay(); // update obyek
217             break;
218         // masukkan perintah disini bila tombol atas ditekan
219         case GLUT_KEY_UP:
220             // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
221             objectAngleX -= 1.0f;
222             glutPostRedisplay(); // update obyek
223             break;
224     }
225 }
```

Below the code editor, the status bar shows: Line: 203, Col: 1, Sel: 0, Lines: 287, Length: 8718, Insert, Done parsing in 0,078 seconds. The taskbar at the bottom shows various application icons.

Gambar 12 laprak 3

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 214 Col: 16 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor displays main.cpp with the following content:

```
214 // dalam hal ini perintah rotasi obyek ke kanan sebanyak 1 derajat
215 objectAngleY += 1.0f;
216 glutPostRedisplay(); // update obyek
217 break;
218 // masukkan perintah disini bila tombol atas ditekan
219 case GLUT_KEY_UP:
220 // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
221 objectAngleX -= 1.0f;
222 glutPostRedisplay(); // update obyek
223 break;
224 // masukkan perintah disini bila tombol bawah ditekan
225 case GLUT_KEY_DOWN:
226 // dalam hal ini perintah rotasi obyek ke bawah sebanyak 1 derajat
227 objectAngleX += 1.0f;
228 glutPostRedisplay(); // update obyek
229 break;
230 // zoom in
231 case GLUT_KEY_PAGE_UP:
232 // masukkan perintah disini bila tombol PgUp ditekan
233 posX += rotX * fraction;
234 posZ += rotZ * fraction;
235 glutPostRedisplay(); // update obyek
236 break;
237 // zoom out
238 case GLUT_KEY_PAGE_DOWN:
```

Gambar 13 laprak 3

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 228 Col: 41 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor displays main.cpp with the following content:

```
235 glutPostRedisplay(); // update obyek
236 break;
237 // zoom out
238 case GLUT_KEY_PAGE_DOWN:
239 // masukkan perintah disini bila tombol PgDn ditekan
240 posX -= rotX * fraction;
241 posZ -= rotZ * fraction;
242 glutPostRedisplay(); // update obyek
243 break;
244 }
245 }
246 // timer untuk animasi (gunakan bila perlu)
247 void timer(int value)
248 {
249 {
250 glutPostRedisplay();
251 glutTimerFunc(55, timer, 0);
252 }
253
254 // program utama
255 int main(int argc, char** argv)
256 {
257 // inisialisasi jendela OpenGL
258 // GLUT_SINGLE berarti memakai single buffer
259 // GLUT_DOUBLE berarti memakai double buffer
```

Gambar 14 laprak 3

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 250 Col: 25 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor displays the following C++ code:

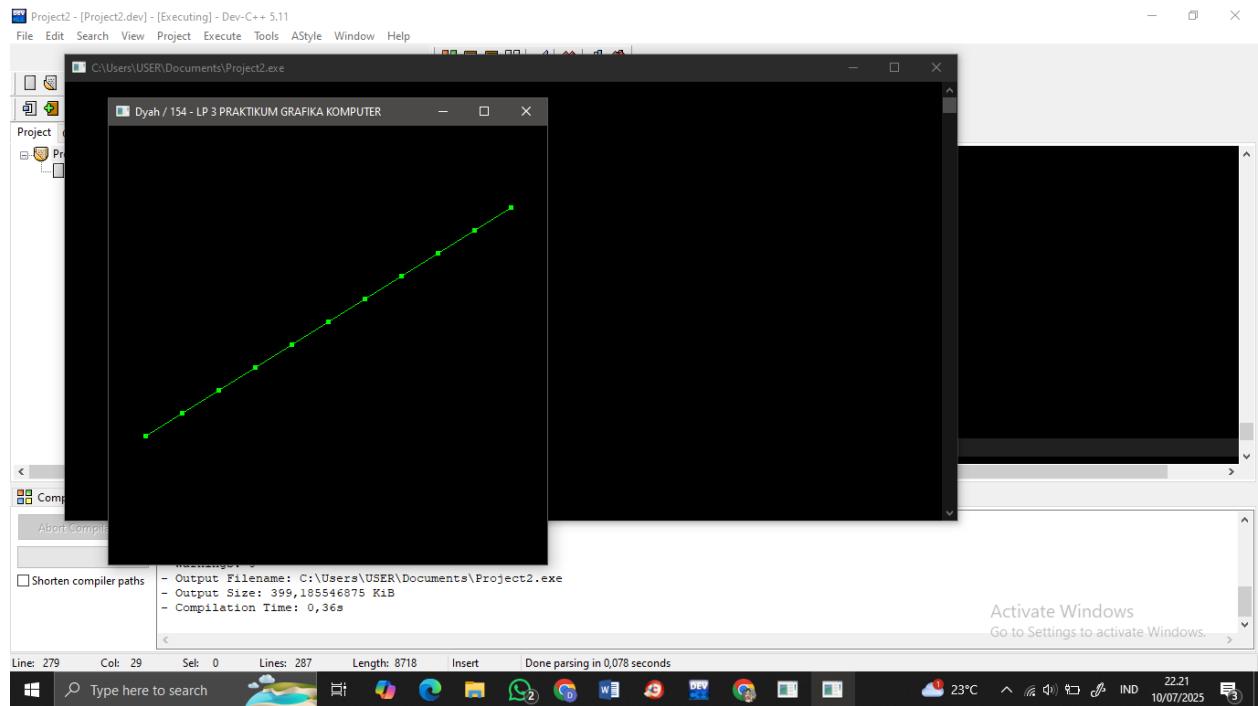
```
253 // program utama
254 int main(int argc, char** argv)
255 {
256     // inisialisasi jendela OpenGL
257     // GLUT_SINGLE berarti memakai single buffer
258     // GLUT_DOUBLE berarti memakai double buffer
259     // GLUT_RGB berarti mode tampilan yang dipakai RGB
260     // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
261     // GLUT_DEPTH berarti memakai depth buffer
262     glutInit(&argc, argv);
263     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
264
265     // set ukuran jendela tampilan
266     glutInitWindowSize(480, 480);      // besarnya jendela dalam piksel dalam hal ini 480x480
267     glutInitWindowPosition(100, 100);  // posisi jendela dilayar komputer dalam piksel
268     // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
269     glutCreateWindow("Dyah / 154 - LP 3 PRAKTIKUM GRAFIKA KOMPUTER");
270
271     // panggil fungsi init untuk inisialisasi awal
272     init();
273
274     // event handler untuk display, reshape dan keyboard
275     glutDisplayFunc(display); // display
276     glutReshapeFunc(reshape); // reshape
277     glutSpecialFunc(keyboard); // keyboard
278     //glutTimerFunc(0, timer, 0); // aktifkan timer bila perlu
279
280     // Looping
281     glutMainLoop();
282
283
284     //Mengembalikan nilai
285     return 0;
286 }
```

Gambar 15 laprak 3

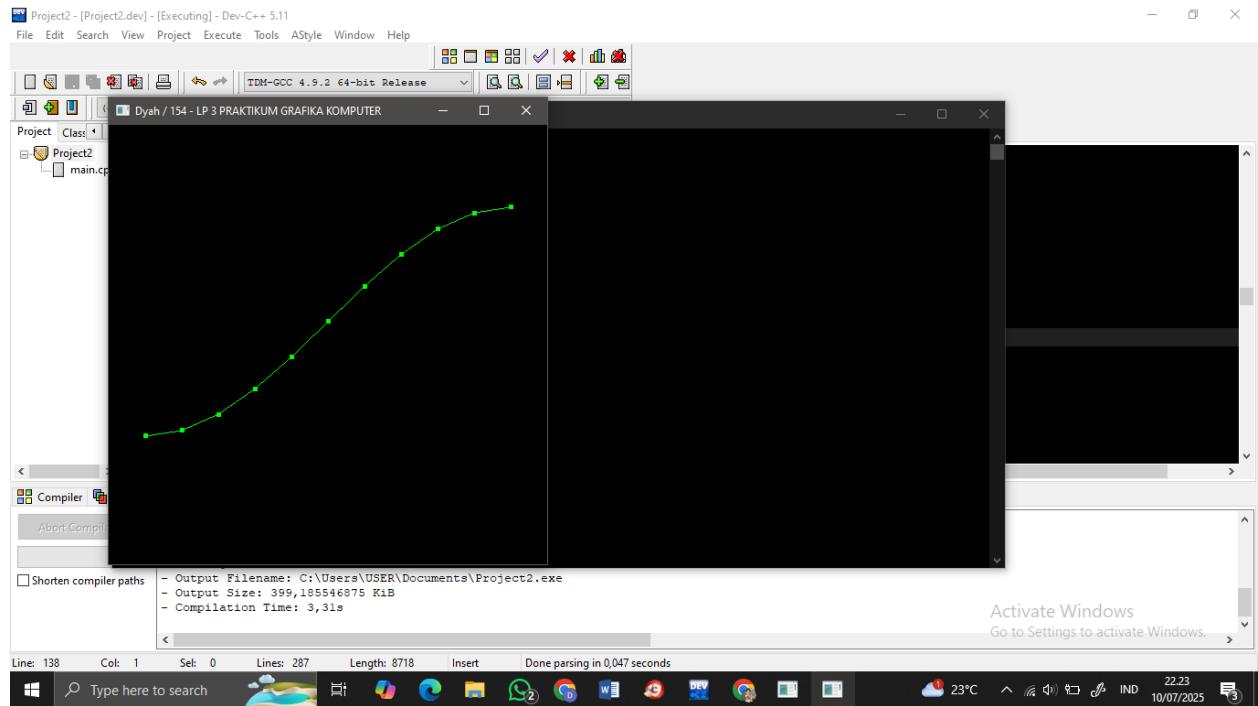
The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 268 Col: 52 Sel: 0 Lines: 287 Length: 8718 Insert Done parsing in 0,078 seconds". The code editor displays the following C++ code:

```
263     glutInit(&argc, argv);
264     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
265
266     // set ukuran jendela tampilan
267     glutInitWindowSize(480, 480);      // besarnya jendela dalam piksel dalam hal ini 480x480
268     glutInitWindowPosition(100, 100);  // posisi jendela dilayar komputer dalam piksel
269     // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
270     glutCreateWindow("Dyah / 154 - LP 3 PRAKTIKUM GRAFIKA KOMPUTER");
271
272     // panggil fungsi init untuk inisialisasi awal
273     init();
274
275     // event handler untuk display, reshape dan keyboard
276     glutDisplayFunc(display); // display
277     glutReshapeFunc(reshape); // reshape
278     glutSpecialFunc(keyboard); // keyboard
279     //glutTimerFunc(0, timer, 0); // aktifkan timer bila perlu
280
281     // Looping
282     glutMainLoop();
283
284
285     //Mengembalikan nilai
286     return 0;
287 }
```

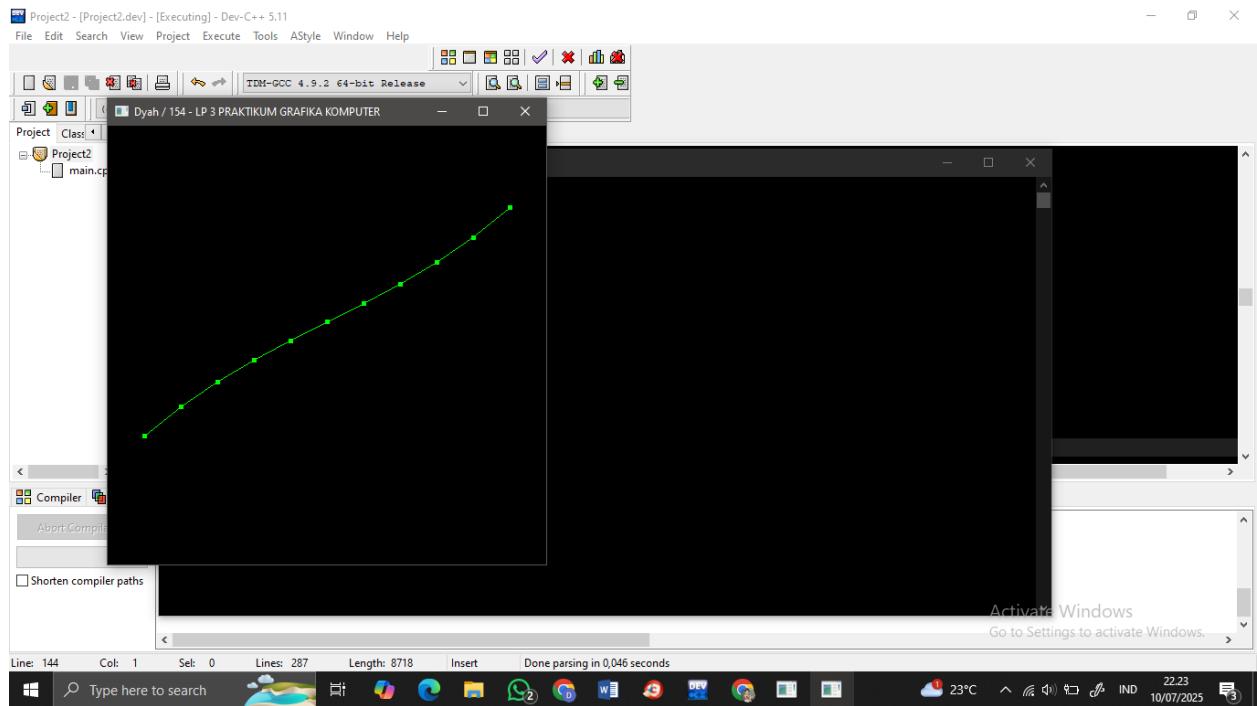
Output 1 laprak 3



Output 2 laprak 3

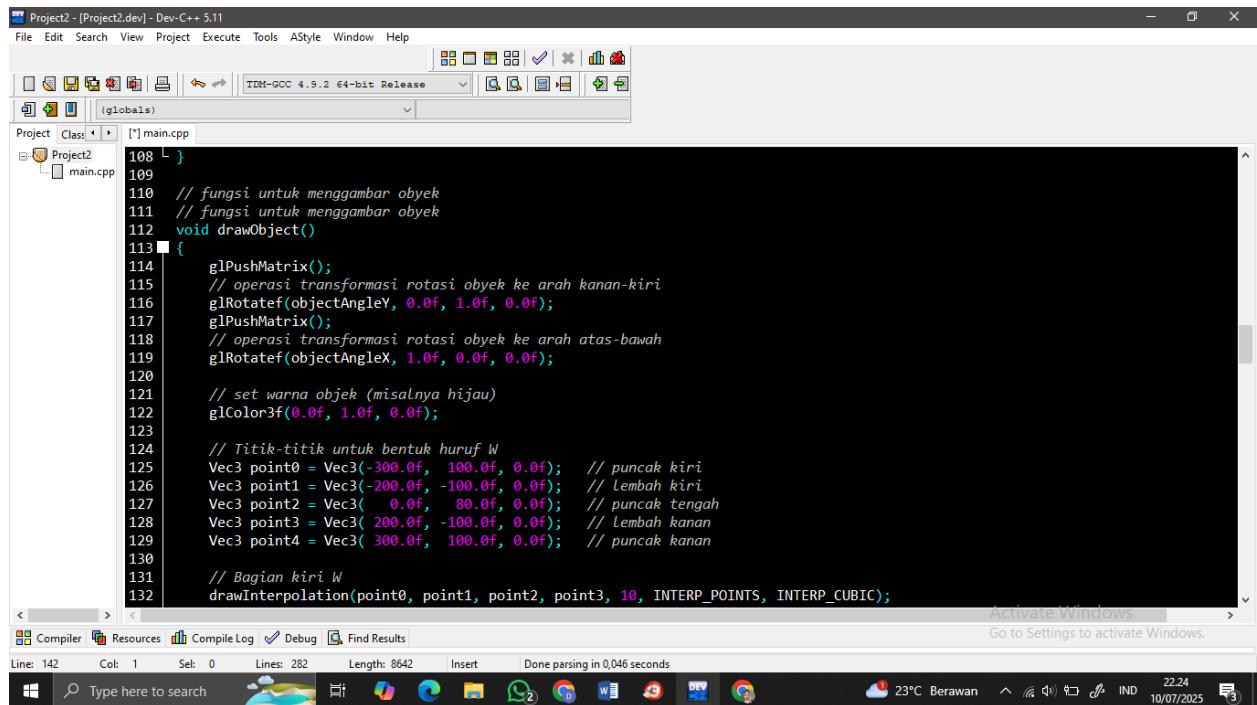


Output 3 laprak 3

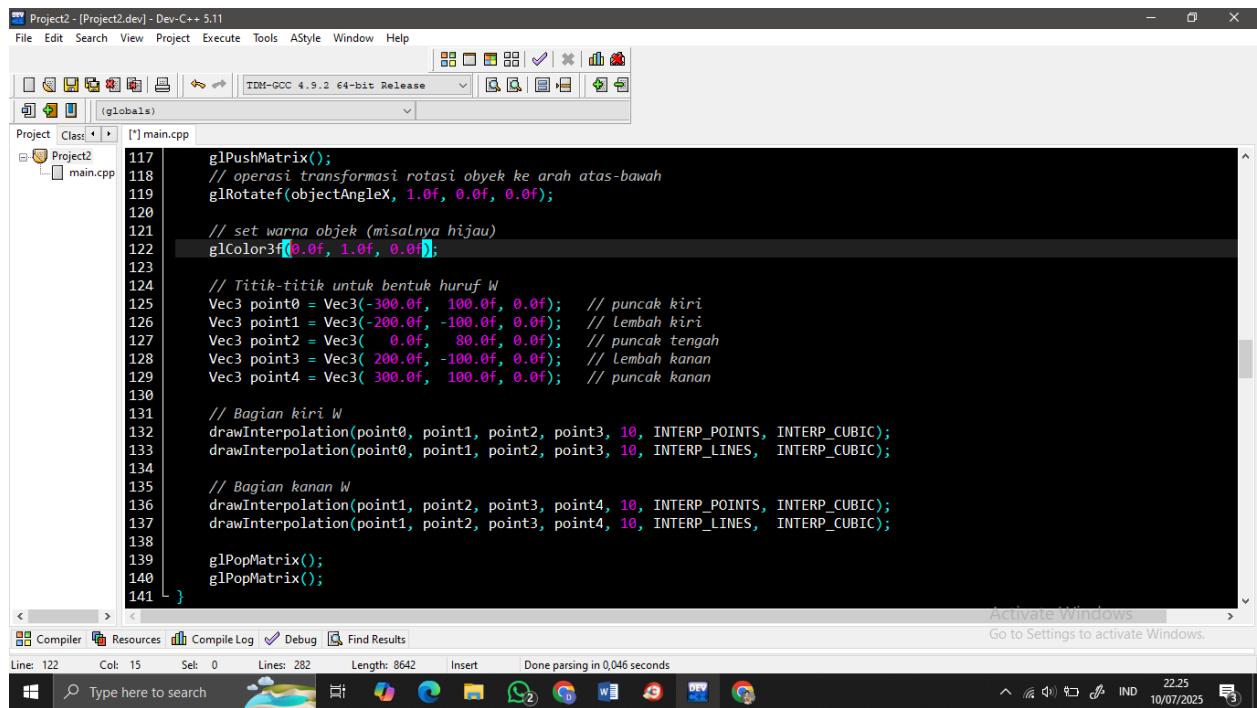


Posttest 3

Gambar 3 posttest 3



Gambar 2 postest 3

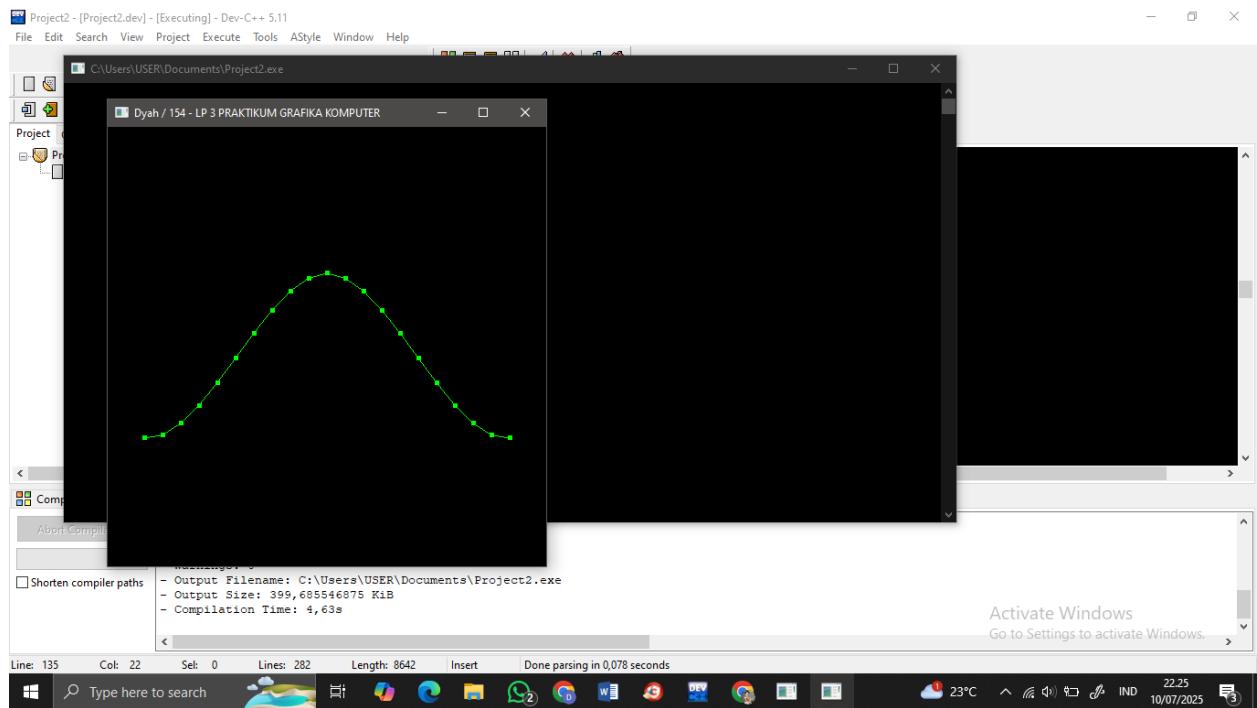


The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has various icons for file operations. The status bar at the bottom shows "Line: 122 Col: 15 Sel: 0 Lines: 282 Length: 8642 Insert Done parsing in 0,046 seconds". The code editor window displays main.cpp with the following content:

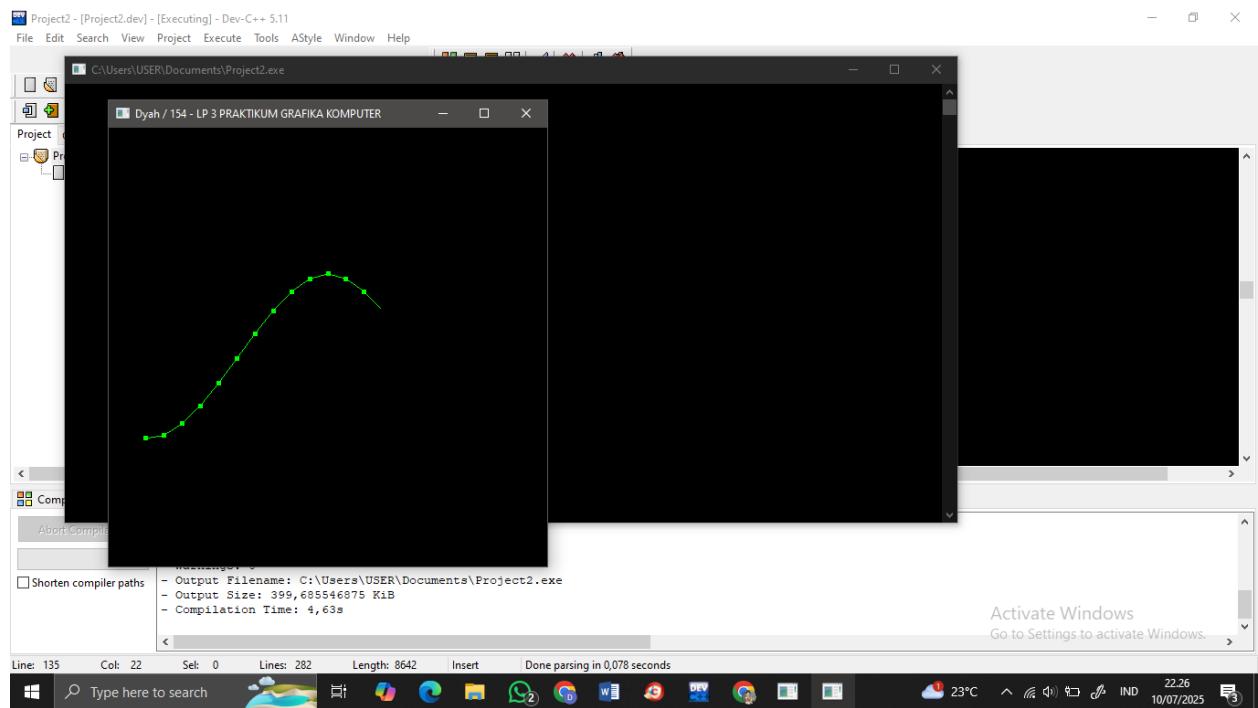
```
117     glPushMatrix();
118     // operasi transformasi rotasi obyek ke arah atas-bawah
119     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
120
121     // set warna objek (misalnya hijau)
122     glColor3f(0.0f, 1.0f, 0.0f);
123
124     // Titik-titik untuk bentuk huruf W
125     Vec3 point0 = Vec3(-300.0f, 100.0f, 0.0f); // puncak kiri
126     Vec3 point1 = Vec3(-200.0f, -100.0f, 0.0f); // Lembah kiri
127     Vec3 point2 = Vec3( 0.0f, -80.0f, 0.0f); // puncak tengah
128     Vec3 point3 = Vec3( 200.0f, -100.0f, 0.0f); // Lembah kanan
129     Vec3 point4 = Vec3( 300.0f, 100.0f, 0.0f); // puncak kanan
130
131     // Bagian kiri W
132     drawInterpolation(point0, point1, point2, point3, 10, INTERP_POINTS, INTERP_CUBIC);
133     drawInterpolation(point0, point1, point2, point3, 10, INTERP_LINES, INTERP_CUBIC);
134
135     // Bagian kanan W
136     drawInterpolation(point1, point2, point3, point4, 10, INTERP_POINTS, INTERP_CUBIC);
137     drawInterpolation(point1, point2, point3, point4, 10, INTERP_LINES, INTERP_CUBIC);
138
139     glPopMatrix();
140     glPopMatrix();
141 }
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates 22.25, 10/07/2025.

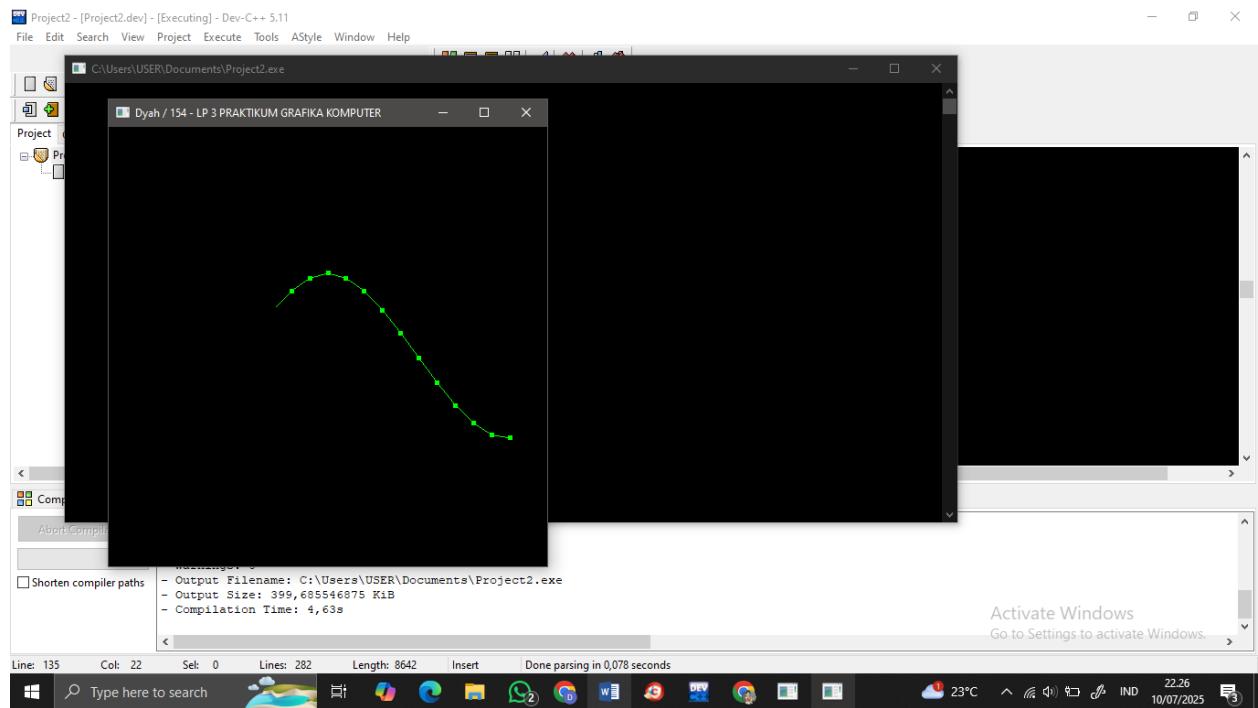
Output 1 postest 3



Output 2 postest 3



Output 3 postest 3



BAB IV. TRANSFORMASI 2D DAN 3D

Pretest 4

Pertanyaan:

1. Diketahui suatu garis P dengan titik-titik ada di koordinat A (-1, -1) dan B (1, 1). Apabila garis P dikenakan transformasi berikut, Berapa koordinat titik-titik yang baru?
 1. Garis P ditranslasi sejauh T (2, 2)!
 2. Garis P discaling sebesar S (2, 1)!
 3. Garis P dirotasi sejauh 30 derajat!

Jawaban:

1. Translasi

$$X' = x + tx', y' = y + ty$$

$$\text{Dengan } tx = 2, ty = 2$$

$$\text{Titik A : } x' = -1 + 2 = 1, y' = -1 + 2 = 1 \Rightarrow A' = (1, 1)$$

$$\text{Titik B : } x' = 1 + 2 = 3, y' = 1 + 2 = 3 \Rightarrow B' = (3, 3)$$

$$\text{Hasil : } A' = (1, 1), B' = (3, 3)$$

Scaling

$$X' = -1 \cdot 2 = -2, y' = -1 \cdot 1 = -1 \Rightarrow A' = (-2, -1)$$

$$Y' = 1 \cdot 2 = 2, y' = 1 \cdot 1 = 1 \Rightarrow B' = (2, 1)$$

$$\text{Hasil : } A' = (-2, -1), B' = (2, 1)$$

Rotasi 30°

$$\text{Titik A : } (-1, -1)$$

$$X' = -1 \cdot 0,866 - (-1) \cdot 0,5 = -0,866 + 0,5 = 0,366$$

$$Y' = -1 \cdot 0,5 + (-1) \cdot 0,866 = -0,5 - 0,866 = -1,366 \Rightarrow A' \sim (-0,366, -1,366)$$

$$\text{Titik B : } (1, 1)$$

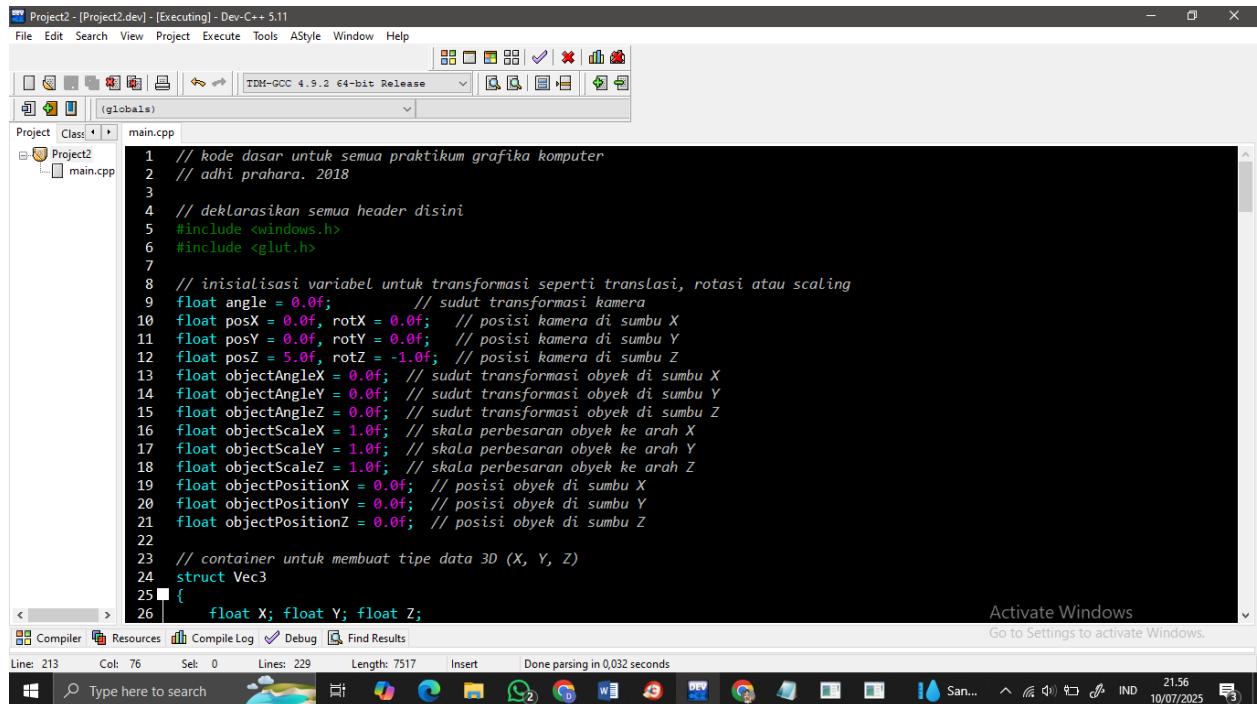
$$X' = 1 \cdot 0,866 - 1 \cdot 0,5 = 0,866 - 0,5 = 0,366$$

$$Y' = 1 \cdot 0,5 + (1) \cdot 0,866 = 0,5 + 0,866 = 1,366 \Rightarrow B' \sim (0,366, 1,366)$$

$$\text{Hasil : } A' \sim (-0,366, -1,366), B' \sim (0,366, 1,366)$$

Langkah Praktikum 4

Gambar 1 laprak 4



The screenshot shows the Dev-C++ IDE interface with the following details:

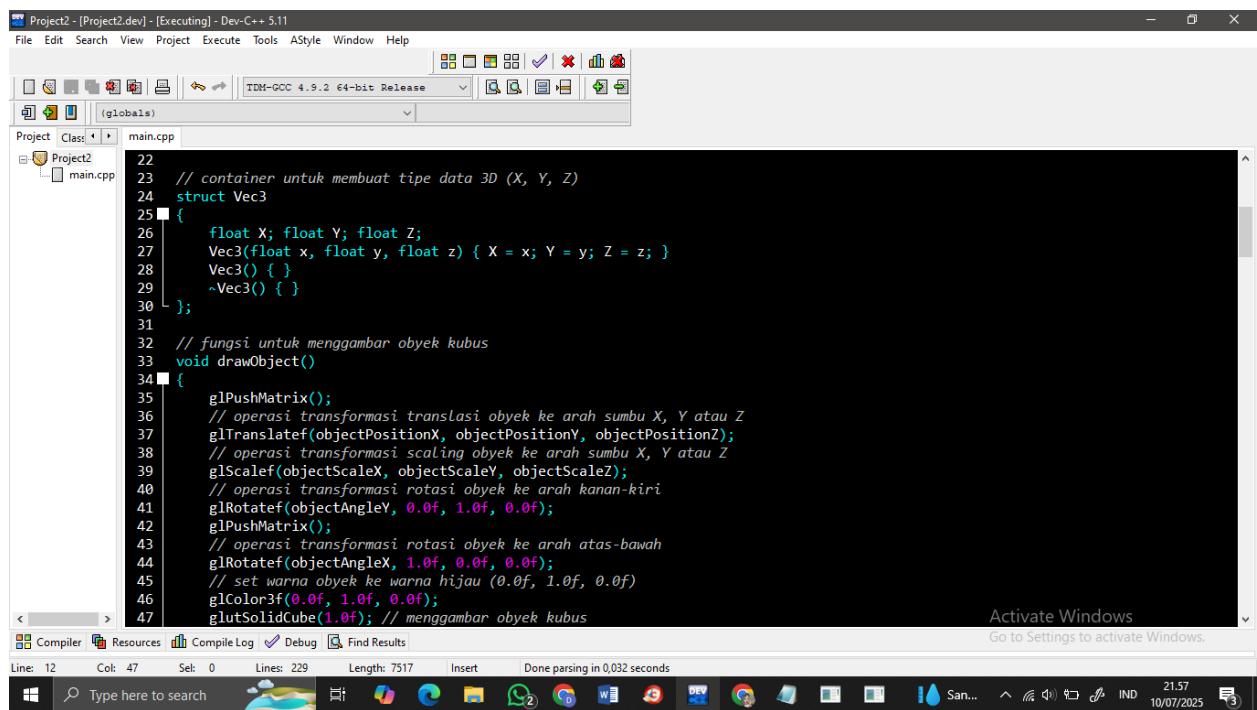
- Title Bar:** Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11
- Menu Bar:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help
- Toolbar:** Standard Dev-C++ toolbar with icons for project management, file operations, and compilation.
- Toolbox:** Global toolbox with various icons for file operations.
- Project Explorer:** Shows a project named "Project2" containing a file "main.cpp".
- Code Editor:** The main window displays the following C++ code:

```
1 // kode dasar untuk semua praktikum grafika komputer
2 // adhi prahara. 2018
3
4 // deklarasikan semua header disini
5 #include <windows.h>
6 #include <glut.h>
7
8 // inisialisasi variabel untuk transformasi seperti translasi, rotasi atau scaling
9 float angle = 0.0f; // sudut transformasi kamera
10 float posX = 0.0f, rotX = 0.0f; // posisi kamera di sumbu X
11 float posY = 0.0f, rotY = 0.0f; // posisi kamera di sumbu Y
12 float posZ = 5.0f, rotZ = -1.0f; // posisi kamera di sumbu Z
13 float objectAngleX = 0.0f; // sudut transformasi obyek di sumbu X
14 float objectAngleY = 0.0f; // sudut transformasi obyek di sumbu Y
15 float objectAngleZ = 0.0f; // sudut transformasi obyek di sumbu Z
16 float objectScaleX = 1.0f; // skala perbesaran obyek ke arah X
17 float objectScaleY = 1.0f; // skala perbesaran obyek ke arah Y
18 float objectScaleZ = 1.0f; // skala perbesaran obyek ke arah Z
19 float objectPositionX = 0.0f; // posisi obyek di sumbu X
20 float objectPositionY = 0.0f; // posisi obyek di sumbu Y
21 float objectPositionZ = 0.0f; // posisi obyek di sumbu Z
22
23 // container untuk membuat tipe data 3D (X, Y, Z)
24 struct Vec3
25 {
26     float X; float Y; float Z;
27 }
28
29
30
31
32 // fungsi untuk menggambar obyek kubus
33 void drawObject()
34 {
35     glPushMatrix();
36     // operasi transformasi translasi obyek ke arah sumbu X, Y atau Z
37     glTranslatef(objectPositionX, objectPositionY, objectPositionZ);
38     // operasi transformasi scaling obyek ke arah sumbu X, Y atau Z
39     glScalef(objectScaleX, objectScaleY, objectScaleZ);
40     // operasi transformasi rotasi obyek ke arah kanan-kiri
41     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
42     glPushMatrix();
43     // operasi transformasi rotasi obyek ke arah atas-bawah
44     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
45     // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
46     glColor3f(0.0f, 1.0f, 0.0f);
47     glutSolidCube(1.0f); // menggambar obyek kubus
48 }
```

Bottom status bar: Line: 213 Col: 76 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0.032 seconds

Bottom taskbar: Windows Start button, Task View, File Explorer, File Manager, Task Scheduler, Taskbar settings, and system clock (21:56, 10/07/2025).

Gambar 2 laprak 4



The screenshot shows the Dev-C++ IDE interface with the following details:

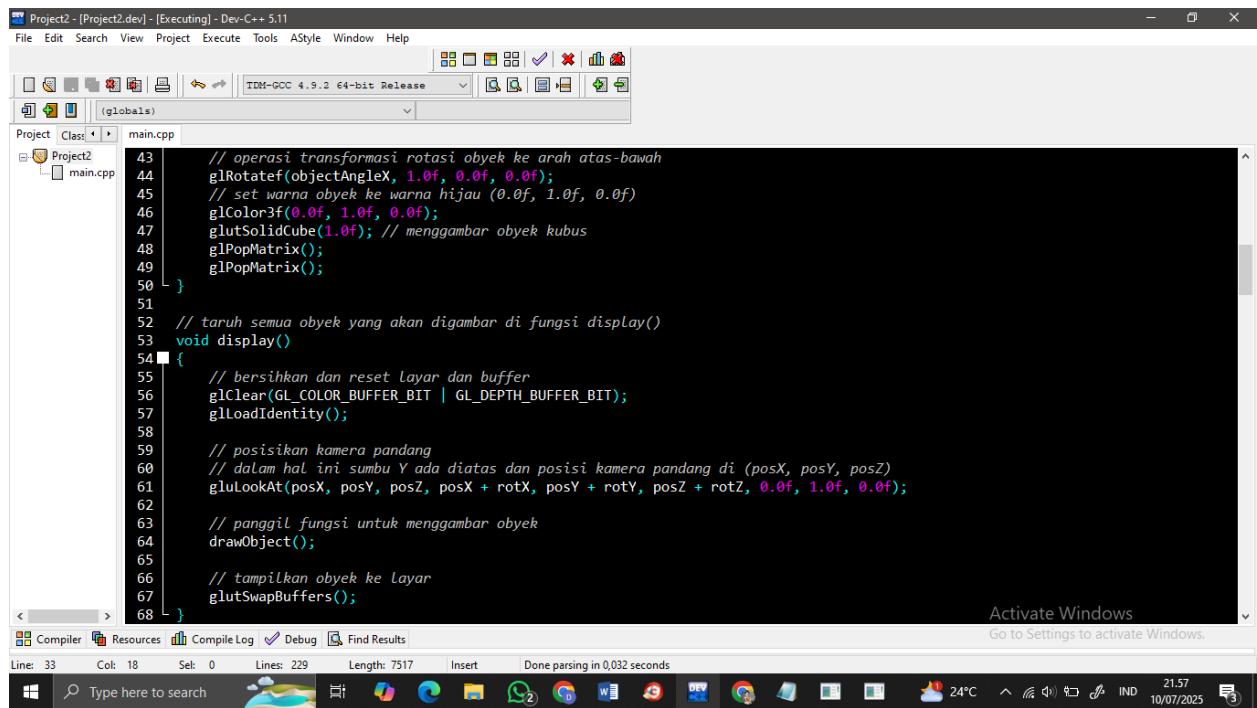
- Title Bar:** Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11
- Menu Bar:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help
- Toolbar:** Standard Dev-C++ toolbar with icons for project management, file operations, and compilation.
- Toolbox:** Global toolbox with various icons for file operations.
- Project Explorer:** Shows a project named "Project2" containing a file "main.cpp".
- Code Editor:** The main window displays the following C++ code, which includes the code from Gambar 1 and adds a constructor for the Vec3 struct:

```
22 // container untuk membuat tipe data 3D (X, Y, Z)
23 struct Vec3
24 {
25     float X; float Y; float Z;
26     Vec3(float x, float y, float z) { X = x; Y = y; Z = z; }
27     Vec3() { }
28     ~Vec3() { }
29 };
30
31
32 // fungsi untuk menggambar obyek kubus
33 void drawObject()
34 {
35     glPushMatrix();
36     // operasi transformasi translasi obyek ke arah sumbu X, Y atau Z
37     glTranslatef(objectPositionX, objectPositionY, objectPositionZ);
38     // operasi transformasi scaling obyek ke arah sumbu X, Y atau Z
39     glScalef(objectScaleX, objectScaleY, objectScaleZ);
40     // operasi transformasi rotasi obyek ke arah kanan-kiri
41     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
42     glPushMatrix();
43     // operasi transformasi rotasi obyek ke arah atas-bawah
44     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
45     // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
46     glColor3f(0.0f, 1.0f, 0.0f);
47     glutSolidCube(1.0f); // menggambar obyek kubus
48 }
```

Bottom status bar: Line: 12 Col: 47 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0.032 seconds

Bottom taskbar: Windows Start button, Task View, File Explorer, File Manager, Task Scheduler, Taskbar settings, and system clock (21:57, 10/07/2025).

Gambar 3 laprak 4



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 33 Col: 1 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code:

```
// operasi transformasi rotasi obyek ke arah atas-bawah
glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
// set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
	glColor3f(0.0f, 1.0f, 0.0f);
	glutSolidCube(1.0f); // menggambar obyek kubus
glPopMatrix();
glPopMatrix();
glPopMatrix();

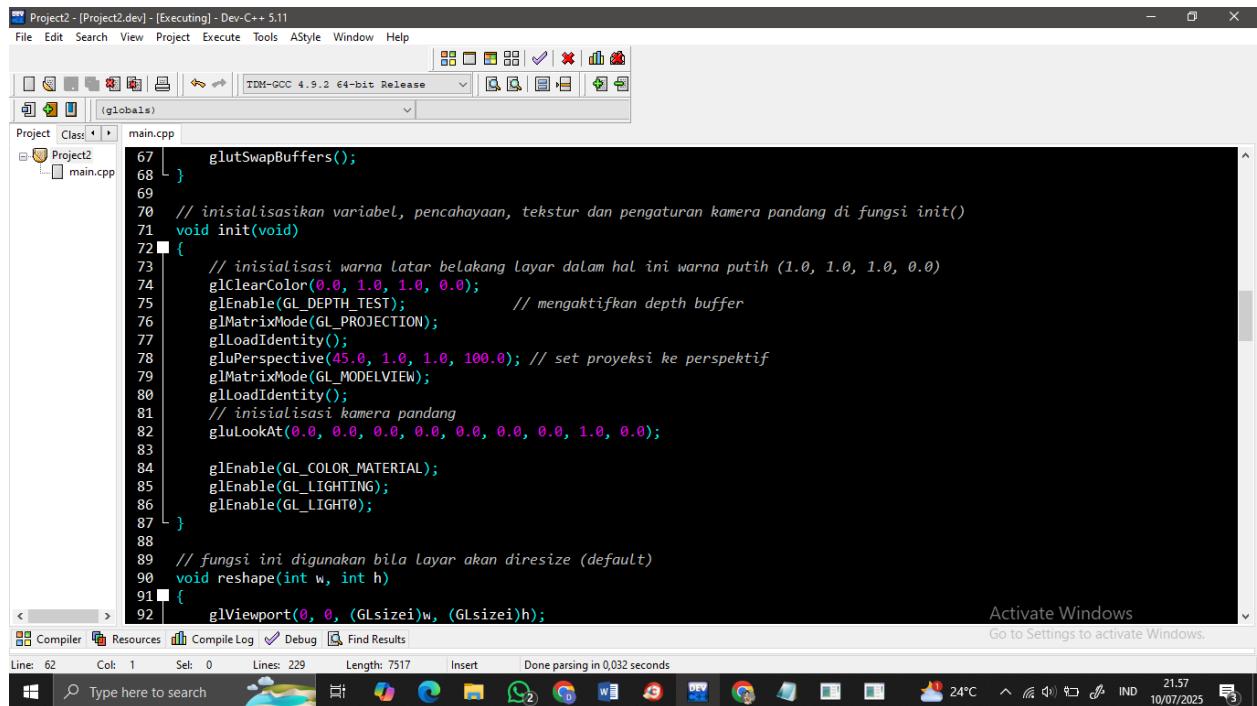
// taruh semua obyek yang akan digambar di fungsi display()
void display()
{
    // bersihkan dan reset Layar dan buffer
    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
    glLoadIdentity();

    // posisikan kamera pandang
    // dalam hal ini sumbu Y ada diatas dan posisi kamera pandang di (posX, posY, posZ)
    gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);

    // panggil fungsi untuk menggambar obyek
    drawObject();

    // tampilkan obyek ke Layar
    glutSwapBuffers();
}
```

Gambar 4 laprak 4



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 62 Col: 1 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code:

```
glutSwapBuffers();

// inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
void init(void)
{
    // inisialisasi warna latar belakang layar dalam hal ini warna putih (1.0, 1.0, 1.0, 0.0)
    glClearColor(0.0, 1.0, 1.0, 0.0);
    glEnable(GL_DEPTH_TEST); // mengaktifkan depth buffer
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    gluPerspective(45.0, 1.0, 1.0, 100.0); // set proyeksi ke perspektif
    glMatrixMode(GL_MODELVIEW);
    glLoadIdentity();
    // inisialisasi kamera pandang
    gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);

    glEnable(GL_COLOR_MATERIAL);
    glEnable(GL_LIGHTING);
    glEnable(GL_LIGHT0);
}

// fungsi ini digunakan bila layar akan diresize (default)
void reshape(int w, int h)
{
    glViewport(0, 0, (GLsizei)w, (GLsizei)h);
}
```

Gambar 5 laprak 4

The screenshot shows the Dev-C++ IDE interface with the following details:

- Title Bar:** Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11
- Menu Bar:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help
- Toolbar:** Standard Dev-C++ toolbar with icons for file operations.
- Project Explorer:** Shows "Project2" and "main.cpp".
- Code Editor:** Displays the following C++ code:

```
88 // fungsi ini digunakan bila Layar akan diresize (default)
89 void reshape(int w, int h)
90 {
91     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
92     glMatrixMode(GL_PROJECTION);
93     glLoadIdentity();
94     gluPerspective(45, (GLfloat)w / (GLfloat)h, 1.0, 100.0);
95     glMatrixMode(GL_MODELVIEW);
96 }
97
98 // fungsi untuk mengatur masukan dari keyboard
99 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
100 void keyboard(int key, int x, int y)
101 {
102     float fraction = 0.1f;
103
104     switch (key)
105     {
106         case GLUT_KEY_LEFT: // rotasi obyek ke kiri
107             objectAngleY -= 1.0f;
108             glutPostRedisplay(); // update obyek
109             break;
110         case GLUT_KEY_RIGHT: // rotasi obyek ke kanan
111             objectAngleY += 1.0f;
112             glutPostRedisplay(); // update obyek
113     }
114 }
```

At the bottom of the code editor, status bar shows: Line: 62 Col: 1 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0,032 seconds.

The taskbar at the bottom includes the Start button, a search bar, and various pinned application icons like File Explorer, Edge, and File Manager. The system tray shows the date (10/07/2025), time (21:57), battery level, and network status.

Gambar 6 laprak 4

The screenshot shows the Dev-C++ IDE interface with the following details:

- Title Bar:** Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11
- Menu Bar:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help
- Toolbar:** Standard Dev-C++ toolbar with icons for file operations.
- Project Explorer:** Shows "Project2" and "main.cpp".
- Code Editor:** Displays the following C++ code, showing more cases for keyboard input:

```
100 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
101 void keyboard(int key, int x, int y)
102 {
103     float fraction = 0.1f;
104
105     switch (key)
106     {
107         case GLUT_KEY_LEFT: // rotasi obyek ke kiri
108             objectAngleY -= 1.0f;
109             glutPostRedisplay(); // update obyek
110             break;
111         case GLUT_KEY_RIGHT: // rotasi obyek ke kanan
112             objectAngleY += 1.0f;
113             glutPostRedisplay(); // update obyek
114             break;
115         case GLUT_KEY_UP: // rotasi obyek ke atas
116             objectAngleX -= 1.0f;
117             glutPostRedisplay(); // update obyek
118             break;
119         case GLUT_KEY_DOWN: // rotasi obyek ke bawah
120             objectAngleX += 1.0f;
121             glutPostRedisplay(); // update obyek
122             break;
123         case GLUT_KEY_PAGE_UP: // zoom in
124             posX += rotX * fraction;
125             posY += rotY * fraction;
```

At the bottom of the code editor, status bar shows: Line: 103 Col: 27 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0,032 seconds.

The taskbar at the bottom includes the Start button, a search bar, and various pinned application icons like File Explorer, Edge, and File Manager. The system tray shows the date (10/07/2025), time (21:58), battery level, and network status.

Gambar 7 laprak 4

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 115 Col: 25 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code:

```
112     objectAngleY += 1.0f; // update obyek
113     glutPostRedisplay(); // update obyek
114     break;
115     case GLUT_KEY_UP: // rotasi obyek ke atas
116         objectAngleX -= 1.0f;
117         glutPostRedisplay(); // update obyek
118         break;
119     case GLUT_KEY_DOWN: // rotasi obyek ke bawah
120         objectAngleX += 1.0f;
121         glutPostRedisplay(); // update obyek
122         break;
123     case GLUT_KEY_PAGE_UP: // zoom in
124         posX += rotX * fraction;
125         posY += rotY * fraction;
126         glutPostRedisplay(); // update obyek
127         break;
128     case GLUT_KEY_PAGE_DOWN: // zoom out
129         posX -= rotX * fraction;
130         posY -= rotY * fraction;
131         glutPostRedisplay(); // update obyek
132         break;
133     }
134 }
135
136 // fungsi untuk mengatur masukan dari keyboard
137 void keyboard1(unsigned char key, int x, int y)
```

The code handles keyboard input for rotation and zoom. It includes logic for GLUT_KEY_UP, GLUT_KEY_DOWN, GLUT_KEY_PAGE_UP, and GLUT_KEY_PAGE_DOWN. It also defines a function keyboard1 that takes a character key and coordinates x, y.

Gambar 8 laprak 4

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 127 Col: 15 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code:

```
136 // fungsi untuk mengatur masukan dari keyboard
137 void keyboard1(unsigned char key, int x, int y)
138 {
139     float fraction = 0.5f;
140     switch (key)
141     {
142         case 'w': // translasi ke atas
143             objectPositionY += fraction;
144             glutPostRedisplay();
145             break;
146         case 's': // translasi ke bawah
147             objectPositionY -= fraction;
148             glutPostRedisplay();
149             break;
150         case 'a': // translasi ke kiri
151             objectPositionX -= fraction;
152             glutPostRedisplay();
153             break;
154         case 'd': // translasi ke kanan
155             objectPositionX += fraction;
156             glutPostRedisplay();
157             break;
158         case 'q': // translasi ke depan
159             objectPositionZ += fraction;
160             glutPostRedisplay();
161             break;
```

This version of the code uses standard ASCII characters ('w', 's', 'a', 'd', 'q') for movement instead of GLUT keys. It includes logic for moving up, down, left, right, and forward. The function name remains keyboard1.

Gambar 9 laprak 4

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 152 Col: 29 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0,032 seconds". The bottom taskbar includes the Start button, a search bar, and various pinned application icons.

```
case 'd': // translasi ke kanan
objectPositionX += fraction;
glutPostRedisplay();
break;
case 'q': // translasi ke depan
objectPositionZ += fraction;
glutPostRedisplay();
break;
case 'e': // translasi ke belakang
objectPositionZ -= fraction;
glutPostRedisplay();
break;
case 't': // perbesar ke arah sumbu Y
objectScaleY += 0.1f;
glutPostRedisplay();
break;
case 'g': // perkecil ke arah sumbu Y
objectScaleY = (objectScaleY - 0.1f < 1.0f) ? 1.0f : objectScaleY - 0.1f;
glutPostRedisplay();
break;
case 'f': // perbesar ke arah sumbu X
objectScaleX += 0.1f;
glutPostRedisplay();
break;
case 'h': // perkecil ke arah sumbu X
objectScaleX = (objectScaleX - 0.1f < 1.0f) ? 1.0f : objectScaleX - 0.1f;
glutPostRedisplay();
break;
case 'r': // perbesar ke arah sumbu Z
objectScaleZ += 0.1f;
glutPostRedisplay();
break;
case 'y': // perkecil ke arah sumbu Z
objectScaleZ = (objectScaleZ - 0.1f < 1.0f) ? 1.0f : objectScaleZ - 0.1f;
glutPostRedisplay();
break;
case 27: // keluar program
exit(0);
break;
```

Gambar 10 laprak 4

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 173 Col: 15 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0,032 seconds". The bottom taskbar includes the Start button, a search bar, and various pinned application icons.

```
break;
case 'g': // perkecil ke arah sumbu Y
objectScaleY = (objectScaleY - 0.1f < 1.0f) ? 1.0f : objectScaleY - 0.1f;
glutPostRedisplay();
break;
case 'f': // perbesar ke arah sumbu X
objectScaleX += 0.1f;
glutPostRedisplay();
break;
case 'h': // perkecil ke arah sumbu X
objectScaleX = (objectScaleX - 0.1f < 1.0f) ? 1.0f : objectScaleX - 0.1f;
glutPostRedisplay();
break;
case 'r': // perbesar ke arah sumbu Z
objectScaleZ += 0.1f;
glutPostRedisplay();
break;
case 'y': // perkecil ke arah sumbu Z
objectScaleZ = (objectScaleZ - 0.1f < 1.0f) ? 1.0f : objectScaleZ - 0.1f;
glutPostRedisplay();
break;
case 27: // keluar program
exit(0);
break;
```

Gambar 11 laprak 4

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 187 Col: 36 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0,032 seconds". The code editor window displays the main.cpp file with the following content:

```
193     }
194 }
195 // timer untuk animasi (gunakan bila perlu)
196 void timer(int value)
197 {
198     glutPostRedisplay();
199     glutTimerFunc(5, timer, 0);
200 }
201
202 // program utama
203 int main(int argc, char** argv)
204 {
205     // inisialisasi jendela OpenGL
206     glutInit(&argc, argv);
207     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
208
209     // set ukuran jendela tampilan
210     glutInitWindowSize(480, 480);      // besarnya jendela dalam piksel
211     glutInitWindowPosition(100, 100); // posisi jendela di layar komputer
212     glutCreateWindow("Dyah / 154 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");
213
214     // panggil fungsi init untuk inisialisasi awal
215     init();
216
217     // event handler untuk display, reshape dan keyboard
218     glutDisplayFunc(display); // display
219     glutReshapeFunc(reshape); // reshape
220     glutSpecialFunc(keyboard); // keyboard
221     glutKeyboardFunc(keyboard1); // keyboard
222
223     // Looping
224     glutMainLoop();
225
226     return 0;
227 }
228 }
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 24°C, 10/07/2025.

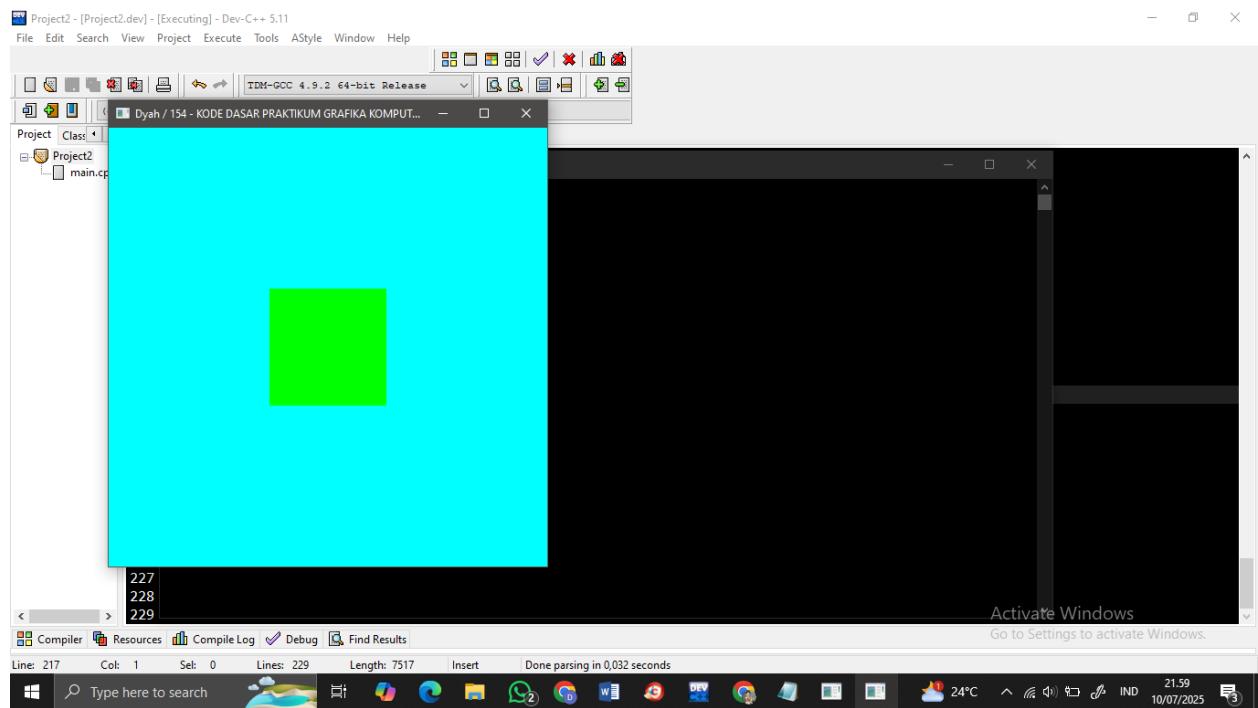
Gambar 12 laprak 4

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 208 Col: 24 Sel: 0 Lines: 229 Length: 7517 Insert Done parsing in 0,032 seconds". The code editor window displays the main.cpp file with the following content, highlighting a syntax error in the line "glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);":

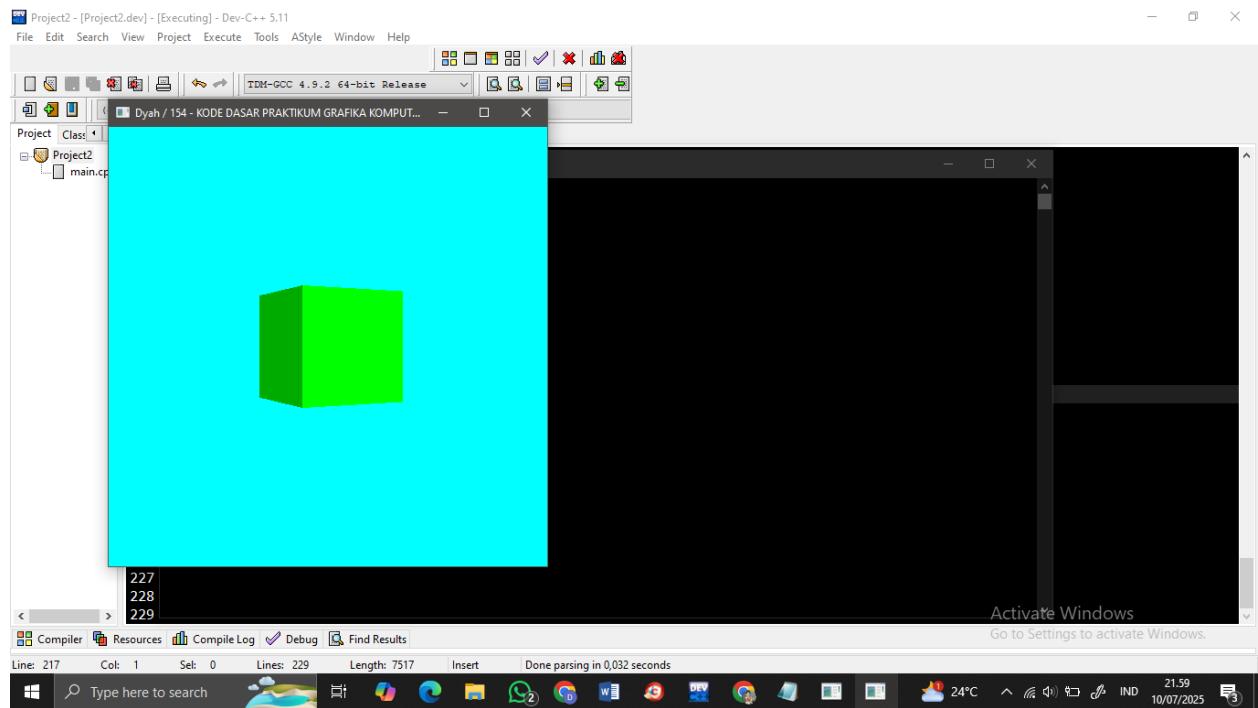
```
204     int main(int argc, char** argv)
205     {
206         // inisialisasi jendela OpenGL
207         glutInit(&argc, argv);
208         glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH); // Syntax Error
209
210         // set ukuran jendela tampilan
211         glutInitWindowSize(480, 480);      // besarnya jendela dalam piksel
212         glutInitWindowPosition(100, 100); // posisi jendela di layar komputer
213         glutCreateWindow("Dyah / 154 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");
214
215         // panggil fungsi init untuk inisialisasi awal
216         init();
217
218         // event handler untuk display, reshape dan keyboard
219         glutDisplayFunc(display); // display
220         glutReshapeFunc(reshape); // reshape
221         glutSpecialFunc(keyboard); // keyboard
222         glutKeyboardFunc(keyboard1); // keyboard
223
224         // Looping
225         glutMainLoop();
226
227         return 0;
228     }
229 }
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 24°C, 10/07/2025.

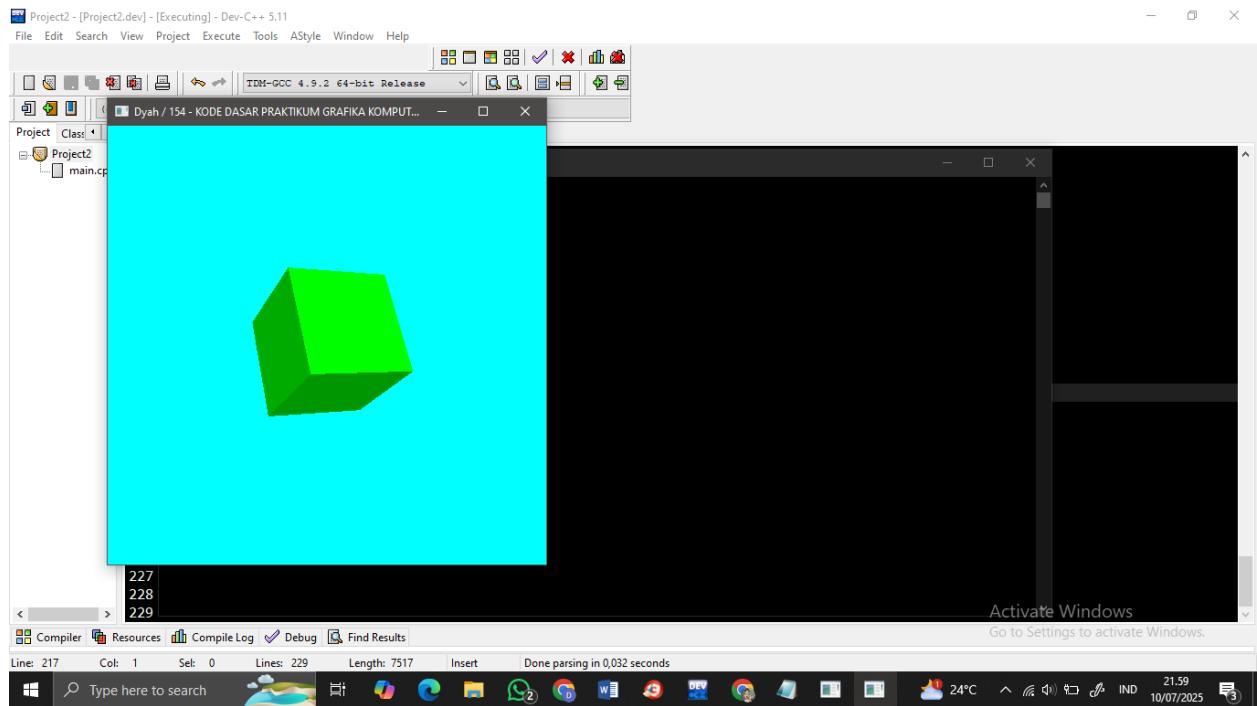
Output 11 laprak 4



Output 2 laprak 4



Output 3 laprak 4



Posttest 4

Gambar 4 posttest 4

```
Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11
File Edit Search View Project Execute Tools AStyle Window Help
Project Class[*] main.cpp
28     Vec3() { }
29     ~Vec3() { }
30 };
31
32 // fungsi untuk menggambar objek kubus
33 void drawObject()
34 {
35     glPushMatrix();
36     // operasi transformasi translasi objek ke arah sumbu X, Y atau Z
37     glTranslatef(objectPositionX, objectPositionY, objectPositionZ);
38     // operasi transformasi scaling objek ke arah sumbu X, Y atau Z
39     glScalef(objectScaleX, objectScaleY, objectScaleZ);
40     // operasi transformasi rotasi objek ke arah kanan-kiri
41     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
42     glPushMatrix();
43     // operasi transformasi rotasi objek ke arah atas-bawah
44     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
45     // set warna objek ke warna hijau (0.0f, 1.0f, 0.0f)
46     glColor3f(0.0f, 1.0f, 0.0f); // Warna cyan
47     glutSolidCube(1.0f); // menggambar objek kubus
48     glPopMatrix();
49 }
50
51 // taruh semua objek yang akan digambar di fungsi display()
52 void display()
53 {

```

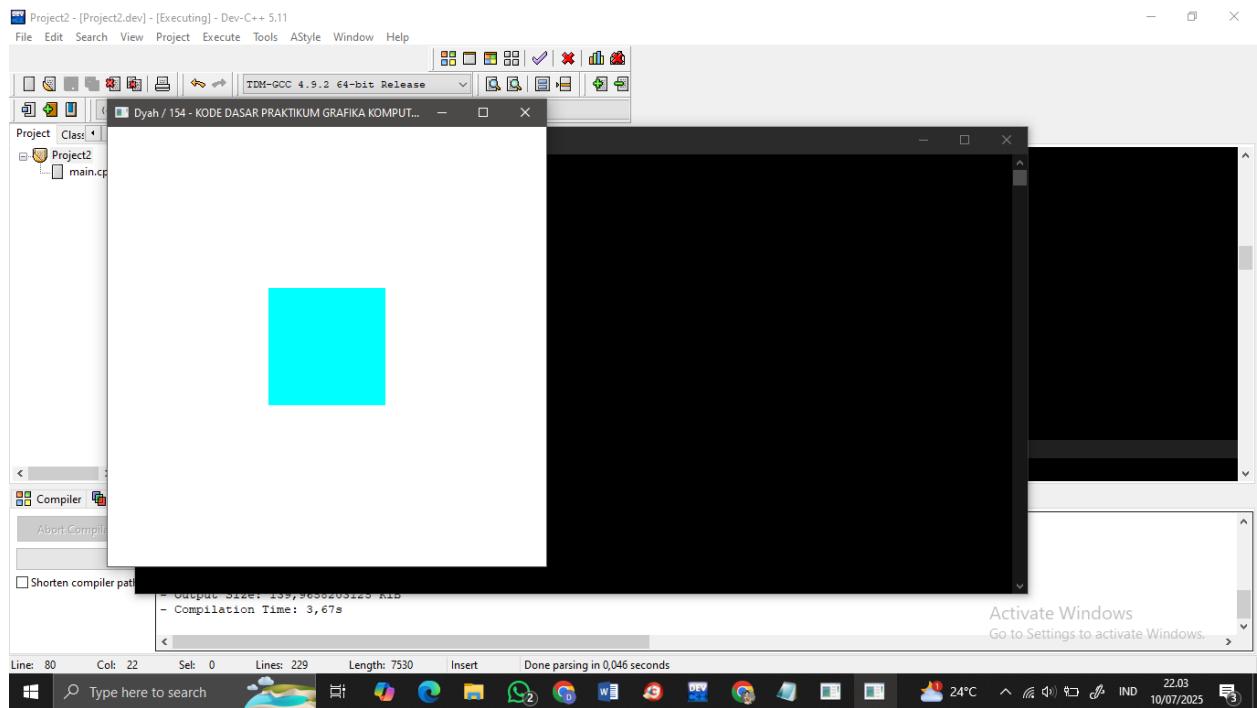
A screenshot of the Dev-C++ IDE showing the source code for a 3D cube. The code uses OpenGL functions like glPushMatrix(), glTranslatef(), glScalef(), and glutSolidCube() to define and render a cyan cube. The code editor shows lines 28 through 53 of the main.cpp file.

Gambar 2 postest 4

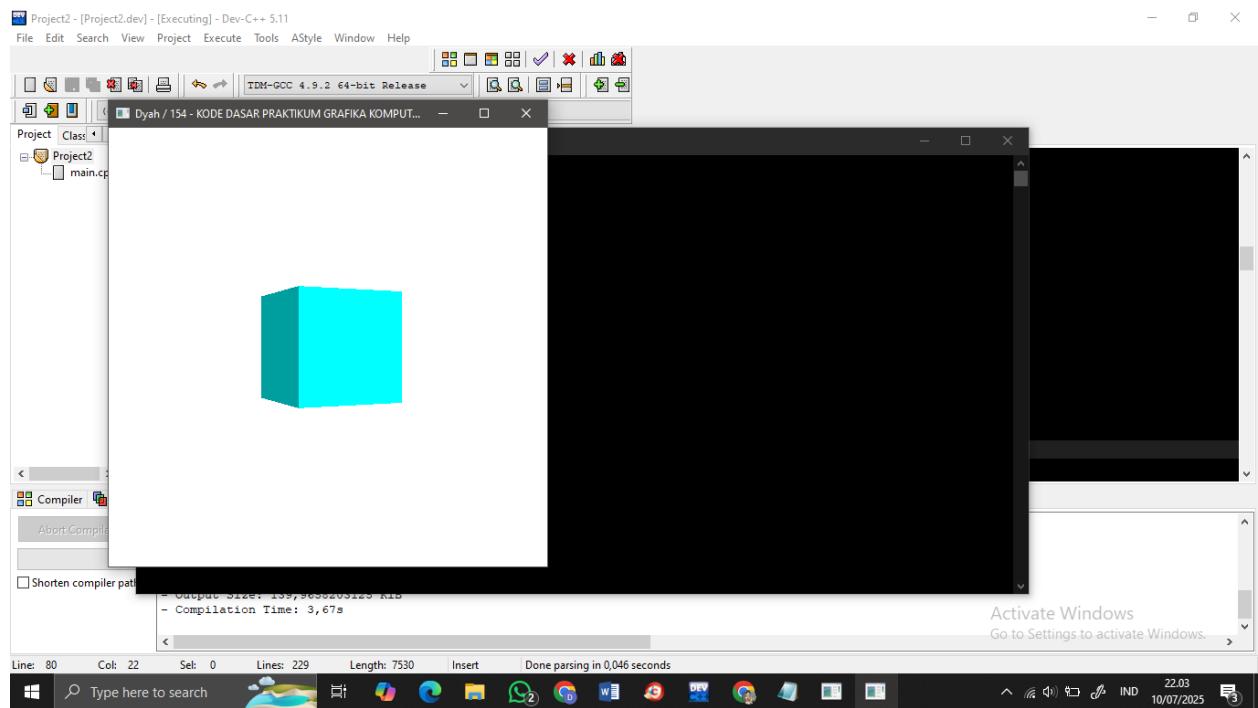
The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has various icons for file operations. The main window displays the code for "main.cpp". The code initializes OpenGL settings, including clearing the color buffer to white (1.0, 1.0, 1.0, 1.0), enabling depth testing, setting projection mode, and defining a perspective view. It also sets up lighting and material properties. The status bar at the bottom shows "Line: 74 Col: 34 Sel: 0 Lines: 229 Length: 7530 Insert Done parsing in 0,031 seconds". The taskbar at the bottom right shows system icons and the date/time: 22.02 10/07/2025.

```
64 drawObject();
65 // tampilkan obyek ke layar
66 glutSwapBuffers();
67 }
68 }
69 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
70 void init(void)
71 {
72     // inisialisasi warna Latar belakang Layar dalam hal ini warna putih (1.0, 1.0, 1.0, 0.0)
73     glClearColor(1.0, 1.0, 1.0, 1.0);
74     glEnable(GL_DEPTH_TEST); // mengaktifkan depth buffer
75     glMatrixMode(GL_PROJECTION);
76     glLoadIdentity();
77     gluPerspective(45.0, 1.0, 1.0, 100.0); // set proyeksi ke perspektif
78     glMatrixMode(GL_MODELVIEW);
79     glLoadIdentity();
80     // inisialisasi kamera pandang
81     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
82
83     glEnable(GL_COLOR_MATERIAL);
84     glEnable(GL_LIGHTING);
85     glEnable(GL_LIGHT0);
86 }
87 }
88 }
89 // fungsi ini digunakan bila layar akan diresize (default)
```

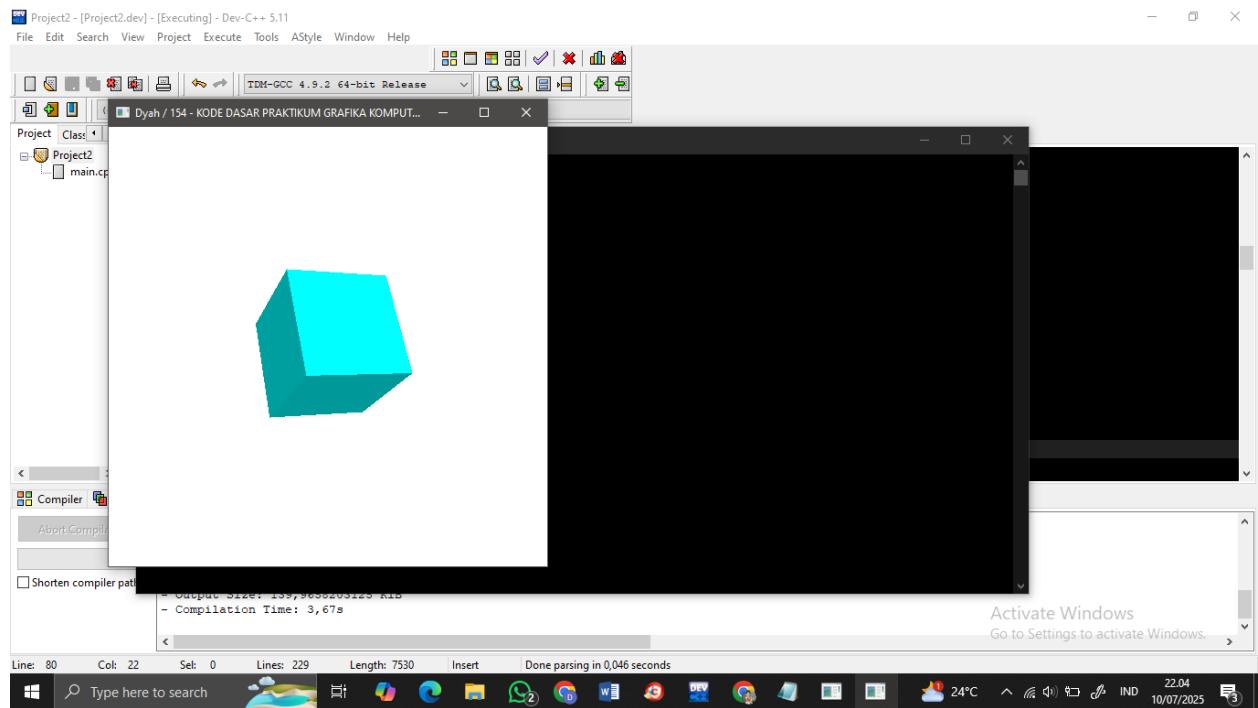
Output 1 postest 4



Output 2 postest 4



Gambar 2 postest 4



BAB V. PROYEKSI 3D

Pretest 5

Pertanyaan:

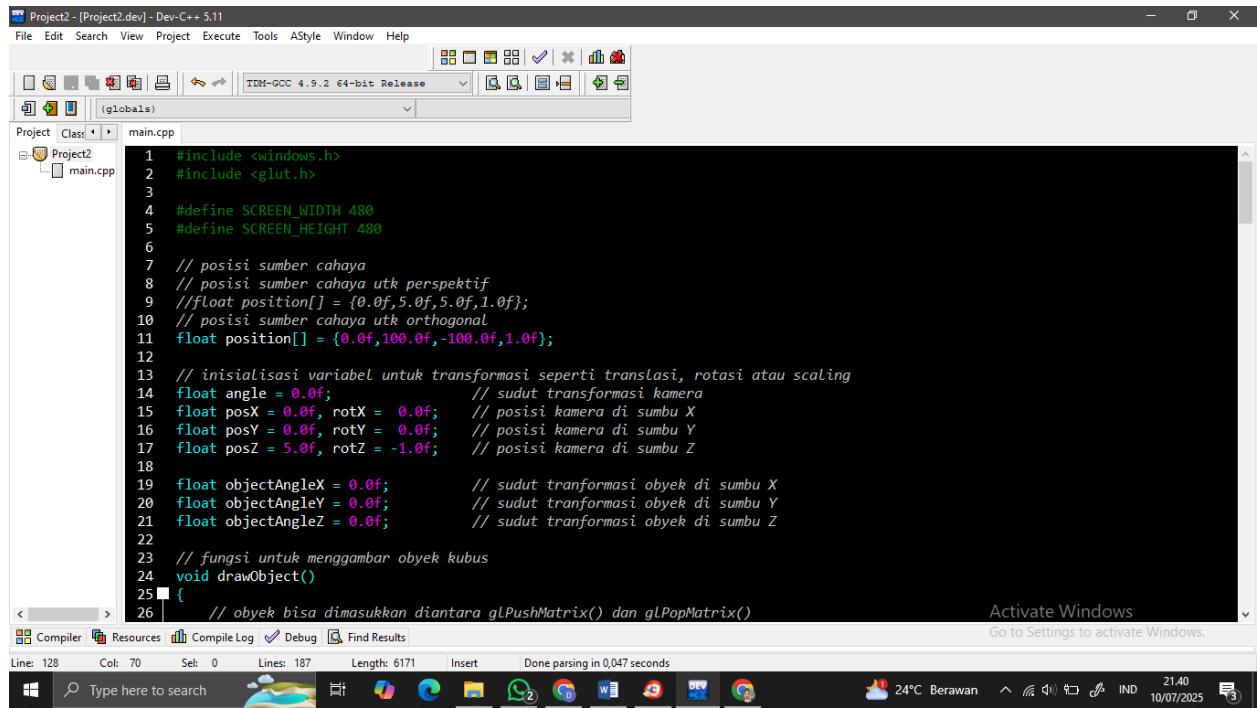
1. Jelaskan yang dimaksud dengan proyeksi orthogonal
2. Jelaskan yang dimaksud dengan proyeksi perspektif
3. Jelaskan perbedaan antara proyeksi orthogonal dengan perspektif

Jawaban:

1. Teknik proyeksi 3D ke 2D tanpa perspektif
2. Teknik proyeksi 3D ke 2D yang meniru cara mata manusia melihat dunia
3. Orthogonal : ukura objek tetap sama berapa pun jaraknya dari kamera dan perspektif : memberi ilusi kedalaman jauh jaid kecil dekat jadi lebih besar

Langkah Praktikum 5

Gambar 1 laprak 5



The screenshot shows the Dev-C++ IDE interface with the following details:

- Title Bar:** Project2 - [Project2.dev] - Dev-C++ 5.11
- Menu Bar:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help
- Toolbar:** Includes icons for file operations like Open, Save, Build, and Run.
- Toolbox:** Standard C++ development tools.
- Project Explorer:** Shows a project named "Project2" containing a file "main.cpp".
- Code Editor:** Displays the following C++ code:

```
1 #include <windows.h>
2 #include <glut.h>
3
4 #define SCREEN_WIDTH 480
5 #define SCREEN_HEIGHT 480
6
7 // posisi sumber cahaya
8 // posisi sumber cahaya utk perspektif
9 //float position[] = {0.0f, 5.0f, 5.0f, 1.0f};
10 // posisi sumber cahaya utk orthogonal
11 float position[] = {0.0f, 100.0f, -100.0f, 1.0f};
12
13 // inisialisasi variabel untuk transformasi seperti translasi, rotasi atau scaling
14 float angle = 0.0f; // sudut transformasi kamera
15 float posX = 0.0f, rotX = 0.0f; // posisi kamera di sumbu X
16 float posY = 0.0f, rotY = 0.0f; // posisi kamera di sumbu Y
17 float posZ = 5.0f, rotZ = -1.0f; // posisi kamera di sumbu Z
18
19 float objectAngleX = 0.0f; // sudut transformasi obyek di sumbu X
20 float objectAngleY = 0.0f; // sudut transformasi obyek di sumbu Y
21 float objectAngleZ = 0.0f; // sudut transformasi obyek di sumbu Z
22
23 // fungsi untuk menggambar obyek kubus
24 void drawObject()
25 {
26     // obyek bisa dimasukkan diantara glPushMatrix() dan glPopMatrix()
}
```

The code implements a 3D rendering setup using OpenGL, defining camera and object positions, and setting up transformations.

Gambar 2 laprak 5

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 15 Col: 46 Sel: 0 Lines: 187 Length: 6171 Insert Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
22 // fungsi untuk menggambar objek kubus
23 void drawObject()
24 {
25     // objek bisa dimasukkan diantara glPushMatrix() dan glPopMatrix()
26     // fungsinya agar objek tidak terpengaruh atau mempengaruhi objek lain
27     // saat diwarnai, ditransformasi dan sebagainya
28     glPushMatrix();
29
30     // operasi transformasi rotasi objek ke arah kanan-kiri
31     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
32
33     glPushMatrix();
34
35     // operasi transformasi rotasi objek ke arah atas-bawah
36     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
37
38     // set warna objek ke warna hijau (0.0f, 1.0f, 0.0f)
39     glColor3f(0.0f, 1.0f, 0.0f);
40
41     // bila menggambar objek harus diawali glBegin(tipe objek) dan diakhiri dengan glEnd()
42     // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
43     glutSolidCube(50.0f); // menggambar objek kubus di proyeksi orthogonal
44
45     glPopMatrix();
46
47 }
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates the date and time as 10/07/2025 21:41.

Gambar 3 laprak 5

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 42 Col: 50 Sel: 0 Lines: 187 Length: 6171 Insert Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
46     glPopMatrix();
47
48     glPopMatrix();
49 }
50
51 // taruh semua objek yang akan digambar di fungsi display()
52 void display()
53 {
54     // bersihkan dan reset layar dan buffer
55     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
56     glLoadIdentity();
57
58     // posisikan kamera pandang
59     // dalam hal ini sumbu Y ada diatas dan posisi kamera pandang di (posX, posY, posZ)
60     gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
61
62     // panggil fungsi untuk menggambar objek
63     drawObject();
64
65     // tampilkan objek ke layar
66     // gunakan glFlush() bila memakai single buffer
67     // gunakan glutSwapBuffers() bila memakai double buffer
68     glutSwapBuffers();
69 }
70
71 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates the date and time as 10/07/2025 21:41.

Gambar 4 laprak 5

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 62 Col: 30 Sel: 0 Lines: 187 Length: 6171 Insert Done parsing in 0,047 seconds". The code editor displays the following C++ code:

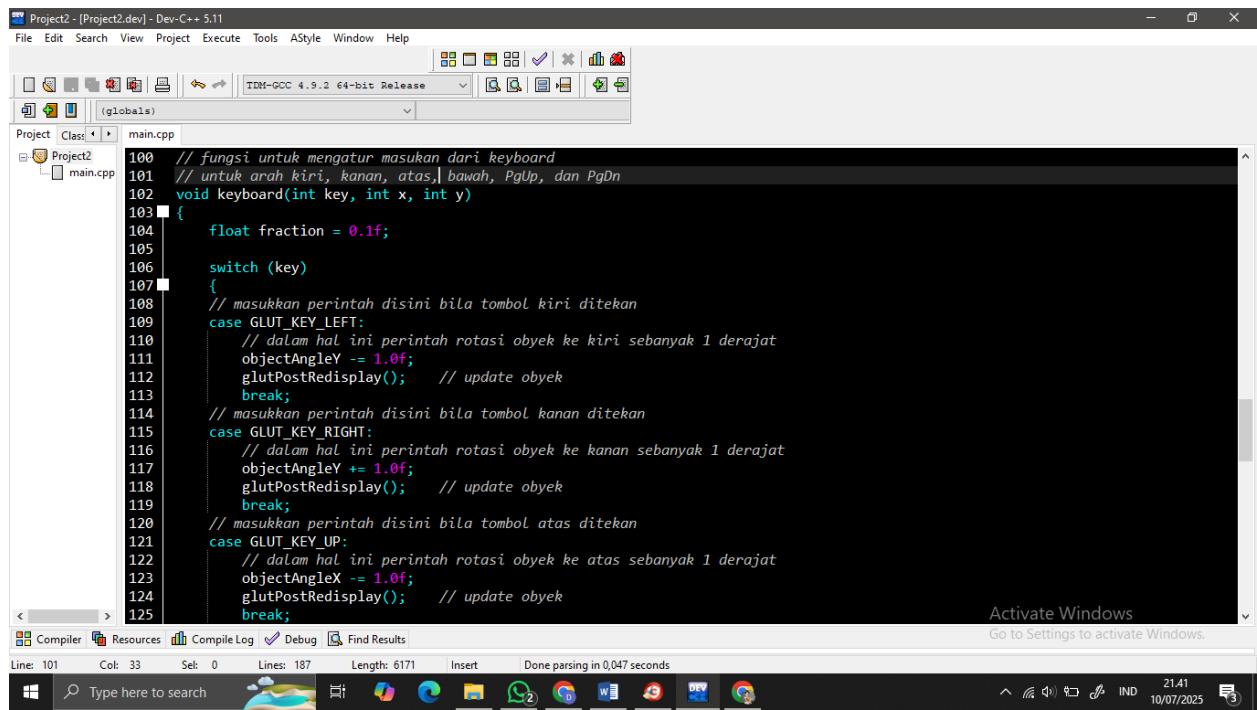
```
70 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
71 void init(void)
72 {
73     // inisialisasi warna latar belakang Layar dalam hal ini warna putih (1.0, 1.0, 1.0, 0.0)
74     glClearColor(1.0, 1.0, 1.0, 0.0);
75     glEnable(GL_DEPTH_TEST); // mengaktifkan depth buffer
76     glMatrixMode(GL_PROJECTION);
77     glLoadIdentity();
78     gluOrtho((GLfloat)SCREEN_WIDTH/2, (GLfloat)SCREEN_WIDTH/2, (GLfloat)-SCREEN_HEIGHT/2, (GLfloat)SCREEN_HEIGHT/2, 1.0, 100.0);
79     glMatrixMode(GL_MODELVIEW);
80     glLoadIdentity();
81     // inisialisasi kamera pandang
82     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
83     // aktifkan pencahayaan
84     glEnable(GL_LIGHTING);
85     glEnable(GL_COLOR_MATERIAL);
86     glEnable(GL_LIGHT0);
87 }
88
89 // fungsi ini digunakan bila layar akan diresize (default)
90 void reshape(int w, int h)
91 {
92     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
93     glMatrixMode(GL_PROJECTION);
94     glLoadIdentity();
95 }
```

Gambar 5 laprak 5

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 86 Col: 33 Sel: 0 Lines: 187 Length: 6171 Insert Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
88 }
89
90 // fungsi ini digunakan bila layar akan diresize (default)
91 void reshape(int w, int h)
92 {
93     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
94     glMatrixMode(GL_PROJECTION);
95     glLoadIdentity();
96     gluOrtho((GLfloat)-w/2, (GLfloat)w/2, (GLfloat)-h/2, (GLfloat)h/2, 1.0, 100.0);
97     glMatrixMode(GL_MODELVIEW);
98 }
99
100 // fungsi untuk mengatur masukan dari keyboard
101 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
102 void keyboard(int key, int x, int y)
103 {
104     float fraction = 0.1f;
105
106     switch (key)
107     {
108         // masukkan perintah disini bila tombol kiri ditekan
109         case GLUT_KEY_LEFT:
110             // dalam hal ini perintah rotasi objek ke kiri sebanyak 1 derajat
111             objectAngleY -= 1.0f;
112             glutPostRedisplay(); // update objek
113             break;
```

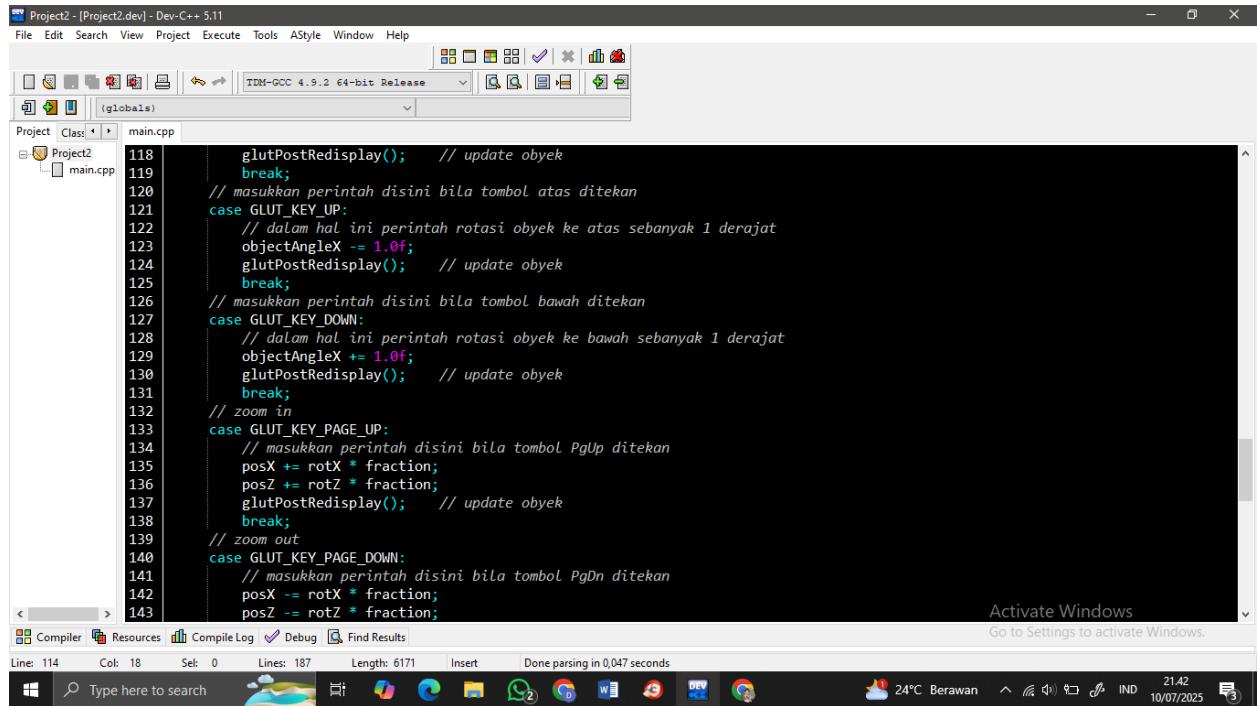
Gambar 6 laprak 5



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 101 Col: 33 Sel: 0 Lines: 187 Length: 6171 Insert Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
100 // fungsi untuk mengatur masukan dari keyboard
101 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
102 void keyboard(int key, int x, int y)
103 {
104     float fraction = 0.1f;
105
106     switch (key)
107     {
108         // masukkan perintah disini bila tombol kiri ditekan
109         case GLUT_KEY_LEFT:
110             // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
111             objectAngleY -= 1.0f;
112             glutPostRedisplay(); // update obyek
113             break;
114         // masukkan perintah disini bila tombol kanan ditekan
115         case GLUT_KEY_RIGHT:
116             // dalam hal ini perintah rotasi obyek ke kanan sebanyak 1 derajat
117             objectAngleY += 1.0f;
118             glutPostRedisplay(); // update obyek
119             break;
120         // masukkan perintah disini bila tombol atas ditekan
121         case GLUT_KEY_UP:
122             // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
123             objectAngleX -= 1.0f;
124             glutPostRedisplay(); // update obyek
125             break;
```

Gambar 7 laprak 5



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 114 Col: 18 Sel: 0 Lines: 187 Length: 6171 Insert Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
118     glutPostRedisplay(); // update obyek
119     break;
120     // masukkan perintah disini bila tombol atas ditekan
121     case GLUT_KEY_UP:
122         // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
123         objectAngleX -= 1.0f;
124         glutPostRedisplay(); // update obyek
125         break;
126     // masukkan perintah disini bila tombol bawah ditekan
127     case GLUT_KEY_DOWN:
128         // dalam hal ini perintah rotasi obyek ke bawah sebanyak 1 derajat
129         objectAngleX += 1.0f;
130         glutPostRedisplay(); // update obyek
131         break;
132     // zoom in
133     case GLUT_KEY_PAGE_UP:
134         // masukkan perintah disini bila tombol PgUp ditekan
135         posX += rotX * fraction;
136         posZ += rotZ * fraction;
137         glutPostRedisplay(); // update obyek
138         break;
139     // zoom out
140     case GLUT_KEY_PAGE_DOWN:
141         // masukkan perintah disini bila tombol PgDn ditekan
142         posX -= rotX * fraction;
143         posZ -= rotZ * fraction;
```

Gambar 8 laprak 5

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 131 Col: 15 Sel: 0 Lines: 187 Length: 6171 Insert Done parsing in 0,047 seconds". The code editor displays main.cpp with the following content:

```
136     posZ += rotZ * fraction;
137     glutPostRedisplay(); // update obyek
138     break;
139     // zoom out
140     case GLUT_KEY_PAGE_DOWN:
141         // masukkan perintah disini bila tombol PgDn ditekan
142         posX -= rotX * fraction;
143         posZ -= rotZ * fraction;
144         glutPostRedisplay(); // update obyek
145         break;
146     }
147 }
148 // timer untuk animasi (gunakan bila perlu)
149 void timer(int value)
150 {
151     glutPostRedisplay();
152     glutTimerFunc(55, timer, 0);
153 }
154 // program utama
155 int main(int argc, char** argv)
156 {
157     // inisialisasi jendela OpenGL
158     // GLUT_SINGLE berarti memakai single buffer
159     // GLUT_DOUBLE berarti memakai double buffer
160 }
```

The status bar also shows system information: "Activate Windows Go to Settings to activate Windows.", "24°C Berawan", "21.42 10/07/2025", and a battery icon.

Gambar 9 laprak 5

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 154 Col: 2 Sel: 0 Lines: 187 Length: 6171 Insert Done parsing in 0,047 seconds". The code editor displays main.cpp with the following content:

```
154 L
155
156 // program utama
157 int main(int argc, char** argv)
158 {
159     // inisialisasi jendela OpenGL
160     // GLUT_SINGLE berarti memakai single buffer
161     // GLUT_DOUBLE berarti memakai double buffer
162     // GLUT_RGB berarti mode tampilan yang dipakai RGB
163     // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
164     // GLUT_DEPTH berarti memakai depth buffer
165     glutInit(&argc, argv);
166     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGBA | GLUT_DEPTH);
167
168     // set ukuran jendela tampilan
169     glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
170     glutInitWindowPosition(100, 100); // posisi jendela di layar komputer dalam piksel
171     // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
172     glutCreateWindow("Dyah / 154 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");
173
174     // panggil fungsi init untuk inisialisasi awal
175     init();
176
177     // event handler untuk display, reshape dan keyboard
178     glutDisplayFunc(display); // display
179     glutReshapeFunc(reshape); // reshape
```

The status bar also shows system information: "Activate Windows Go to Settings to activate Windows.", "24°C Berawan", "21.42 10/07/2025", and a battery icon.

Gambar 10 laprak 5

The screenshot shows the Dev-C++ IDE interface. The main window displays a C++ source code file named 'main.cpp' with line numbers 162 to 187. The code initializes an OpenGL window with a size of 480x480 pixels at position (100, 100), titled 'Dyah / 154 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER'. It includes event handlers for display, reshape, and keyboard events, and activates a timer. The status bar at the bottom shows the code has been parsed in 0.047 seconds.

```
// GLUT_RGB berarti mode tampilan yang dipakai RGB
// GLUT_RGBA berarti mode tampilan yang dipakai RGBA
// GLUT_DEPTH berarti memakai depth buffer
glutInit(&argc, argv);
glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGBA | GLUT_DEPTH);

// set ukuran jendela tampilan
glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
glutInitWindowPosition(100, 100); // posisi jendela dilayar komputer dalam piksel
// judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
glutCreateWindow("Dyah / 154 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");

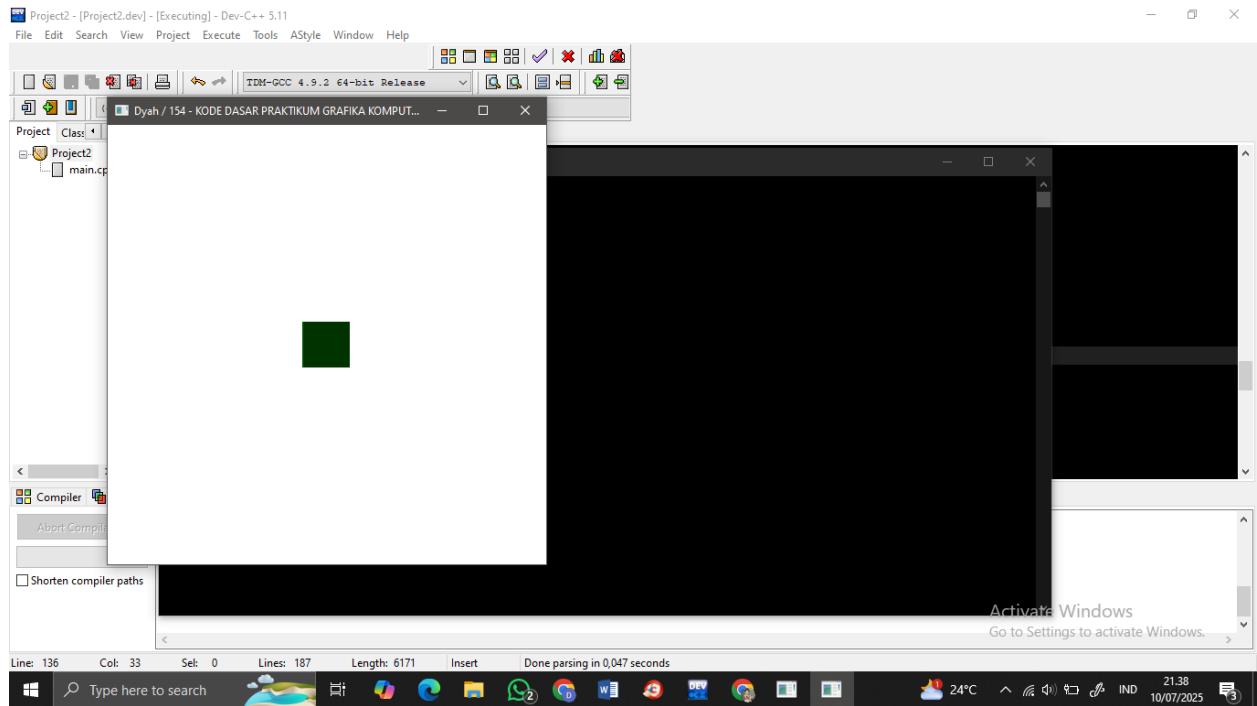
// panggil fungsi init untuk inisialisasi awal
init();

// event handler untuk display, reshape dan keyboard
glutDisplayFunc(display); // display
glutReshapeFunc(reshape); // reshape
glutSpecialFunc(keyboard); // keyboard
//glutTimerFunc(0, timer, 0); // aktifkan timer bila perlu

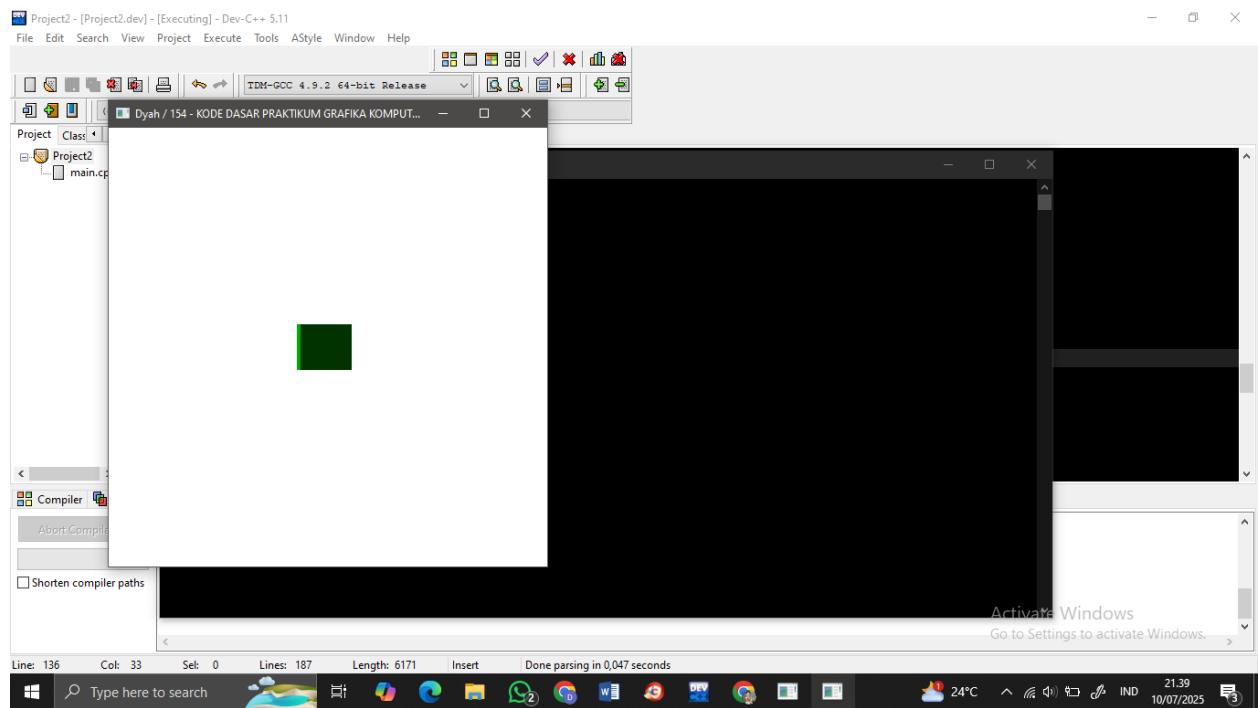
// Looping
glutMainLoop();

return 0;
}
```

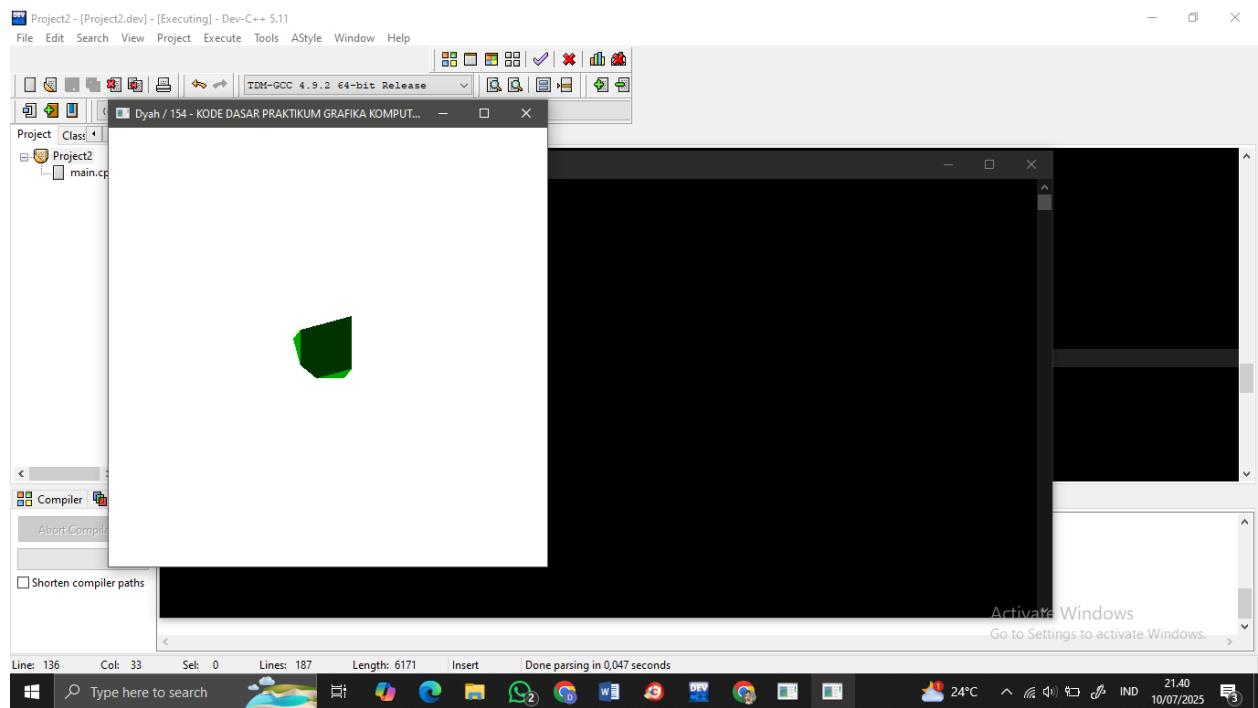
Output 1 laprak 5



Output 2 laprak 5

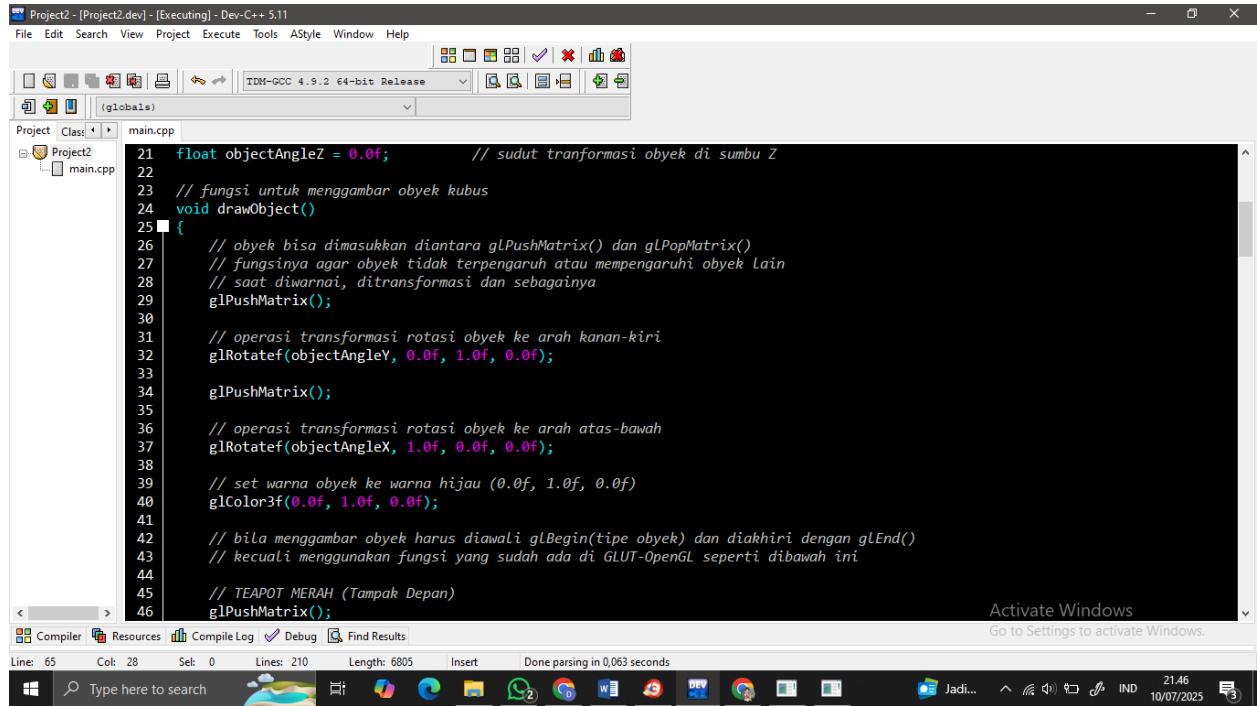


Output 3 laprak 5



Posttest 5

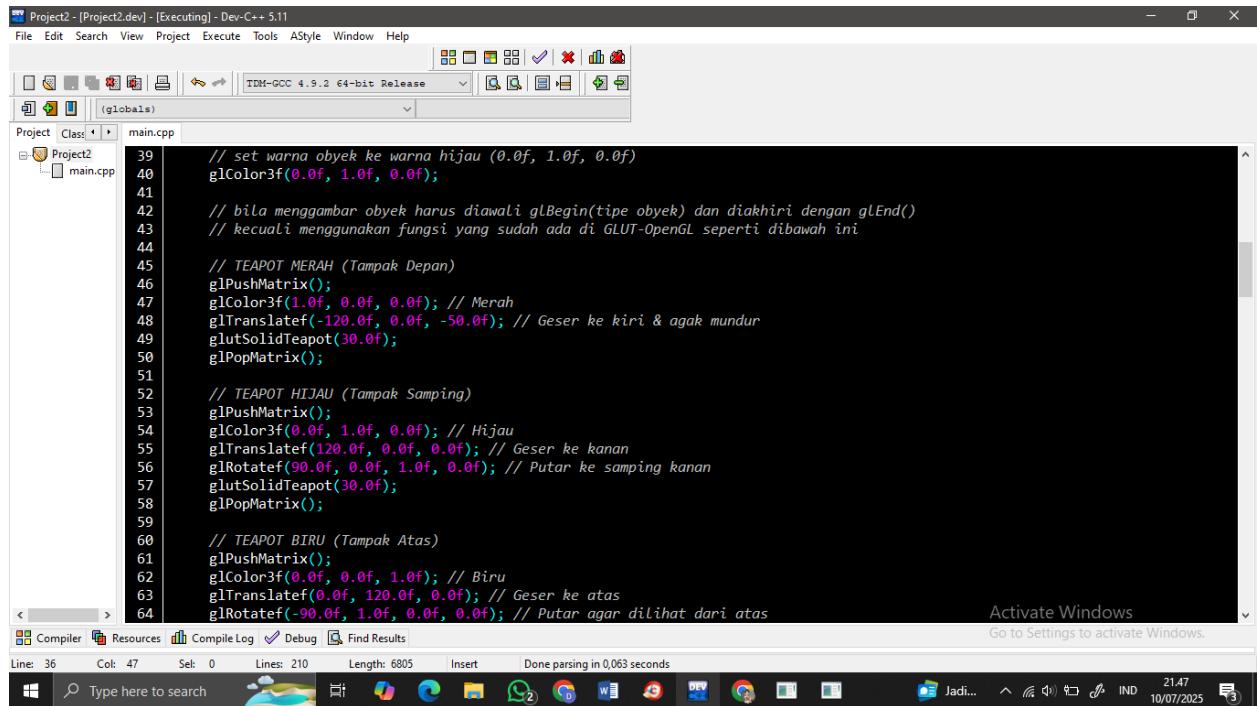
Gambar 5 posttest 5



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has icons for project management, file operations, and compilation. The status bar at the bottom shows "Line: 65 Col: 28 Sel: 0 Lines: 210 Length: 6805 Insert Done parsing in 0,063 seconds". The code editor displays main.cpp:

```
21 float objectAngleZ = 0.0f; // sudut transformasi obyek di sumbu Z
22
23 // fungsi untuk menggambar obyek kubus
24 void drawObject()
25 {
26     // obyek bisa dimasukkan diantara glPushMatrix() dan glPopMatrix()
27     // fungsinya agar obyek tidak terpengaruh atau mempengaruhi obyek lain
28     // saat diwarnai, ditransformasi dan sebagainya
29     glPushMatrix();
30
31     // operasi transformasi rotasi obyek ke arah kanan-kiri
32     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
33
34     glPushMatrix();
35
36     // operasi transformasi rotasi obyek ke arah atas-bawah
37     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
38
39     // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
40     glColor3f(0.0f, 1.0f, 0.0f);
41
42     // bila menggambar obyek harus diawali glBegin(tipe obyek) dan diakhiri dengan glEnd()
43     // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
44
45     // TEAPOT MERAH (Tampak Depan)
46     glPushMatrix();
```

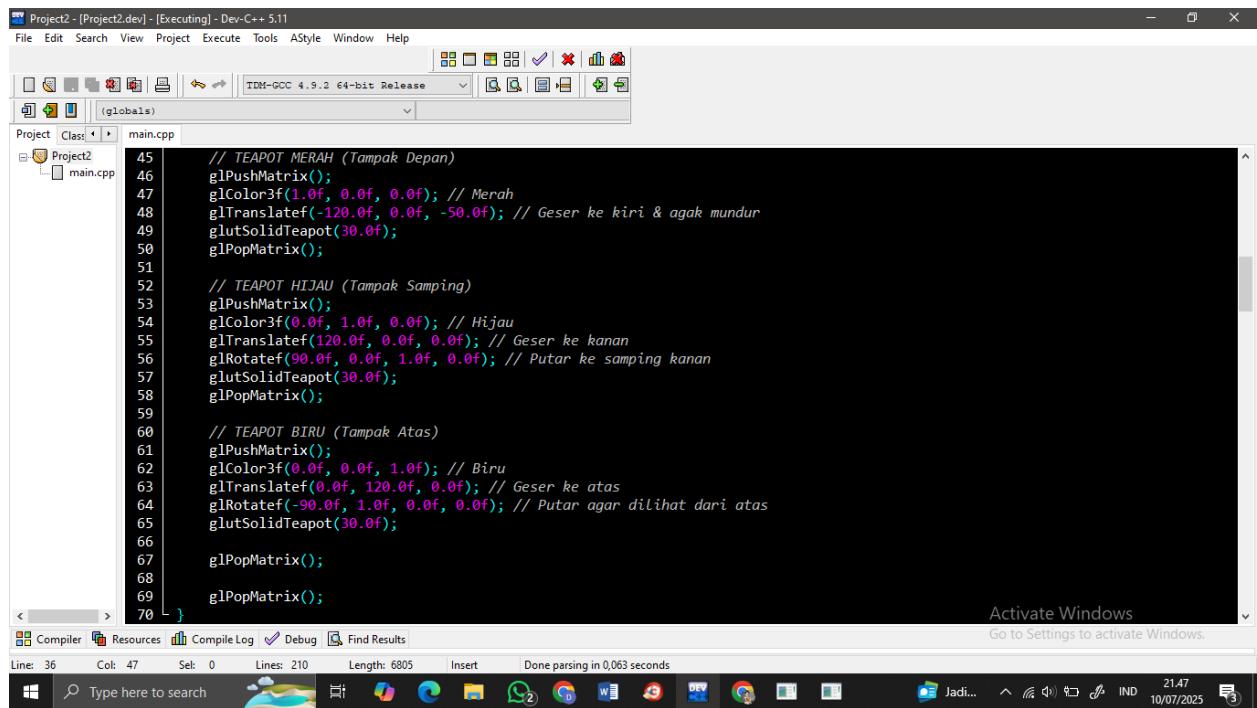
Gambar 2 posttest 5



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has icons for project management, file operations, and compilation. The status bar at the bottom shows "Line: 36 Col: 47 Sel: 0 Lines: 210 Length: 6805 Insert Done parsing in 0,063 seconds". The code editor displays main.cpp:

```
39     // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
40     glColor3f(0.0f, 1.0f, 0.0f);
41
42     // bila menggambar obyek harus diawali glBegin(tipe obyek) dan diakhiri dengan glEnd()
43     // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
44
45     // TEAPOT MERAH (Tampak Depan)
46     glPushMatrix();
47     glColor3f(1.0f, 0.0f, 0.0f); // Merah
48     glTranslatef(-120.0f, 0.0f, -50.0f); // Geser ke kiri & agak mundur
49     glutSolidTeapot(30.0f);
50     glPopMatrix();
51
52     // TEAPOT HIJAU (Tampak Samping)
53     glPushMatrix();
54     glColor3f(0.0f, 1.0f, 0.0f); // Hijau
55     glTranslatef(120.0f, 0.0f, 0.0f); // Geser ke kanan
56     glRotatef(90.0f, 0.0f, 1.0f, 0.0f); // Putar ke samping kanan
57     glutSolidTeapot(30.0f);
58     glPopMatrix();
59
60     // TEAPOT BIRU (Tampak Atas)
61     glPushMatrix();
62     glColor3f(0.0f, 0.0f, 1.0f); // Biru
63     glTranslatef(0.0f, 120.0f, 0.0f); // Geser ke atas
64     glRotatef(-90.0f, 1.0f, 0.0f, 0.0f); // Putar agar dilihat dari atas
```

Gambar 3 postest 5

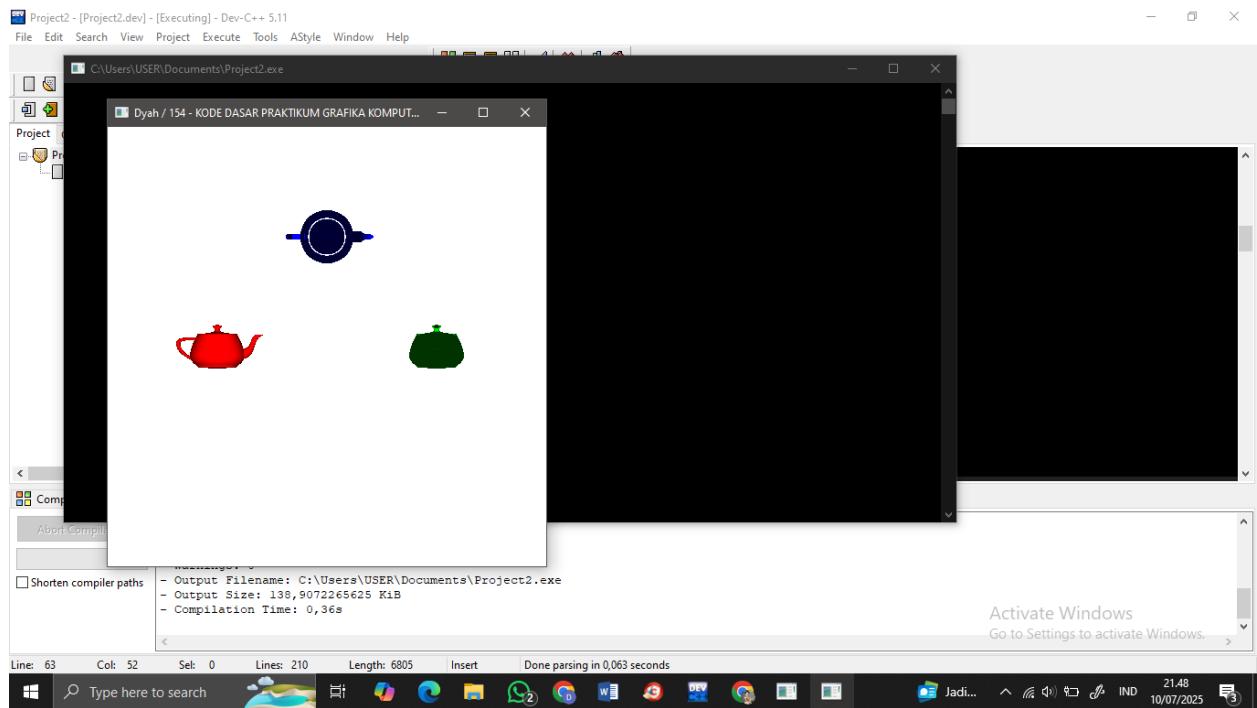


The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - [Executing] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 36 Col: 47 Sel: 0 Lines: 210 Length: 6805 Insert Done parsing in 0,063 seconds". The code editor displays main.cpp with the following content:

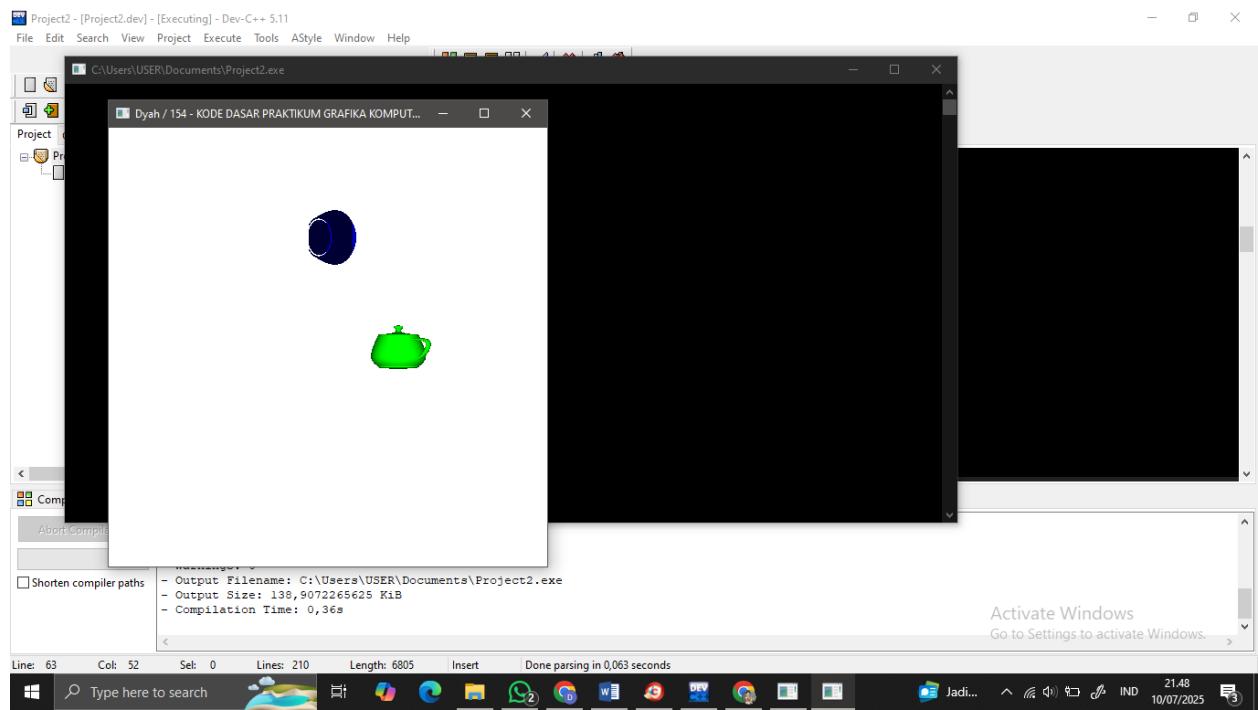
```
45 // TEAPOT MERAH (Tampak Depan)
46 glPushMatrix();
47 glColor3f(1.0f, 0.0f, 0.0f); // Merah
48 glTranslatef(-120.0f, 0.0f, -50.0f); // Geser ke kiri & agak mundur
49 glutSolidTeapot(30.0f);
50 glPopMatrix();
51
52 // TEAPOT HIJAU (Tampak Samping)
53 glPushMatrix();
54 glColor3f(0.0f, 1.0f, 0.0f); // Hijau
55 glTranslatef(120.0f, 0.0f, 0.0f); // Geser ke kanan
56 glRotatef(90.0f, 0.0f, 1.0f, 0.0f); // Putar ke samping kanan
57 glutSolidTeapot(30.0f);
58 glPopMatrix();
59
60 // TEAPOT BIRU (Tampak Atas)
61 glPushMatrix();
62 glColor3f(0.0f, 0.0f, 1.0f); // Biru
63 glTranslatef(0.0f, 120.0f, 0.0f); // Geser ke atas
64 glRotatef(-90.0f, 1.0f, 0.0f, 0.0f); // Putar agar dilihat dari atas
65 glutSolidTeapot(30.0f);
66
67 glPopMatrix();
68
69 glPopMatrix();
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray with icons for battery, signal, and date/time.

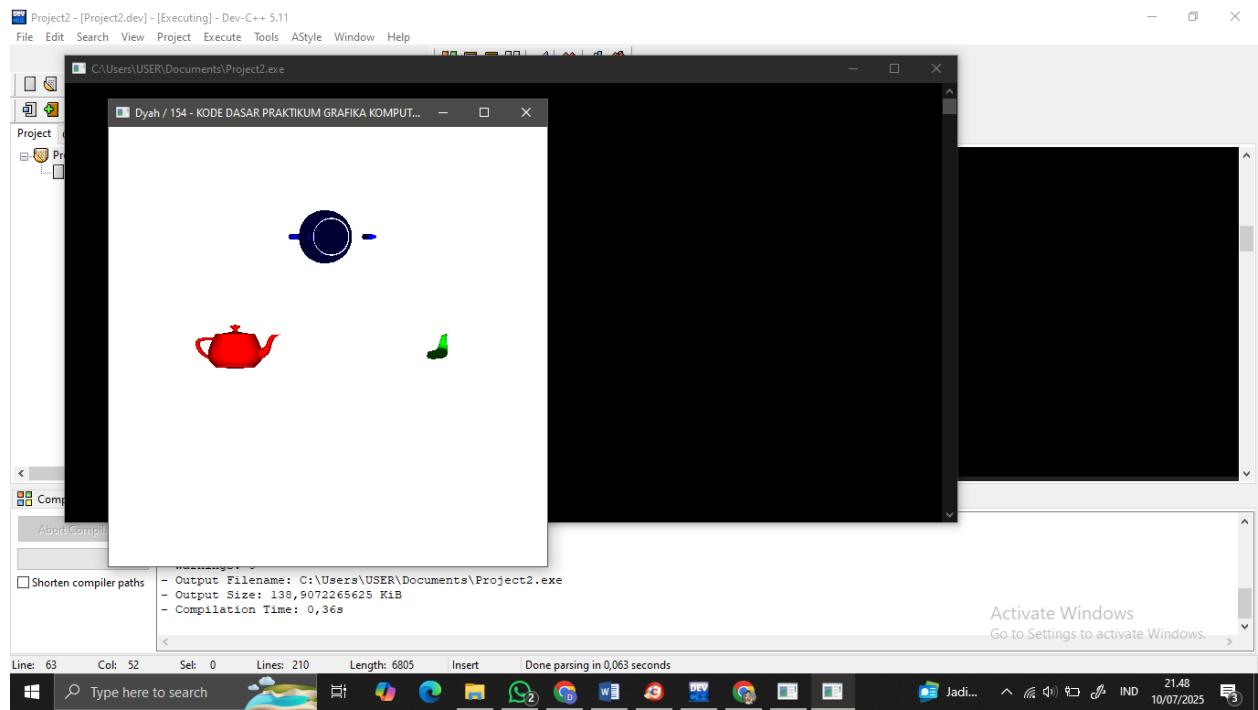
Output 1 postest 5



Output 2 postest 5



Output 3 postest 5



BAB VI. REPRESENTASI OBYEK 3D

Pretest 6

Pertanyaan:

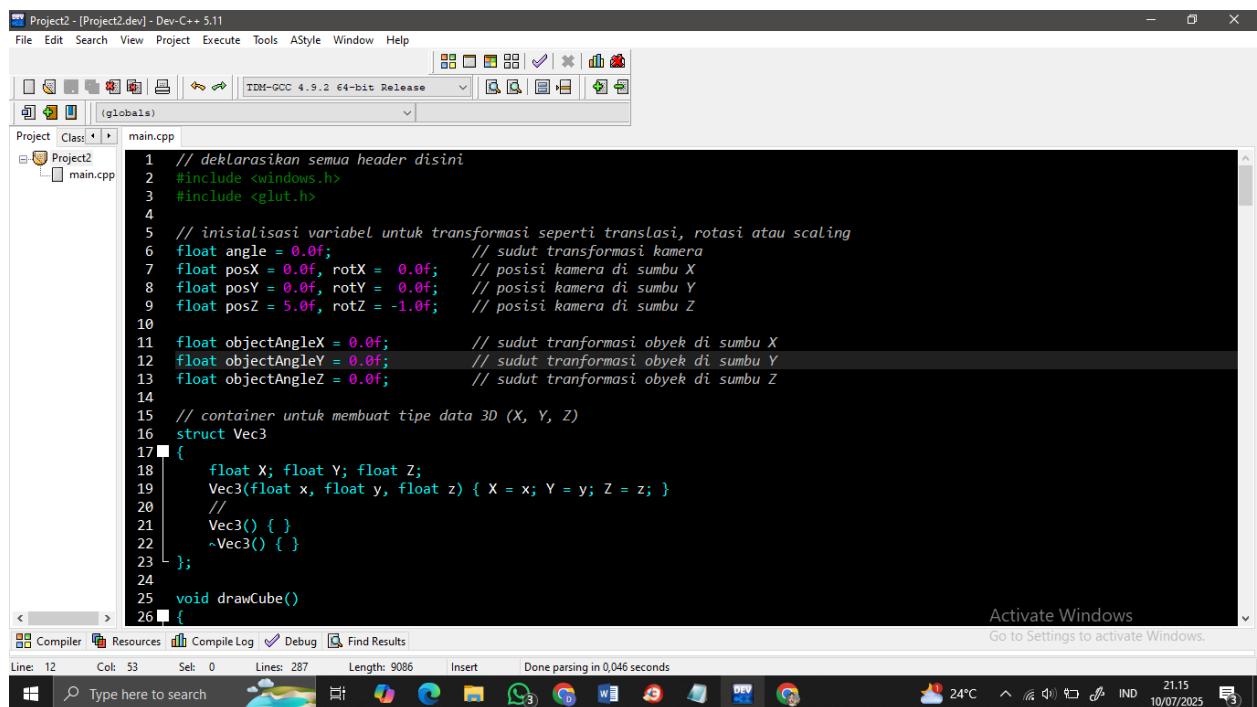
1. Sebutkan metode representasi objek 3D yang anda ketahui
2. Jelaskan setiap metode representasi objek 3D yang anda sebutkan di soal nomor 1

Jawaban:

1. Wireframe, sweep, boundry, spatial, dan contractive solid geometry
2. Wireframe adalah hanya garis/titik bentuk rangka, sweep adalah membentuk objek 3D dengan menggerakkan bentuk 2D di sepanjang jalur, boundry adalah merepresentasikan bentuk padar dengan batas permukaannya, spatial adalah membagi ruang 3D menjadi bagian untuk mendeskripsikan lokasi objek, dan contractive solid geometry adalah membangun bentuk kompleks dengan menggabungkan bentuk primitif

Langkah Praktikum 6

Gambar 1 laprak 6



The screenshot shows the Dev-C++ IDE interface with the following details:

- Title Bar:** Project2 - [Project2.dev] - Dev-C++ 5.11
- Menu Bar:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help
- Toolbar:** Standard Dev-C++ toolbar with icons for file operations.
- Toolbox:** Standard Dev-C++ toolbox with icons for project, class, file, and resource management.
- Project Explorer:** Shows a project named "Project2" containing a file "main.cpp".
- Code Editor:** Displays the following C++ code:

```
1 // deklarasikan semua header disini
2 #include <windows.h>
3 #include <glut.h>
4
5 // inisialisasi variabel untuk transformasi seperti translasi, rotasi atau scaling
6 float angle = 0.0f; // sudut transformasi kamera
7 float posX = 0.0f, rotX = 0.0f; // posisi kamera di sumbu X
8 float posY = 0.0f, rotY = 0.0f; // posisi kamera di sumbu Y
9 float posZ = 5.0f, rotZ = -1.0f; // posisi kamera di sumbu Z
10
11 float objectAngleX = 0.0f; // sudut transformasi objek di sumbu X
12 float objectAngleY = 0.0f; // sudut transformasi objek di sumbu Y
13 float objectAngleZ = 0.0f; // sudut transformasi objek di sumbu Z
14
15 // container untuk membuat tipe data 3D (X, Y, Z)
16 struct Vec3
17 {
18     float X; float Y; float Z;
19     Vec3(float x, float y, float z) { X = x; Y = y; Z = z; }
20     //
21     Vec3() { }
22     ~Vec3() { }
23 };
24
25 void drawCube()
26 {
```

The code defines a `Vec3` struct and a `drawCube()` function.

Status Bar: Line: 12, Col: 53, Sel: 0, Lines: 287, Length: 9086, Insert, Done parsing in 0,046 seconds.

Taskbar: Shows the Windows Start button, a search bar, and various pinned application icons (File Explorer, Edge, Google Chrome, Word, Excel, Dev-C++, etc.). It also displays system status: 24°C, 21.15, 10/07/2025.

Gambar 2 laprak 6

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 17 Col: 2 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor window displays the following C++ code:

```
25 void drawCube()
26 {
27     glBegin(GL_QUADS);
28     // beri warna merah di sisi depan
29     glColor3f(1.0f, 0.0f, 0.0f);
30     // buat sisi depan
31     glVertex3f( -1.0f, -1.0f, 1.0f);
32     glVertex3f( 1.0f, -1.0f, 1.0f);
33     glVertex3f( 1.0f, 1.0f, 1.0f);
34     glVertex3f( -1.0f, 1.0f, 1.0f);
35     // beri warna hijau di sisi belakang
36     glColor3f(0.0f, 1.0f, 0.0f);
37     // buat sisi belakang
38     glVertex3f( -1.0f, -1.0f, -1.0f);
39     glVertex3f( 1.0f, -1.0f, -1.0f);
40     glVertex3f( 1.0f, 1.0f, -1.0f);
41     glVertex3f( -1.0f, 1.0f, -1.0f);
42     // beri warna biru di sisi kiri
43     glColor3f(0.0f, 0.0f, 1.0f);
44     // buat sisi kiri
45     glVertex3f( -1.0f, -1.0f, 1.0f);
46     glVertex3f( -1.0f, -1.0f, -1.0f);
47     glVertex3f( -1.0f, 1.0f, -1.0f);
48     glVertex3f( -1.0f, 1.0f, 1.0f);
49     // beri warna cyan di sisi kanan
50     glColor3f(0.0f, 1.0f, 1.0f);
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 21.16 10/07/2025.

Gambar 3 laprak 6

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 39 Col: 36 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor window displays the following C++ code:

```
46     glVertex3f(-1.0f, -1.0f, -1.0f);
47     glVertex3f(-1.0f, 1.0f, -1.0f);
48     glVertex3f(-1.0f, 1.0f, 1.0f);
49     // beri warna cyan di sisi kanan
50     glColor3f(0.0f, 1.0f, 1.0f);
51     // buat sisi kanan
52     glVertex3f( 1.0f, -1.0f, 1.0f);
53     glVertex3f( 1.0f, -1.0f, -1.0f);
54     glVertex3f( 1.0f, 1.0f, -1.0f);
55     glVertex3f( 1.0f, 1.0f, 1.0f);
56     // beri warna kuning di sisi atas
57     glColor3f(1.0f, 1.0f, 0.0f);
58     // buat sisi atas
59     glVertex3f(-1.0f, 1.0f, 1.0f);
60     glVertex3f( 1.0f, 1.0f, 1.0f);
61     glVertex3f( 1.0f, 1.0f, -1.0f);
62     glVertex3f(-1.0f, 1.0f, -1.0f);
63     // beri warna magenta di sisi bawah
64     glColor3f(1.0f, 0.0f, 1.0f);
65     // buat sisi bawah
66     glVertex3f(-1.0f, -1.0f, 1.0f);
67     glVertex3f( 1.0f, -1.0f, 1.0f);
68     glVertex3f( 1.0f, -1.0f, -1.0f);
69     glVertex3f(-1.0f, -1.0f, -1.0f);
70     glEnd();
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 24°C 21.16 10/07/2025.

Gambar 4 laprak 6

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 62 Col: 29 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor window displays the following C++ code:

```
70     glEnd();
71 }
72
73 // fungsi untuk menggambar silinder
74 void drawCylinder(float radius, float height, int slices, int stacks)
75 {
76     glPushMatrix();
77     GLUquadricObj* cyl = gluNewQuadric();
78     gluQuadricDrawStyle(cyl, GLU_FILL);
79     gluQuadricNormals(cyl, GLU_SMOOTH);
80     gluQuadricOrientation(cyl, GLU_INSIDE);
81     // buat tutup atas silinder
82     glTranslatef(0.0f, -height/2, 0.0f);
83     glRotatef(-90, 1.0f, 0.0f, 0.0f);
84     glColor3f(1.0f, 1.0f, 0.0f); // warna kuning
85     gluDisk(cyl, 0.0f, radius, slices, stacks);
86     // buat badan silinder
87     glColor3f(1.0f, 0.0f, 0.0f); // warna merah
88     gluCylinder(cyl, radius, radius, height, slices, stacks);
89     // buat tutup bawah silinder
90     glColor3f(1.0f, 1.0f, 0.0f); // warna kuning
91     glTranslatef(0.0f, 0.0f, height);
92     gluDisk(cyl, 0.0f, radius, slices, stacks);
93     glPopMatrix();
94 }
95 
```

Gambar 5 laprak 6

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 87 Col: 41 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor window displays the following C++ code:

```
91     glTranslatef(0.0f, 0.0f, height);
92     gluDisk(cyl, 0.0f, radius, slices, stacks);
93     glPopMatrix();
94 }
95
96 // fungsi untuk menggambar bola
97 void drawSphere(float radius, int slices, int stacks)
98 {
99     glPushMatrix();
100    glColor3f(1.0f, 0.0f, 0.0f); // warna merah
101    GLUquadric *sphere = gluNewQuadric();
102    gluQuadricDrawStyle(sphere, GLU_FILL);
103    gluQuadricNormals(sphere, GLU_SMOOTH);
104    gluSphere(sphere, radius, slices, stacks);
105    glPopMatrix();
106 }
107
108 // fungsi untuk menggambar objek
109 void drawObject()
110 {
111     // objek bisa dimasukkan diantara glPushMatrix() dan glPopMatrix()
112     // fungsinya agar objek tidak terpengaruh atau mempengaruhi objek lain
113     // saat diwarnai, ditransformasi dan sebagainya
114     glPushMatrix();
115
116     // operasi transformasi rotasi objek ke arah kanan-kiri
117
118     glPopMatrix();
119 }
```

Gambar 6 laprak 6

The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 107 Col: 1 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The main window displays the code for "main.cpp" under the "Project2" project. The code is as follows:

```
106 L }
107 |
108 // fungsi untuk menggambar obyek
109 void drawObject()
110 {
111     // obyek bisa dimasukkan diantara glPushMatrix() dan glPopMatrix()
112     // fungsinya agar obyek tidak terpengaruh atau mempengaruhi obyek lain
113     // saat diwarnai, ditransformasi dan sebagainya
114     glPushMatrix();
115
116     // operasi transformasi rotasi obyek ke arah kanan-kiri
117     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
118
119     glPushMatrix();
120
121     // operasi transformasi rotasi obyek ke arah atas-bawah
122     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
123
124     // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
125     glColor3f(0.0f, 1.0f, 0.0f);
126
127     // bila menggambar obyek harus diawali glBegin(tipe obyek) dan diakhiri dengan glEnd()
128     // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
129     //glutSolidCube(1.0f); // menggambar obyek kubus
130     //glutWireTeapot(1.0f);
131     //drawCube(); // panggil fungsi untuk membuat obyek kubus
132
133     // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
134     glColor3f(0.0f, 1.0f, 0.0f);
135
136     // bila menggambar obyek harus diawali glBegin(tipe obyek) dan diakhiri dengan glEnd()
137     // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
138     //glutSolidCube(1.0f); // menggambar obyek kubus
139     //glutWireTeapot(1.0f);
140     //drawCube(); // panggil fungsi untuk membuat obyek kubus
141     //drawCylinder(1.0f, 2.0f, 20, 20); // fungsi untuk membuat obyek silinder
142     drawSphere(1.0f, 50, 50); // fungsi untuk membuat obyek bola
143
144     glPopMatrix();
145
146     // membuat obyek polyhedron
147     //glutSolidTetrahedron();
148     //glutSolidOctahedron();
149 }
```

The status bar at the bottom right shows "Activate Windows Go to Settings to activate Windows.", the date "10/07/2025", and the time "21.17".

Gambar 7 laprak 6

The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 117 Col: 27 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The main window displays the code for "main.cpp" under the "Project2" project. The code is as follows:

```
124 // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
125 glColor3f(0.0f, 1.0f, 0.0f);
126
127 // bila menggambar obyek harus diawali glBegin(tipe obyek) dan diakhiri dengan glEnd()
128 // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
129 //glutSolidCube(1.0f); // menggambar obyek kubus
130 //glutWireTeapot(1.0f);
131 //drawCube(); // panggil fungsi untuk membuat obyek kubus
132 //drawCylinder(1.0f, 2.0f, 20, 20); // fungsi untuk membuat obyek silinder
133 drawSphere(1.0f, 50, 50); // fungsi untuk membuat obyek bola
134
135 glPopMatrix();
136
137 glPopMatrix();
138
139 // membuat obyek polyhedron
140 //glutSolidTetrahedron();
141 //glutSolidOctahedron();
142 //glutSolidDodecahedron();
143 //glutSolidIcosahedron();
144 //glutSolidCube(1.0f);
145 //glutSolidCone(1.0f, 1.0f, 50, 50);
146 //glutSolidSphere(1.0f, 50, 50);
147 //glutSolidTeapot(1.0f);
148 //glutSolidTorus(0.5f, 1.0f, 20, 20);
149 }
```

The status bar at the bottom right shows "Activate Windows Go to Settings to activate Windows.", the date "10/07/2025", and the time "21.17".

Gambar 8 laprak 6

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 117 Col: 27 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor displays main.cpp with the following content:

```
148     //glutSolidTorus(0.5f, 1.0f, 20, 20);
149 }
150
151 // taruh semua obyek yang akan digambar di fungsi display()
152 void display()
153 {
154     // bersihkan dan reset layar dan buffer
155     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
156     glLoadIdentity();
157
158     // posisikan kamera pandang
159     // dalam hal ini sumbu Y ada diatas dan posisi kamera pandang di (posX, posY, posZ)
160     gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
161
162     // panggil fungsi untuk menggambar objek
163     drawObject();
164
165     // tampilkan objek ke layar
166     // gunakan glFlush() bila memakai single buffer
167     // gunakan glutSwapBuffers() bila memakai double buffer
168     glutSwapBuffers();
169 }
170
171 // inisialisasi variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
172 void init(void)
173 {
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 21.18 10/07/2025.

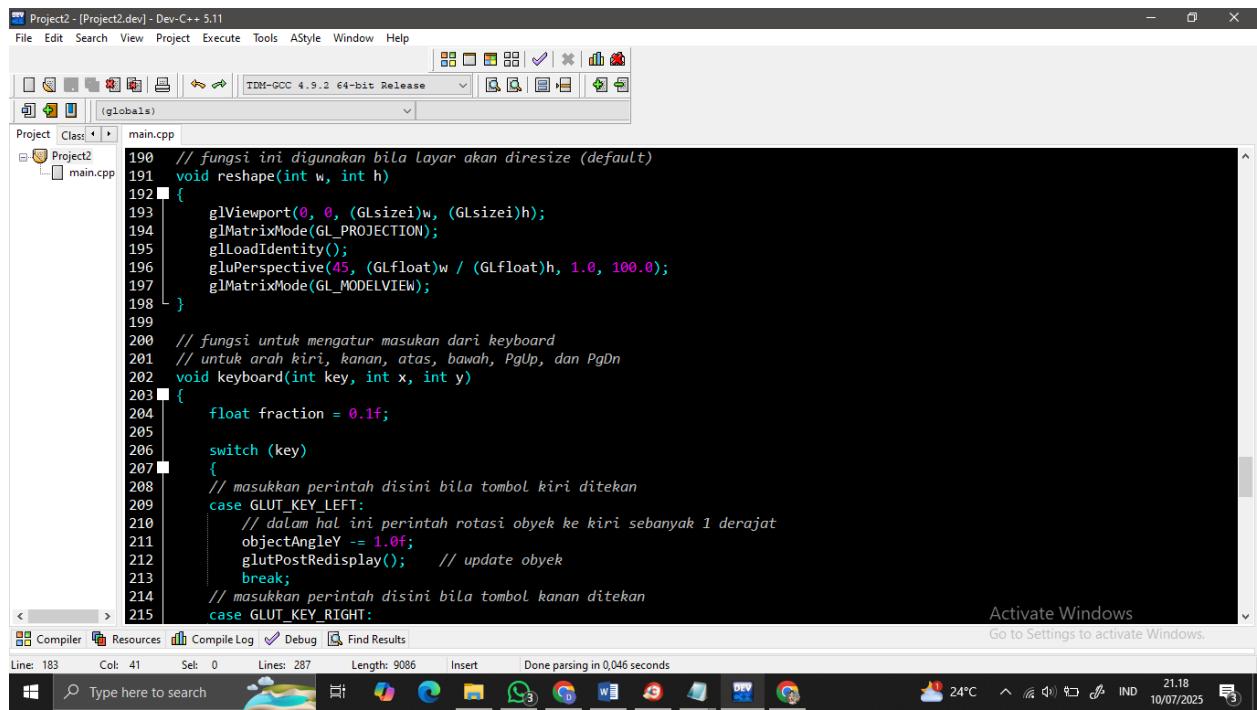
Gambar 9 laprak 6

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 164 Col: 5 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor displays main.cpp with the following content:

```
166     // gunakan glFlush() bila memakai single buffer
167     // gunakan glutSwapBuffers() bila memakai double buffer
168     glutSwapBuffers();
169 }
170
171 // inisialisasi variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
172 void init(void)
173 {
174     // inisialisasi warna latar belakang layar dalam hal ini warna putih (1.0, 1.0, 1.0, 0.0)
175     glColorColor(1.0, 1.0, 1.0, 0.0);
176     glEnable(GL_DEPTH_TEST);           // mengaktifkan depth buffer
177     glMatrixMode(GL_PROJECTION);
178     glLoadIdentity();
179     gluPerspective(45.0, 1.0, 1.0, 100.0); // set proyeksi ke perspektif
180     glMatrixMode(GL_MODELVIEW);
181     glLoadIdentity();
182     // inisialisasi kamera pandang
183     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0, 0.0);
184
185     glEnable(GL_COLOR_MATERIAL);
186     glEnable(GL_LIGHTING);
187     glEnable(GL_LIGHT0);
188 }
189
190 // fungsi ini digunakan bila layar akan diresize (default)
191 void reshape(int w, int h)
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 24°C 21.18 10/07/2025.

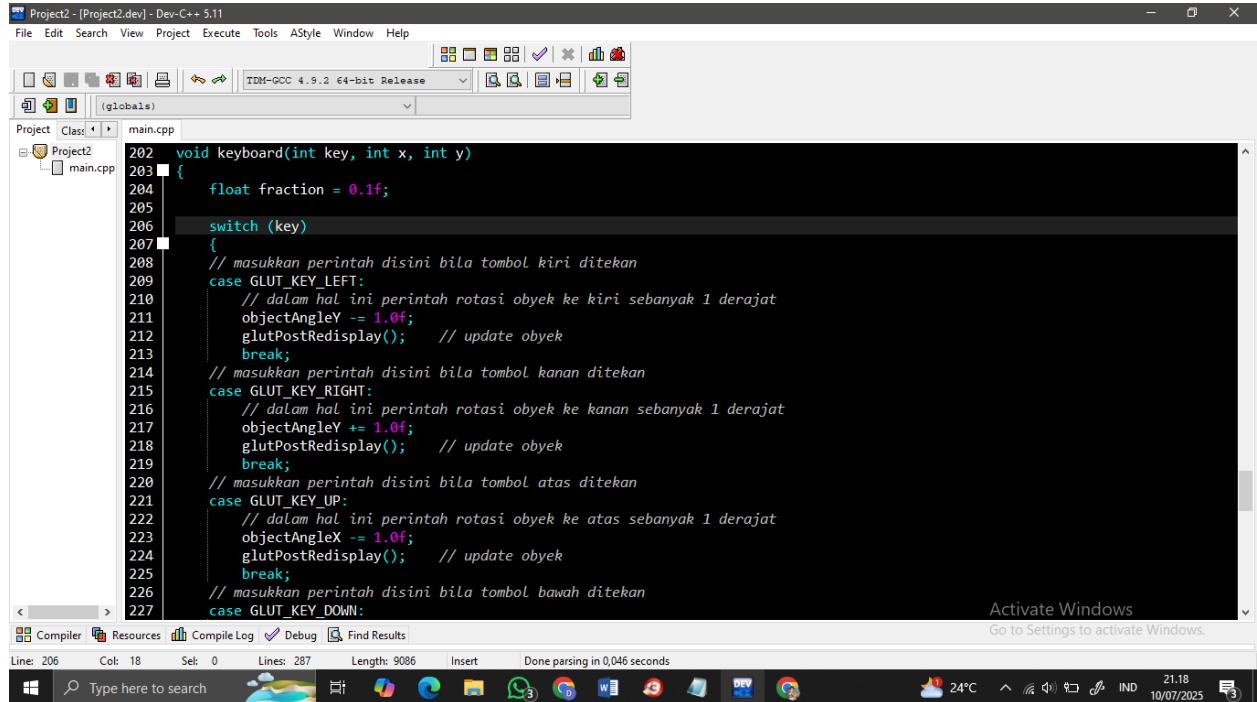
Gambar 10 laprak 6



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 183 Col: 41 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor displays main.cpp with the following content:

```
190 // fungsi ini digunakan bila layar akan diresize (default)
191 void reshape(int w, int h)
192 {
193     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
194     glMatrixMode(GL_PROJECTION);
195     glLoadIdentity();
196     gluPerspective(45, (GLfloat)w / (GLfloat)h, 1.0, 100.0);
197     glMatrixMode(GL_MODELVIEW);
198 }
199
200 // fungsi untuk mengatur masukan dari keyboard
201 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
202 void keyboard(int key, int x, int y)
203 {
204     float fraction = 0.1f;
205
206     switch (key)
207     {
208         // masukkan perintah disini bila tombol kiri ditekan
209         case GLUT_KEY_LEFT:
210             // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
211             objectAngleY -= 1.0f;
212             glutPostRedisplay(); // update obyek
213             break;
214         // masukkan perintah disini bila tombol kanan ditekan
215         case GLUT_KEY_RIGHT:
216             // dalam hal ini perintah rotasi obyek ke kanan sebanyak 1 derajat
217             objectAngleY += 1.0f;
218             glutPostRedisplay(); // update obyek
219             break;
220         // masukkan perintah disini bila tombol atas ditekan
221         case GLUT_KEY_UP:
222             // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
223             objectAngleX -= 1.0f;
224             glutPostRedisplay(); // update obyek
225             break;
226         // masukkan perintah disini bila tombol bawah ditekan
227         case GLUT_KEY_DOWN:
```

Gambar 11 laprak 6



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 206 Col: 18 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor displays main.cpp with the following content:

```
202 void keyboard(int key, int x, int y)
203 {
204     float fraction = 0.1f;
205
206     switch (key)
207     {
208         // masukkan perintah disini bila tombol kiri ditekan
209         case GLUT_KEY_LEFT:
210             // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
211             objectAngleY -= 1.0f;
212             glutPostRedisplay(); // update obyek
213             break;
214         // masukkan perintah disini bila tombol kanan ditekan
215         case GLUT_KEY_RIGHT:
216             // dalam hal ini perintah rotasi obyek ke kanan sebanyak 1 derajat
217             objectAngleY += 1.0f;
218             glutPostRedisplay(); // update obyek
219             break;
220         // masukkan perintah disini bila tombol atas ditekan
221         case GLUT_KEY_UP:
222             // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
223             objectAngleX -= 1.0f;
224             glutPostRedisplay(); // update obyek
225             break;
226         // masukkan perintah disini bila tombol bawah ditekan
227         case GLUT_KEY_DOWN:
```

Gambar 12 laprak 6

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 212 Col: 23 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor window displays main.cpp with the following code:

```
220 // masukkan perintah disini bila tombol atas ditekan
221 case GLUT_KEY_UP:
222     // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
223     objectAngleX -= 1.0f;
224     glutPostRedisplay(); // update obyek
225     break;
226 // masukkan perintah disini bila tombol bawah ditekan
227 case GLUT_KEY_DOWN:
228     // dalam hal ini perintah rotasi obyek ke bawah sebanyak 1 derajat
229     objectAngleX += 1.0f;
230     glutPostRedisplay(); // update obyek
231     break;
232 // zoom in
233 case GLUT_KEY_PAGE_UP:
234     // masukkan perintah disini bila tombol PgUp ditekan
235     posX += rotX * fraction;
236     posY += rotZ * fraction;
237     glutPostRedisplay(); // update obyek
238     break;
239 // zoom out
240 case GLUT_KEY_PAGE_DOWN:
241     // masukkan perintah disini bila tombol PgDn ditekan
242     posX -= rotX * fraction;
243     posY -= rotZ * fraction;
244     glutPostRedisplay(); // update obyek
245     break;
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 24°C, 21.19, and the date is 10/07/2025.

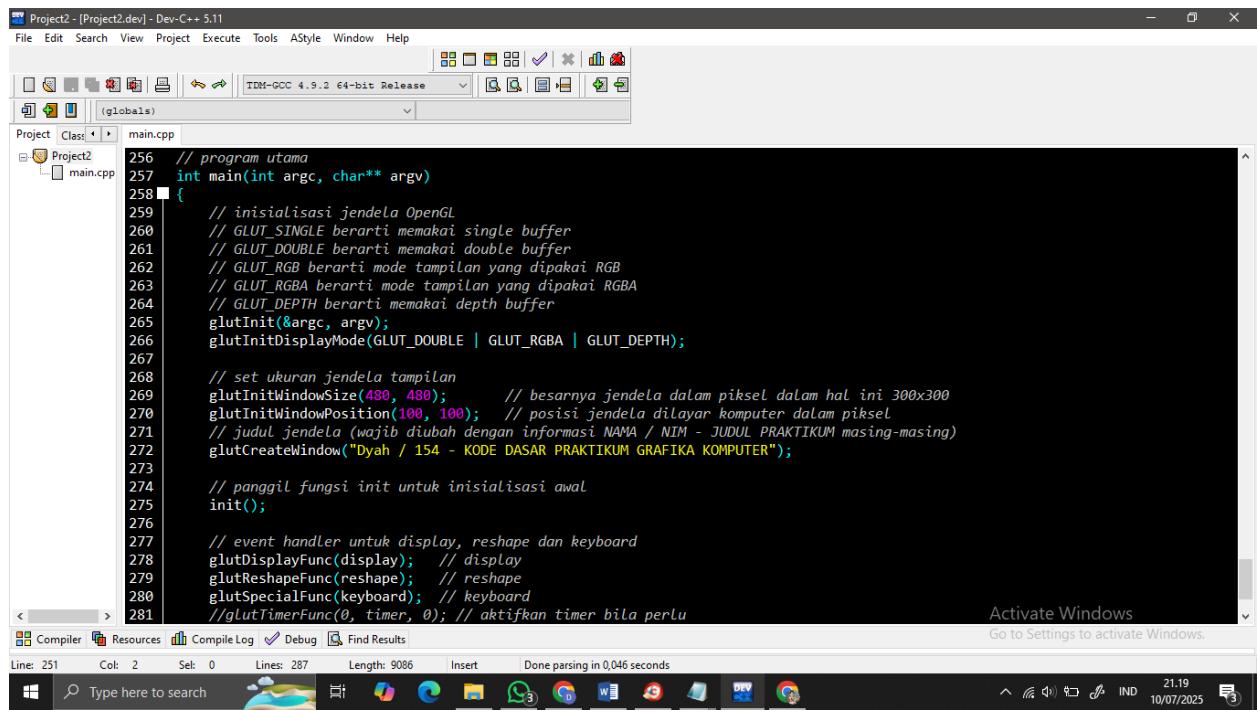
Gambar 13 laprak 6

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 235 Col: 37 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor window displays main.cpp with the following code:

```
238     break;
239 // zoom out
240 case GLUT_KEY_PAGE_DOWN:
241     // masukkan perintah disini bila tombol PgDn ditekan
242     posX -= rotX * fraction;
243     posY -= rotZ * fraction;
244     glutPostRedisplay(); // update obyek
245     break;
246 }
247 }
248
249 // timer untuk animasi (gunakan bila perlu)
250 void timer(int value)
251 {
252     glutPostRedisplay();
253     glutTimerFunc(55, timer, 0);
254 }
255
256 // program utama
257 int main(int argc, char** argv)
258 {
259     // inisialisasi jendela OpenGL
260     // GLUT_SINGLE berarti memakai single buffer
261     // GLUT_DOUBLE berarti memakai double buffer
262     // GLUT_RGB berarti mode tampilan yang dipakai RGB
263     // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 24°C, 21.19, and the date is 10/07/2025.

Gambar 14 laprak 6

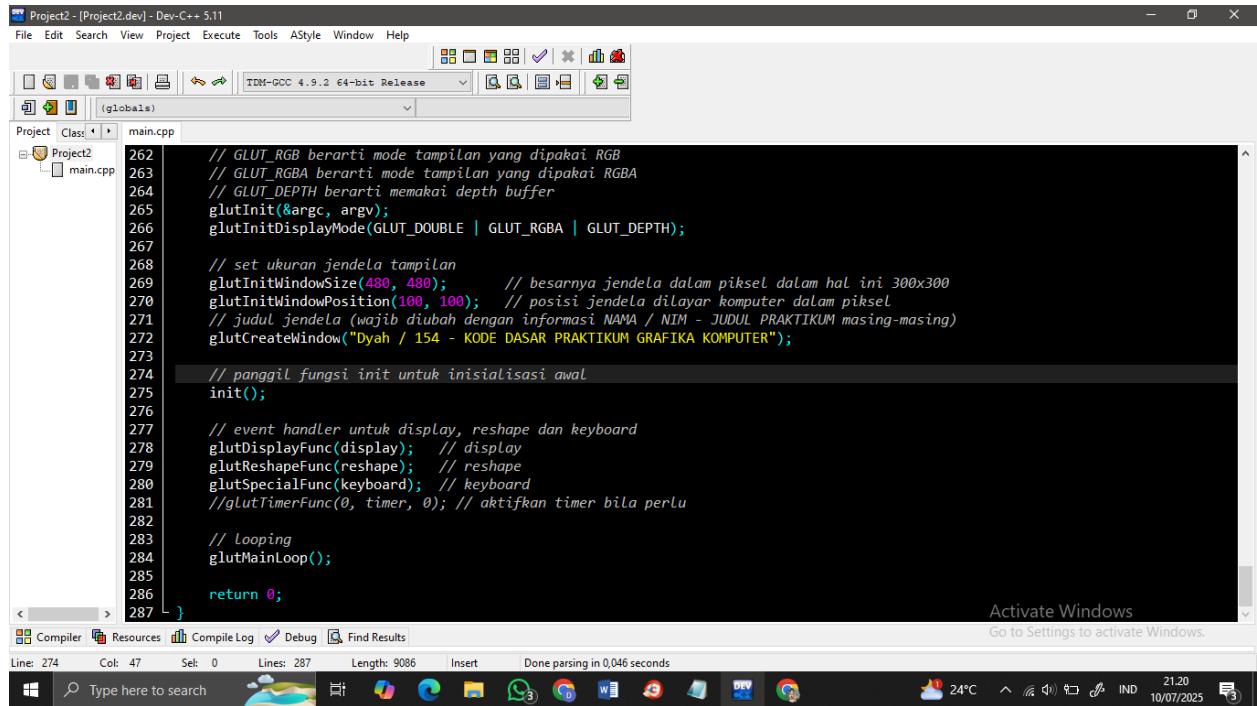


The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 251 Col: 2 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor window displays the following C++ code:

```
256 // program utama
257 int main(int argc, char** argv)
258 {
259     // inisialisasi jendela OpenGL
260     // GLUT_SINGLE berarti memakai single buffer
261     // GLUT_DOUBLE berarti memakai double buffer
262     // GLUT_RGB berarti mode tampilan yang dipakai RGB
263     // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
264     // GLUT_DEPTH berarti memakai depth buffer
265     glutInit(&argc, argv);
266     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
267
268     // set ukuran jendela tampilan
269     glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
270     glutInitWindowPosition(100, 100); // posisi jendela di layar komputer dalam piksel
271     // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
272     glutCreateWindow("Dyah / 154 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");
273
274     // panggil fungsi init untuk inisialisasi awal
275     init();
276
277     // event handler untuk display, reshape dan keyboard
278     glutDisplayFunc(display); // display
279     glutReshapeFunc(reshape); // reshape
280     glutSpecialFunc(keyboard); // keyboard
281     //glutTimerFunc(0, timer, 0); // aktifkan timer bila perlu
282
283     // Looping
284     glutMainLoop();
285
286     return 0;
287 }
```

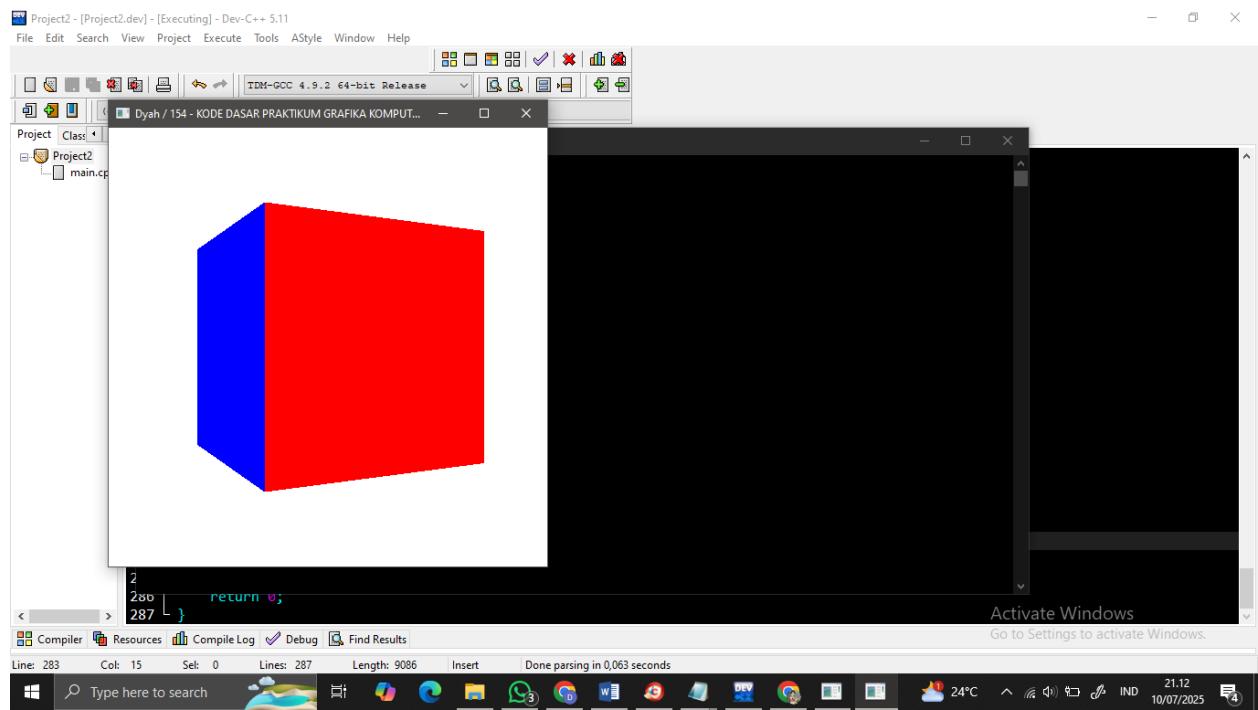
The code is identical to Gambar 14, with the addition of the closing brace for the main function at line 287.

Gambar 15 laprak 6

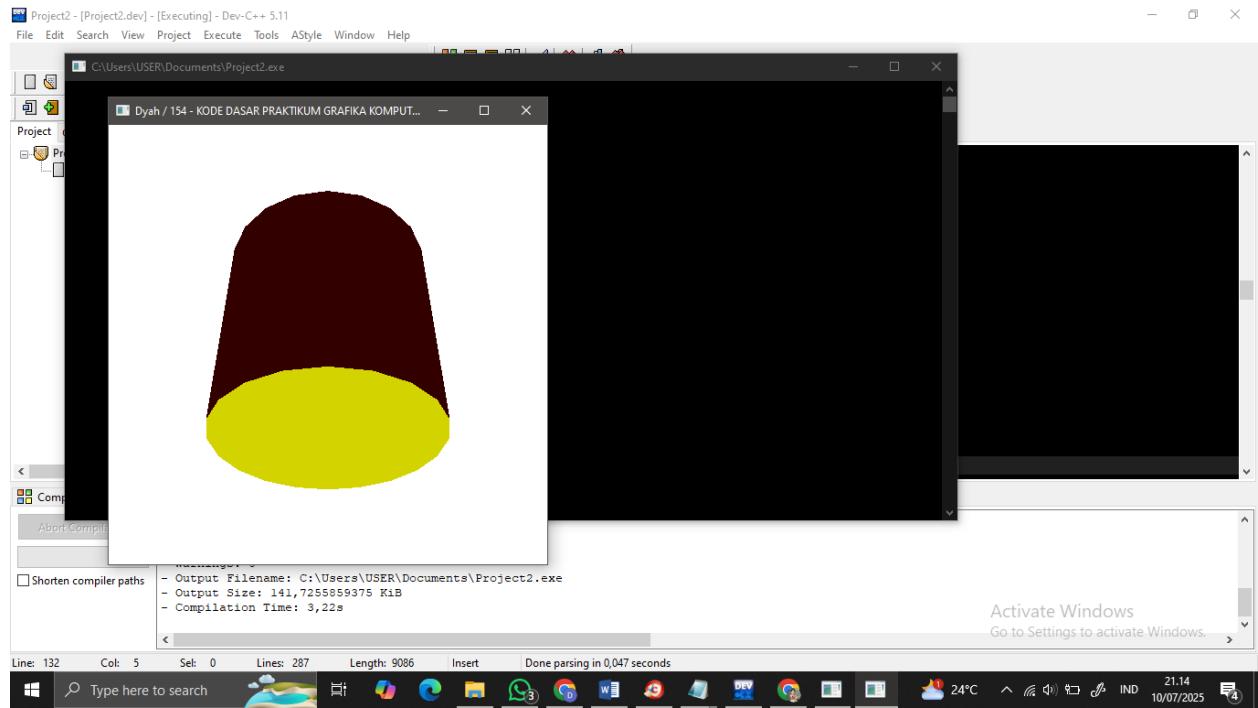


The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 274 Col: 47 Sel: 0 Lines: 287 Length: 9086 Insert Done parsing in 0,046 seconds". The code editor window displays the same C++ code as in Gambar 14, but with the cursor positioned at the closing brace of the main function at line 287.

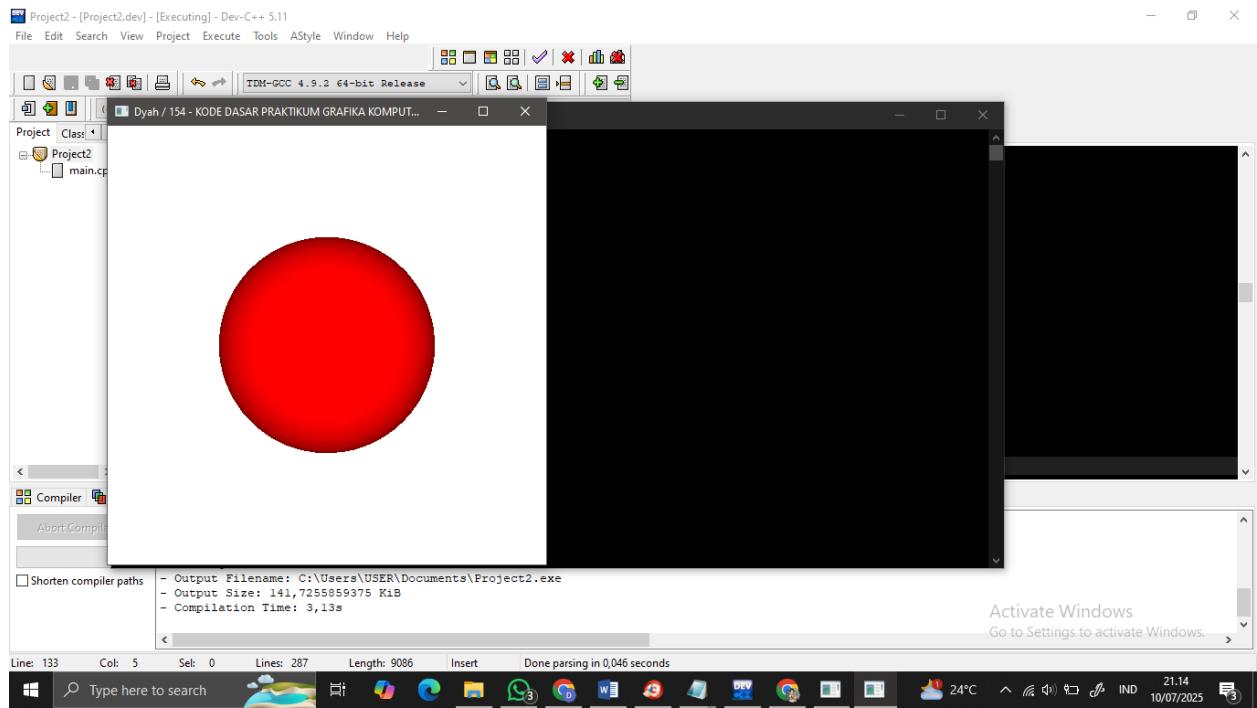
Output 1 laprak 6



Output 2 laprak 6



Output 3 laprak 6



Posttest 6

Gambar 6 posttest 6

```
Project2 - [Project2.dev] - Dev-C++ 5.11
File Edit Search View Project Execute Tools AStyle Window Help
[Project2]
Project Class[*] main.cpp
109 void drawPyramid(float baseRadius, float height, int slices, int stacks)
110 {
111     glPushMatrix();
112
113     // buat objek quadric
114     GLUquadricObj* quad = gluNewQuadric();
115     gluQuadricDrawStyle(quad, GLU_FILL);
116     gluQuadricNormals(quad, GLU_SMOOTH);
117     gluQuadricOrientation(quad, GLU_OUTSIDE);
118
119     // atur posisi dan orientasi piramid
120     glTranslatef(0.0f, -height / 2, 0.0f);    // geser ke bawah agar pusat di tengah
121     glRotatef(-90, 1.0f, 0.0f, 0.0f);        // rotasi agar tegak ke atas
122
123     // warna merah
124     glColor3f(1.0f, 0.0f, 0.0f);
125
126     // gambar piramid (seperti kerucut) dengan radius atas 0
127     gluCylinder(quad, baseRadius, 0.0f, height, slices, stacks);
128
129     // tambahkan alas bundar berwarna merah
130     gluDisk(quad, 0.0f, baseRadius, slices, stacks);
131
132     glPopMatrix();
133 }
```

A screenshot of the Dev-C++ IDE showing the code for drawing a pyramid. The code uses OpenGL functions like glPushMatrix(), gluNewQuadric(), gluQuadricDrawStyle(), gluQuadricNormals(), gluQuadricOrientation(), glTranslatef(), glRotatef(), glColor3f(), gluCylinder(), and gluDisk(). The code is written in C++ and defines a function 'drawPyramid' that takes parameters for base radius, height, number of slices, and number of stacks. The taskbar at the bottom shows various application icons.

Gambar 2 postest 6

The screenshot shows the Dev-C++ IDE interface. The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for opening files, saving, building, and running. The status bar at the bottom shows the line number (Line: 154), column (Col: 1), selection (Sel: 0), lines (Lines: 316), length (Length: 10013), and a message "Done parsing in 0,047 seconds". The code editor displays main.cpp with the following content:

```
151 // set warna obyek ke warna hijau (0.0f, 1.0f, 0.0f)
152 glColor3f(0.0f, 1.0f, 0.0f);
153
154
155 // bila menggambar obyek harus diawali glBegin(tipe obyek) dan diakhiri dengan glEnd()
156 // kecuali menggunakan fungsi yang sudah ada di GLUT-OpenGL seperti dibawah ini
157 //glutSolidCube(1.0f); // menggambar obyek kubus
158 //glutWireTeapot(1.0f);
159 //drawCube(); //panggil fungsi untuk membuat obyek kubus
160 //drawCylinder(1.0f, 2.0f, 20, 20); // fungsi untuk membuat obyek silinder
161 //drawSphere(1.0f, 50, 50); // fungsi untuk membuat obyek bola
162 drawPyramid(1.0f, 2.0f, 4, 4);
163
164 glPopMatrix();
165
166 glPopMatrix();
167
168 // membuat obyek polyhedron
169 //glutSolidTetrahedron();
170 //glutSolidOctahedron();
171 //glutSolidDodecahedron();
172 //glutSolidIcosahedron();
173 //glutSolidCube(1.0f);
174 //glutSolidCone(1.0f, 1.0f, 50, 50);
175 //glutSolidSphere(1.0f, 50, 50);
176 //glutSolidTeapot(1.0f);
```

The output window shows a red pyramid rendered in a 3D perspective view.

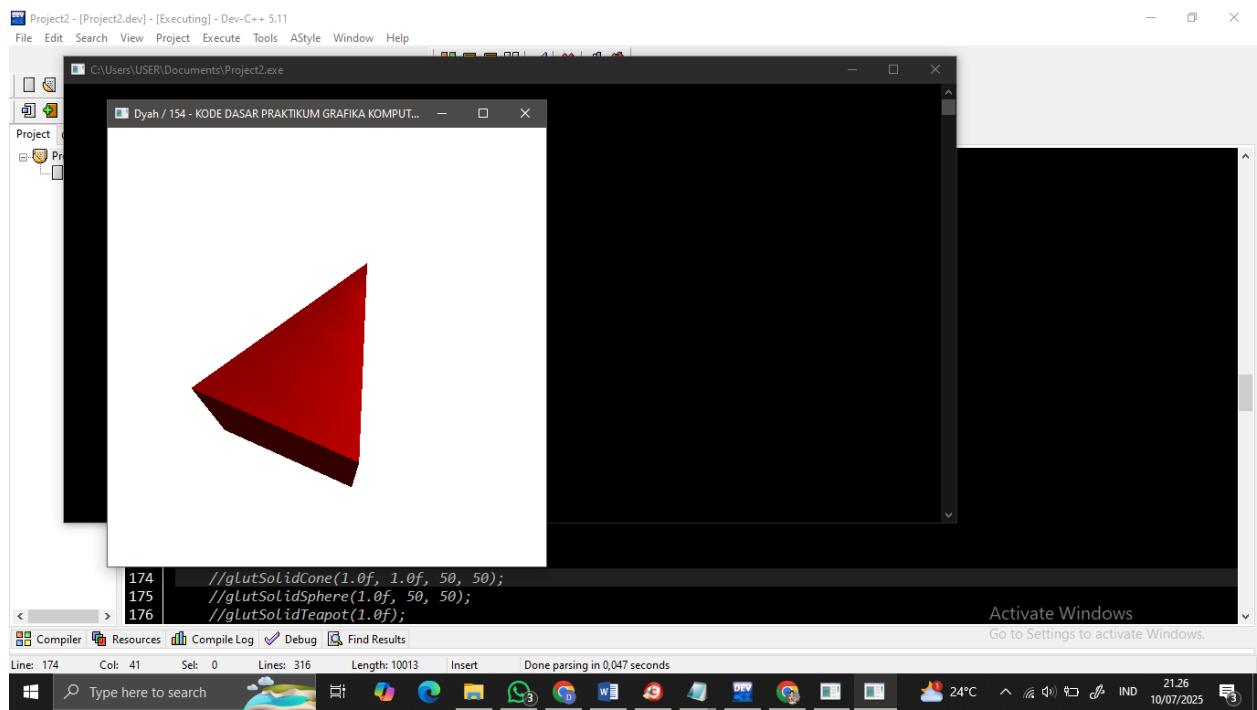
Output 7 posttest 6

The screenshot shows the Dev-C++ IDE interface. The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for opening files, saving, building, and running. The status bar at the bottom shows the line number (Line: 172), column (Col: 30), selection (Sel: 0), lines (Lines: 316), length (Length: 10013), and a message "Done parsing in 0,047 seconds". The code editor displays main.cpp with the following content:

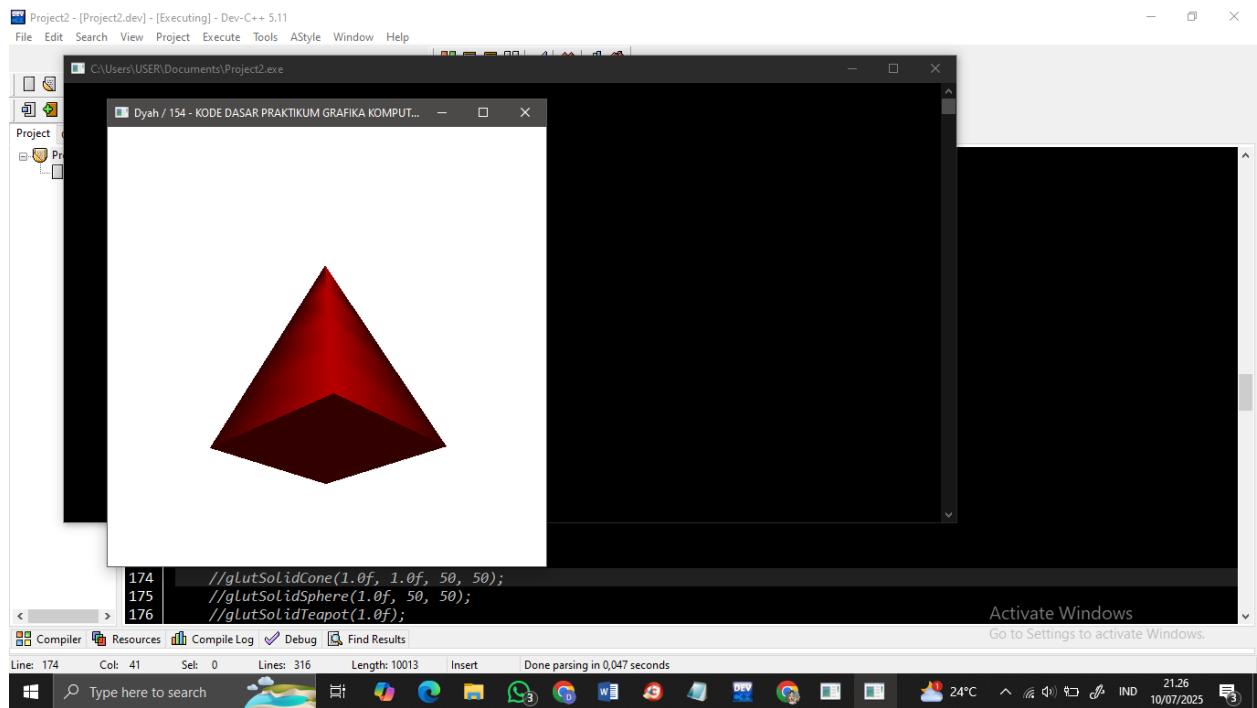
```
174 //glutSolidCone(1.0f, 1.0f, 50, 50);
175 //glutSolidSphere(1.0f, 50, 50);
176 //glutSolidTeapot(1.0f);
```

The output window shows a red pyramid rendered in a 3D perspective view.

Output 2 postest 6



Output 3 postest 6



BAB VII. KURVA SPLINE

Pretest 7

Pertanyaan:

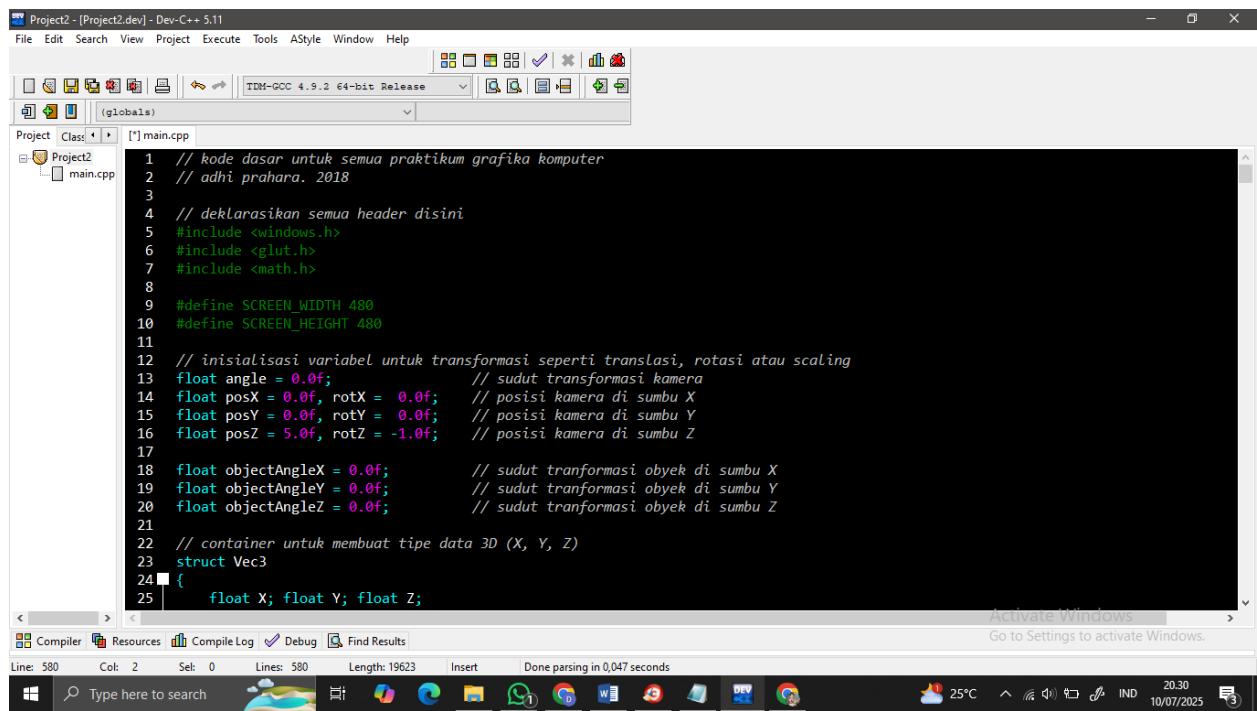
1. Jelaskan perbedaan antara kurva spline cubic, catmull-rom, hermit, dan bezier

Jawaban:

1. Spline cubic : dibuat dari potongan polinomial kubik yang saling terhubung halus, catmull-rom : sangat mudah dipakai untuk jalur lewat titik, hermit : kontrol detail bentuk dengan turunan, dan bezier : menggunakan titik ujung dari titik kontrol untuk interpolasi kemudian menghitung arah tangen untuk menentukan arah kurva.

Langkah Praktikum 7

Gambar 1 laprak 7



The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has various icons for file operations. The main window shows a code editor with the file "main.cpp" open. The code is as follows:

```
1 // kode dasar untuk semua praktikum grafika komputer
2 // adhi prahara. 2018
3
4 // deklarasikan semua header disini
5 #include <windows.h>
6 #include <glut.h>
7 #include <math.h>
8
9 #define SCREEN_WIDTH 480
10 #define SCREEN_HEIGHT 480
11
12 // inisialisasi variabel untuk transformasi seperti translasi, rotasi atau scaling
13 float angle = 0.0f; // sudut transformasi kamera
14 float posX = 0.0f, rotX = 0.0f; // posisi kamera di sumbu X
15 float posY = 0.0f, rotY = 0.0f; // posisi kamera di sumbu Y
16 float posZ = 5.0f, rotZ = -1.0f; // posisi kamera di sumbu Z
17
18 float objectAngleX = 0.0f; // sudut transformasi objek di sumbu X
19 float objectAngleY = 0.0f; // sudut transformasi objek di sumbu Y
20 float objectAngleZ = 0.0f; // sudut transformasi objek di sumbu Z
21
22 // container untuk membuat tipe data 3D (X, Y, Z)
23 struct Vec3
24 {
25     float X; float Y; float Z;
}
```

The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Insert Done parsing in 0,047 seconds". The taskbar at the bottom includes icons for Start, Search, Task View, File Explorer, Edge, File Manager, Taskbar View, Dev-C++, and Google Chrome. The system tray shows the date and time as "10/07/2025 20:30".

Gambar 2 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Insert Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
22 // container untuk membuat tipe data 3D (X, Y, Z)
23 struct Vec3
24 {
25     float X; float Y; float Z;
26     Vec3(float x, float y, float z) { X = x; Y = y; Z = z; }
27     //
28     Vec3() { }
29     ~Vec3() { }
30 };
31
32 void markPoint(Vec3 points, Vec3 colors, float width);
33 bool inverse(float inMat[16], float outMat[16]);
34 void DotMatrix(float inMat1[16], float inMat2[4], float outMat[4]);
35
36 // menggambar setiap titik kontrol kurva
37 void markPoint(Vec3 points, Vec3 colors, float width)
38 {
39     // tandai setiap titik dengan warna
40     glPushMatrix();
41     glColor3f(colors.X, colors.Y, colors.Z);
42
43     glBegin(GL_QUADS);
44     glVertex3f(points.X - width, points.Y - width, points.Z);
45     glVertex3f(points.X + width, points.Y - width, points.Z);
46     glVertex3f(points.X + width, points.Y + width, points.Z);
47     glVertex3f(points.X - width, points.Y + width, points.Z);
48
49     glEnd();
50 }
51
52
53 // fungsi untuk menghitung invers matriks ordo 4x4
54 bool inverse(float inMat[16], float outMat[16])
55 {
56     float inv[16], det;
57     int i;
58
59     inv[0] =
60         inMat[5] * inMat[10] * inMat[15] -
61         inMat[5] * inMat[11] * inMat[14] -
```

Gambar 3 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Insert Done parsing in 0,047 seconds". The code editor displays the following C++ code, which is identical to the one in Gambar 2 but includes additional code from line 53 onwards:

```
37 void markPoint(Vec3 points, Vec3 colors, float width)
38 {
39     // tandai setiap titik dengan warna
40     glPushMatrix();
41     glColor3f(colors.X, colors.Y, colors.Z);
42
43     glBegin(GL_QUADS);
44     glVertex3f(points.X - width, points.Y - width, points.Z);
45     glVertex3f(points.X + width, points.Y - width, points.Z);
46     glVertex3f(points.X + width, points.Y + width, points.Z);
47     glVertex3f(points.X - width, points.Y + width, points.Z);
48
49     glEnd();
50 }
51
52
53 // fungsi untuk menghitung invers matriks ordo 4x4
54 bool inverse(float inMat[16], float outMat[16])
55 {
56     float inv[16], det;
57     int i;
58
59     inv[0] =
60         inMat[5] * inMat[10] * inMat[15] -
61         inMat[5] * inMat[11] * inMat[14] -
```

Gambar 5 laprak 7

The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Insert Done parsing in 0,047 seconds". The main window displays the code for "main.cpp" under the "Project2" project. The code calculates the inverse of a 4x4 matrix using determinants and cofactors. The code is as follows:

```
52 // fungsi untuk menghitung invers matriks ordo 4x4
53 bool inverse(float inMat[16], float outMat[16])
54 {
55     float inv[16], det;
56     int i;
57
58     inv[0] =
59         inMat[5] * inMat[10] * inMat[15] -
60         inMat[5] * inMat[11] * inMat[14] -
61         inMat[9] * inMat[6] * inMat[15] +
62         inMat[9] * inMat[7] * inMat[14] +
63         inMat[13] * inMat[6] * inMat[11] -
64         inMat[13] * inMat[7] * inMat[10];
65
66     inv[4] =
67         -inMat[4] * inMat[10] * inMat[15] +
68         inMat[4] * inMat[11] * inMat[14] +
69         inMat[8] * inMat[6] * inMat[15] -
70         inMat[8] * inMat[7] * inMat[14] -
71         inMat[12] * inMat[6] * inMat[11] +
72         inMat[12] * inMat[7] * inMat[10];
73
74     inv[8] =
75         inMat[4] * inMat[9] * inMat[15] -
76
77     inv[12] * inMat[7] * inMat[10];
78
79     inv[8] =
80         inMat[4] * inMat[9] * inMat[15] -
81         inMat[4] * inMat[11] * inMat[13] -
82         inMat[8] * inMat[5] * inMat[15] +
83         inMat[8] * inMat[7] * inMat[13] +
84         inMat[12] * inMat[5] * inMat[11] -
85         inMat[12] * inMat[7] * inMat[9];
86
87     inv[12] =
88         -inMat[4] * inMat[9] * inMat[14] +
89         inMat[4] * inMat[10] * inMat[13] +
90         inMat[8] * inMat[5] * inMat[14] -
91         inMat[8] * inMat[6] * inMat[13] -
92         inMat[12] * inMat[5] * inMat[10] +
93         inMat[12] * inMat[6] * inMat[9];
94
95     inv[1] =
96         -inMat[1] * inMat[10] * inMat[15] +
97         inMat[1] * inMat[11] * inMat[14] +
98         inMat[9] * inMat[2] * inMat[15] -
99         inMat[9] * inMat[3] * inMat[14] -
100        inMat[13] * inMat[2] * inMat[11] +
101        inMat[13] * inMat[3] * inMat[10];
```

Gambar 6 laprak 7

The screenshot shows the Dev-C++ IDE interface, identical to Gambar 5, but with more code visible in the editor. The code continues from line 73 to line 97, calculating the remaining elements of the inverse matrix. The code is as follows:

```
73     inMat[12] * inMat[7] * inMat[10];
74
75     inv[8] =
76         inMat[4] * inMat[9] * inMat[15] -
77         inMat[4] * inMat[11] * inMat[13] -
78         inMat[8] * inMat[5] * inMat[15] +
79         inMat[8] * inMat[7] * inMat[13] +
80         inMat[12] * inMat[5] * inMat[11] -
81         inMat[12] * inMat[7] * inMat[9];
82
83     inv[12] =
84         -inMat[4] * inMat[9] * inMat[14] +
85         inMat[4] * inMat[10] * inMat[13] +
86         inMat[8] * inMat[5] * inMat[14] -
87         inMat[8] * inMat[6] * inMat[13] -
88         inMat[12] * inMat[5] * inMat[10] +
89         inMat[12] * inMat[6] * inMat[9];
90
91     inv[1] =
92         -inMat[1] * inMat[10] * inMat[15] +
93         inMat[1] * inMat[11] * inMat[14] +
94         inMat[9] * inMat[2] * inMat[15] -
95         inMat[9] * inMat[3] * inMat[14] -
96         inMat[13] * inMat[2] * inMat[11] +
97         inMat[13] * inMat[3] * inMat[10];
```

Gambar 7 laprak 7

The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Insert Done parsing in 0,047 seconds". The bottom taskbar includes icons for Start, Task View, File Explorer, Edge, File History, Mail, Photos, OneDrive, Word, Excel, Power BI, and Google Chrome. The system tray shows the date as 10/07/2025 and the time as 20:33. The main code editor window displays C++ code for calculating matrix inverses, specifically for a 13x13 matrix. The code uses nested loops and multiplication operations. The code editor also shows the line number 580 and column number 2.

```
97     inMat[13] * inMat[3] * inMat[10];
98
99     inv[5] =
100    inMat[0] * inMat[10] * inMat[15] -
101    inMat[0] * inMat[11] * inMat[14] -
102    inMat[8] * inMat[2] * inMat[15] +
103    inMat[8] * inMat[3] * inMat[14] +
104    inMat[12] * inMat[2] * inMat[11] -
105    inMat[12] * inMat[3] * inMat[10];
106
107    inv[9] =
108    -inMat[0] * inMat[9] * inMat[15] +
109    inMat[0] * inMat[11] * inMat[13] +
110    inMat[8] * inMat[1] * inMat[15] -
111    inMat[8] * inMat[3] * inMat[13] -
112    inMat[12] * inMat[1] * inMat[11] +
113    inMat[12] * inMat[3] * inMat[9];
114
115    inv[13] =
116    inMat[0] * inMat[9] * inMat[14] -
117    inMat[0] * inMat[10] * inMat[13] -
118    inMat[8] * inMat[1] * inMat[14] +
119    inMat[8] * inMat[2] * inMat[13] +
120    inMat[12] * inMat[1] * inMat[10] -
121    inMat[12] * inMat[2] * inMat[9];
```

Gambar 8 laprak 7

The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Insert Done parsing in 0,047 seconds". The bottom taskbar includes icons for Start, Task View, File Explorer, Edge, File History, Mail, Photos, OneDrive, Word, Excel, Power BI, and Google Chrome. The system tray shows the date as 10/07/2025 and the time as 20:33. The main code editor window displays C++ code for calculating matrix inverses, specifically for a 13x13 matrix. The code uses nested loops and multiplication operations. The code editor also shows the line number 580 and column number 2.

```
115    inv[13] =
116    inMat[0] * inMat[9] * inMat[14] -
117    inMat[0] * inMat[10] * inMat[13] -
118    inMat[8] * inMat[1] * inMat[14] +
119    inMat[8] * inMat[2] * inMat[13] +
120    inMat[12] * inMat[1] * inMat[10] -
121    inMat[12] * inMat[2] * inMat[9];
122
123    inv[2] =
124    inMat[1] * inMat[6] * inMat[15] -
125    inMat[1] * inMat[7] * inMat[14] -
126    inMat[5] * inMat[2] * inMat[15] +
127    inMat[5] * inMat[3] * inMat[14] +
128    inMat[13] * inMat[2] * inMat[7] -
129    inMat[13] * inMat[3] * inMat[6];
130
131    inv[6] =
132    -inMat[0] * inMat[6] * inMat[15] +
133    inMat[0] * inMat[7] * inMat[14] +
134    inMat[4] * inMat[2] * inMat[15] -
135    inMat[4] * inMat[3] * inMat[14] -
136    inMat[12] * inMat[2] * inMat[7] +
137    inMat[12] * inMat[3] * inMat[6];
138
139    inv[10] =
```

Gambar 9 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Insert Done parsing in 0,047 seconds". The code editor displays the following C++ code for matrix inversion:

```
139     inv[10] =
140         inMat[0] * inMat[5] * inMat[15] -
141         inMat[0] * inMat[7] * inMat[13] -
142         inMat[4] * inMat[1] * inMat[15] +
143         inMat[4] * inMat[3] * inMat[13] +
144         inMat[12] * inMat[1] * inMat[7] -
145         inMat[12] * inMat[3] * inMat[5];
146
147     inv[14] =
148         inMat[0] * inMat[5] * inMat[14] +
149         inMat[0] * inMat[6] * inMat[13] +
150         inMat[4] * inMat[1] * inMat[14] -
151         inMat[4] * inMat[2] * inMat[13] -
152         inMat[12] * inMat[1] * inMat[6] +
153         inMat[12] * inMat[2] * inMat[5];
154
155     inv[3] =
156         -inMat[1] * inMat[6] * inMat[11] +
157         inMat[1] * inMat[7] * inMat[10] +
158         inMat[5] * inMat[2] * inMat[11] -
159         inMat[5] * inMat[3] * inMat[10] -
160         inMat[9] * inMat[2] * inMat[7] +
161         inMat[9] * inMat[3] * inMat[6];
162
163     inv[7] =
```

Gambar 10 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays the following C++ code for matrix inversion, including a final assignment statement:

```
163     inv[7] =
164         inMat[0] * inMat[6] * inMat[11] -
165         inMat[0] * inMat[7] * inMat[10] -
166         inMat[4] * inMat[2] * inMat[11] +
167         inMat[4] * inMat[3] * inMat[10] +
168         inMat[8] * inMat[2] * inMat[7] -
169         inMat[8] * inMat[3] * inMat[6];
170
171     inv[11] =
172         -inMat[0] * inMat[5] * inMat[11] +
173         inMat[0] * inMat[7] * inMat[9] +
174         inMat[4] * inMat[1] * inMat[11] -
175         inMat[4] * inMat[3] * inMat[9] -
176         inMat[8] * inMat[1] * inMat[7] +
177         inMat[8] * inMat[3] * inMat[5];
178
179     inv[15] =
180         inMat[0] * inMat[5] * inMat[10] -
181         inMat[0] * inMat[6] * inMat[9] -
182         inMat[4] * inMat[1] * inMat[10] +
183         inMat[4] * inMat[2] * inMat[9] +
184         inMat[8] * inMat[1] * inMat[6] -
185         inMat[8] * inMat[2] * inMat[5];
186
187     det = inMat[0] * inv[0] + inMat[1] * inv[4] + inMat[2] * inv[8] + inMat[3] * inv[12];
```

Gambar 11 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays C++ code for matrix operations:

```
184     inMat[8] * inMat[1] * inMat[6] -
185     inMat[8] * inMat[2] * inMat[5];
186
187     det = inMat[0] * inv[0] + inMat[1] * inv[4] + inMat[2] * inv[8] + inMat[3] * inv[12];
188
189     if (det == 0)
190         return false;
191
192     det = 1.0 / det;
193
194     for (i = 0; i < 16; i++)
195         outMat[i] = inv[i] * det;
196
197     return true;
198 }
199
200 // fungsi untuk perkalian matriks 4x4 dengan 4x1
201 void DotMatrix(float inMat1[16], float inMat2[4], float outMat[4])
202 {
203     outMat[0] = inMat1[0] * inMat2[0] + inMat1[1] * inMat2[1] +
204     inMat1[2] * inMat2[2] + inMat1[3] * inMat2[3];
205     outMat[1] = inMat1[4] * inMat2[0] + inMat1[5] * inMat2[1] +
206     inMat1[6] * inMat2[2] + inMat1[7] * inMat2[3];
207     outMat[2] = inMat1[8] * inMat2[0] + inMat1[9] * inMat2[1] +
208     inMat1[10] * inMat2[2] + inMat1[11] * inMat2[3];
```

Gambar 12 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays C++ code for drawing a cubic spline curve:

```
214 // fungsi untuk membuat kurva spline cubic dari 4 titik kontrol
215 // point1 sampai point4 = titik kontrol
216 // nPoint = jumlah titik interpolasi antara point1 sampai point4
217 void drawSplineCubic(Vec3 point1, Vec3 point2, Vec3 point3, Vec3 point4,int nPoint)
218 {
219     // hitung bobot jarak u di masing-masing titik
220     float utotal = (abs(point2.X - point1.X) + abs(point3.X - point2.X) +
221     abs(point4.X - point3.X));
222     float u1 = 0;
223     float u2 = abs(point2.X - point1.X) / utotal;
224     float u3 = abs((point2.X - point1.X) + abs(point3.X - point2.X)) / utotal;
225     float u4 = 1;
226
227     // hitung inverse matriks dari koefisien u (lihat slide kuliah)
228     float inverseMat[16];
229     float coeffMat[16] = {
230         1.00f, 0.00f, 0.00f, 0.00f,
231         1.00f, u2, pow(u2, 2), pow(u2, 3),
232         1.00f, u3, pow(u3, 2), pow(u3, 3),
233         1.00f, 1.00f, 1.00f, 1.00f};
234
235     bool status = inverse(coeffMat, inverseMat);
236     // hitung koefisien cubic au^3 + bu^2 + cu + d
237     if (status == true)
238     {
239         float outMatX[4], outMatY[4], outMatZ[4];
240         float inMatX[4] = {point1.X, point2.X, point3.X, point4.X};
```

Gambar 13 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays main.cpp with the following content:

```
235     if (status == true)
236     {
237         float outMatX[4], outMatY[4], outMatZ[4];
238         float inMatX[4] = {point1.X, point2.X, point3.X, point4.X};
239         float inMatY[4] = {point1.Y, point2.Y, point3.Y, point4.Y};
240         float inMatZ[4] = {point1.Z, point2.Z, point3.Z, point4.Z};
241         DotMatrix(inverseMat, inMatX, outMatX);
242         DotMatrix(inverseMat, inMatY, outMatY);
243         DotMatrix(inverseMat, inMatZ, outMatZ);
244         // gambar kurva cubic spline dengan titik kontrol diatas hitung
245         // posisi y untuk setiap x di setiap point dengan persamaan diatas
246         for (int i = 0; i < nPoint; i++)
247         {
248             // jeda setiap titik pd bobot u
249             float step = 1.0f / nPoint;
250             // titik awal
251             float pX = point1.X, pY = point1.Y, pZ = point1.Z;
252             //
253             float u = 0.0f;
254             for (int i = 0; i < nPoint; i++)
255             {
256                 // segment kurva cubic spline sebanyak nPoint
257                 u = u + step;
258                 glVertex3f(pX, pY, pZ); // gambar titik awal
259                 // koordinat X pada kurva
260                 pX = outMatX[3] * pow(u, 3) + outMatX[2] * pow(u, 2) + outMatX[1] * u + outMatX[0];
261                 // koordinat Y pada kurva
262                 pY = outMatY[3] * pow(u, 3) + outMatY[2] * pow(u, 2) + outMatY[1] * u + outMatY[0];
263                 // koordinat Z pada kurva
264                 pZ = outMatZ[3] * pow(u, 3) + outMatZ[2] * pow(u, 2) + outMatZ[1] * u + outMatZ[0];
265                 glVertex3f(pX, pY, pZ); // gambar titik akhir
266             }
267         }
268     }
```

The status bar also shows system information: 24°C, 20.35, 10/07/2025.

Gambar 14 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays main.cpp with the following content:

```
247     {
248         // jeda setiap titik pd bobot u
249         float step = 1.0f / nPoint;
250         // titik awal
251         float pX = point1.X, pY = point1.Y, pZ = point1.Z;
252         //
253         float u = 0.0f;
254         for (int i = 0; i < nPoint; i++)
255         {
256             // segment kurva cubic spline sebanyak nPoint
257             u = u + step;
258             glVertex3f(pX, pY, pZ); // gambar titik awal
259             // koordinat X pada kurva
260             pX = outMatX[3] * pow(u, 3) + outMatX[2] * pow(u, 2) + outMatX[1] * u + outMatX[0];
261             // koordinat Y pada kurva
262             pY = outMatY[3] * pow(u, 3) + outMatY[2] * pow(u, 2) + outMatY[1] * u + outMatY[0];
263             // koordinat Z pada kurva
264             pZ = outMatZ[3] * pow(u, 3) + outMatZ[2] * pow(u, 2) + outMatZ[1] * u + outMatZ[0];
265             glVertex3f(pX, pY, pZ); // gambar titik akhir
266         }
267     }
```

The status bar also shows system information: 24°C, 20.36, 10/07/2025.

Gambar 15 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays C++ code for drawing a Bezier curve:

```
271 // fungsi untuk membuat kurva spline bezier dari 4 titik kontrol
272 // point1 dan point4 = titik kontrol awal dan akhir
273 // point2 dan point3 = titik kontrol pembentuk kurva
274 // nPoint = jumlah titik interpolasi antara point1 sampai point4
275 void drawSplineBezier(Vec3 point1, Vec3 point2, Vec3 point3, Vec3 point4, int nPoint)
276 {
277     // hitung bobot jarak u di masing-masing titik
278     float utotal = (abs(point2.X - point1.X) + abs(point3.X - point2.X) +
279                     abs(point4.X - point3.X));
280     float u1 = 0;
281     float u2 = abs(point2.X - point1.X) / utotal;
282     float u3 = (abs(point2.X - point1.X) + abs(point3.X - point2.X)) /
283                 utotal;
284     float u4 = 1;
285     // hitung inverse matriks dari koefisien u (lihat slide kuliah)
286     float inverseMat[16];
287     float coeffMat[16] = {
288         1.0000f, 0.0000f, 0.0000f, 0.0000f,
289         1.0000f, 1.0000f, 1.0000f, 1.0000f,
290         0.0000f, 1.0000f, 0.0000f, 0.0000f,
291         0.0000f, 1.0000f, 2.0000f, 3.0000f};
292     bool status = inverse(coeffMat, inverseMat);
293     // hitung koefisien
294     if (status == true)
```

Gambar 16 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays C++ code for drawing a Bezier curve, continuing from the previous screenshot:

```
292     0.0000f, 1.0000f, 2.0000f, 3.0000f};
293     bool status = inverse(coeffMat, inverseMat);
294     // hitung koefisien
295     if (status == true)
296     {
297         float outMatX[4], outMatY[4], outMatZ[4];
298         float inMatX[4] = {point1.X, point4.X,
299                           1.0f / (u2 - u1) * (point2.X - point1.X),
300                           1.0f / (u4 - u3) * (point4.X - point3.X)};
301         float inMatY[4] = {point1.Y, point4.Y,
302                           1.0f / (u2 - u1) * (point2.Y - point1.Y),
303                           1.0f / (u4 - u3) * (point4.Y - point3.Y)};
304         float inMatZ[4] = {point1.Z, point4.Z,
305                           1.0f / (u2 - u1) * (point2.Z - point1.Z),
306                           1.0f / (u4 - u3) * (point4.Z - point3.Z)};
307         DotMatrix(inverseMat, inMatX, outMatX);
308         DotMatrix(inverseMat, inMatY, outMatY);
309         DotMatrix(inverseMat, inMatZ, outMatZ);
310         // gambar kurva cubic spline dengan titik kontrol diatas hitung
311         // posisi y untuk setiap x di setiap point dengan persamaan diatas
312         for (int i = 0; i < nPoint; i++)
313         {
314             // jeda setiap titik pd bobot u
315             float step = 1.0f / nPoint;
316             // titik awal
```

Gambar 17 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays main.cpp with the following C++ code:

```
313     {
314         // jeda setiap titik pd bobot u
315         float step = 1.0f / nPoint;
316         // titik awal
317         float pX = point1.X, pY = point1.Y, pZ = point1.Z;
318         //
319         float u = 0.0f;
320         for (int i = 0; i < nPoint; i++)
321         {
322             // bentuk segment kurva spline sebanyak nPoint
323             u = u + step;
324             glVertex3f(pX, pY, pZ); // gambar titik awal
325             // koordinat X pada kurva
326             pX = outMatX[3] * pow(u, 3) + outMatX[2] * pow(u, 2) + outMatX[1] * u + outMatX[0];
327             // koordinat Y pada kurva
328             pY = outMatY[3] * pow(u, 3) + outMatY[2] * pow(u, 2) + outMatY[1] * u + outMatY[0];
329             // koordinat Z pada kurva
330             pZ = outMatZ[3] * pow(u, 3) + outMatZ[2] * pow(u, 2) + outMatZ[1] * u + outMatZ[0];
331             glVertex3f(pX, pY, pZ); // gambar titik akhir
332         }
333     }
334 }
335 }
```

Gambar 18 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays main.cpp with the following C++ code:

```
358     0.0000f, 1.0000f, 2.0000f, 3.0000f);
359     bool status = inverse(coeffMat, inverseMat);
360     // hitung koefisien
361     if (status == true)
362     {
363         float outMatX[4], outMatY[4], outMatZ[4];
364         float inMatX[4] = {point1.X, point4.X,
365                           1.0f / (u3 - u1) * (point3.X - point1.X),
366                           1.0f / (u4 - u2) * (point4.X - point2.X)};
367         float inMatY[4] = {point1.Y, point4.Y,
368                           1.0f / (u3 - u1) * (point3.Y - point1.Y),
369                           1.0f / (u4 - u2) * (point4.Y - point2.Y)};
370         float inMatZ[4] = {point1.Z, point4.Z,
371                           1.0f / (u3 - u1) * (point3.Z - point1.Z),
372                           1.0f / (u4 - u2) * (point4.Z - point2.Z)};
373         DotMatrix(inverseMat, inMatX, outMatX);
374         DotMatrix(inverseMat, inMatY, outMatY);
375         DotMatrix(inverseMat, inMatZ, outMatZ);
376         // gambar kurva spline dengan titik kontrol diatas hitung posisi
377         // y untuk setiap x di setiap point dengan persamaan diatas
378         for (int i = 0; i < nPoint; i++)
379         {
380             // jeda setiap titik pd bobot u
381             float step = 1.0f / nPoint;
382             // titik awal
```

Gambar 19 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays main.cpp with the following content:

```
// gambar kurva spline dengan titik kontrol diatas hitung posisi
// y untuk setiap x di setiap point dengan persamaan diatas
for (int i = 0; i < nPoint; i++)
{
    // jeda setiap titik pd bobot u
    float step = 1.0f / nPoint;
    // titik awal
    float pX = point1.X, pY = point1.Y, pZ = point1.Z;
    //
    float u = 0.0f;
    for (int i = 0; i < nPoint; i++)
    {
        // bentuk segment kurva spline sebanyak nPoint
        u = u + step;
        glVertex3f(pX, pY, pZ); // gambar titik awal
        // koordinat X pada kurva
        pX = outMatX[3] * pow(u, 3) + outMatX[2] * pow(u, 2) + outMatX[1] * u + outMatX[0];
        // koordinat Y pada kurva
        pY = outMatY[3] * pow(u, 3) + outMatY[2] * pow(u, 2) + outMatY[1] * u + outMatY[0];
        // koordinat Z pada kurva
        pZ = outMatZ[3] * pow(u, 3) + outMatZ[2] * pow(u, 2) + outMatZ[1] * u + outMatZ[0];
        glVertex3f(pX, pY, pZ); // gambar titik akhir
    }
}
```

Gambar 20 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays main.cpp with the following content:

```
// fungsi untuk menggambar obyek
void drawObject()
{
    glPushMatrix();

    // operasi transformasi rotasi obyek ke arah kanan-kiri
    glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
    glPushMatrix();

    // operasi transformasi rotasi obyek ke arah atas-bawah
    glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);

    // membuat 4 titik kontrol kurva
    Vec3 point1 = Vec3(-150.0f, -70.0f, 0.0f);
    Vec3 point2 = Vec3(-50.0f, 50.0f, 0.0f);
    Vec3 point3 = Vec3(50.0f, 10.0f, 0.0f);
    Vec3 point4 = Vec3(150.0f, -50.0f, 0.0f);

    // tandai setiap titik kontrol kurva dengan warna
    markPoint(point1, Vec3(0.0f, 1.0f, 0.0f), 5.0f);
    markPoint(point2, Vec3(1.0f, 0.0f, 0.0f), 5.0f);
    markPoint(point3, Vec3(1.0f, 0.0f, 1.0f), 5.0f);
    markPoint(point4, Vec3(1.0f, 1.0f, 0.0f), 5.0f);
}
```

Gambar 21 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
421 // tandai setiap titik kontrol kurva dengan warna
422 markPoint(point1, Vec3(0.0f, 1.0f, 0.0f), 5.0f);
423 markPoint(point2, Vec3(1.0f, 0.0f, 0.0f), 5.0f);
424 markPoint(point3, Vec3(1.0f, 0.0f, 1.0f), 5.0f);
425 markPoint(point4, Vec3(1.0f, 1.0f, 0.0f), 5.0f);
426
427 // mengatur warna obyek menjadi berwarna putih
428 glColor3f(1.0f, 1.0f, 1.0f);
429 glBegin(GL_LINES);
430
431 // membuat kurva spline cubic dari titik kontrol diatas
432 // drawSplineCubic(point1, point2, point3, point4, 30);
433
434 // membuat kurva spline bezier dari titik kontrol diatas
435 // drawSplineBezier(point1, point2, point3, point4, 30);
436
437 // membuat kurva spline catmullrom dari titik kontrol diatas
438 // drawSplineCatmullRom(point1, point2, point3, point4, 30);
439
440 glEnd();
441 glPopMatrix();
442 glPopMatrix();
443
444 }
445
```

Gambar 22 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
442 glPopMatrix();
443 glPopMatrix();
444 }
445
446 // taruh semua obyek yang akan digambar di fungsi display()
447 void display()
448 {
449     // bersihkan dan reset Layar dan buffer
450     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
451     glLoadIdentity();
452
453     // posisikan kamera pandang
454     // dalam hal ini sumbu Y ada diatas dan posisi kamera pandang di (posX, posY, posZ)
455     gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
456
457     // panggil fungsi untuk menggambar obyek
458     drawObject();
459
460     // tampilkan obyek ke layar
461     // gunakan glFlush() bila memakai single buffer
462     // gunakan glutSwapBuffers() bila memakai double buffer
463     glutSwapBuffers();
464 }
465
466 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
```

Gambar 23 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays the following C++ code:

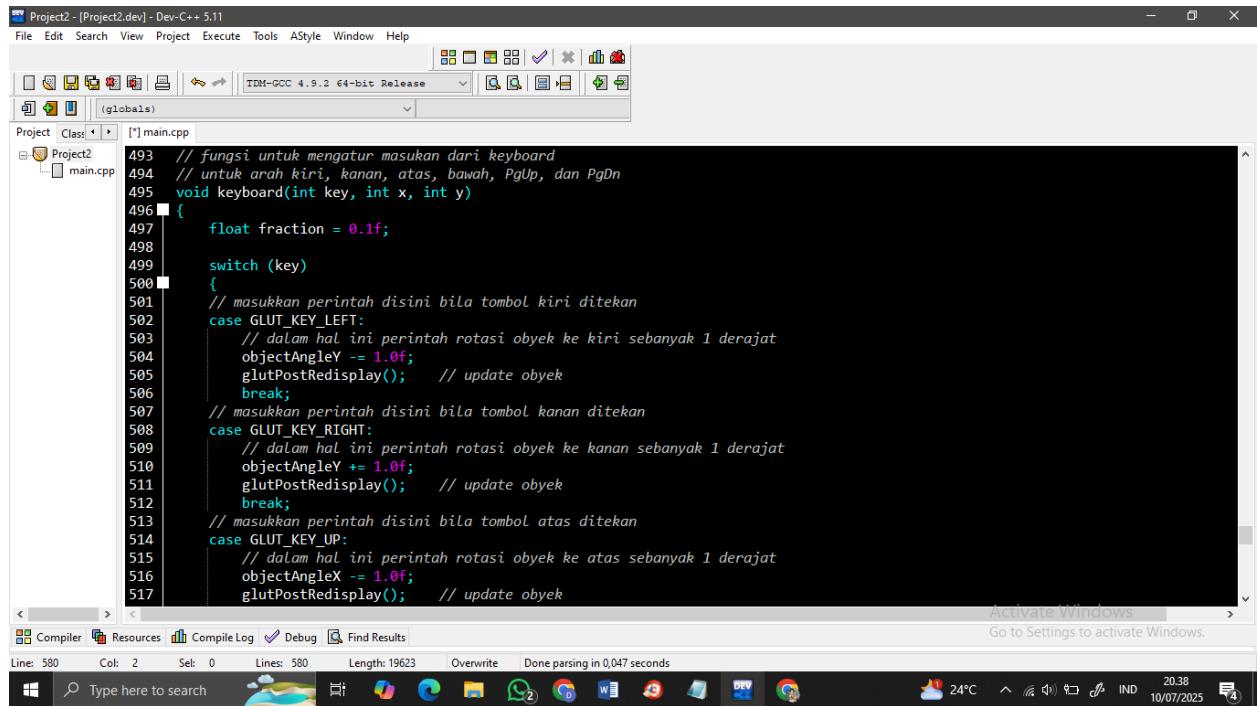
```
463     glutSwapBuffers();
464 }
465
466 // inisialisasikan variabel, pencahayaan, tekstur dan pengaturan kamera pandang di fungsi init()
467 void init(void)
468 {
469     // inisialisasi warna Latar belakang Layar dalam hal ini warna putih (1.0, 1.0, 1.0, 0.0)
470     glClearColor(0.0, 0.0, 0.0, 0.0);
471     glEnable(GL_DEPTH_TEST);           // mengaktifkan depth buffer
472     glMatrixMode(GL_PROJECTION);
473     glLoadIdentity();
474     // gluPerspective(45.0, 1.0, 1.0, 100.0); // set proyeksi ke perspektif
475     glOrtho((GLfloat)SCREEN_WIDTH / 2, (GLfloat)SCREEN_WIDTH / 2, (GLfloat)SCREEN_HEIGHT / 2, (GLfloat)SCREEN_HEIGHT / 2, 1.0,
476             glMatrixMode(GL_MODELVIEW);
477     glLoadIdentity();
478     // inisialisasi kamera pandang
479     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
480 }
481
482 // fungsi ini digunakan bila Layar akan diresize (default)
483 void reshape(int w, int h)
484 {
485     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
486     glMatrixMode(GL_PROJECTION);
487     glLoadIdentity();
```

Gambar 24 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
478     // inisialisasi kamera pandang
479     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
480 }
481
482 // fungsi ini digunakan bila Layar akan diresize (default)
483 void reshape(int w, int h)
484 {
485     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
486     glMatrixMode(GL_PROJECTION);
487     glLoadIdentity();
488     // gluPerspective(45, (GLfloat)w / (GLfloat)h, 1.0, 100.0);
489     glOrtho((GLfloat)SCREEN_WIDTH / 2, (GLfloat)SCREEN_WIDTH / 2, (GLfloat)SCREEN_HEIGHT / 2, (GLfloat)SCREEN_HEIGHT / 2, 1.0,
490             glMatrixMode(GL_MODELVIEW);
491 }
492
493 // fungsi untuk mengatur masukan dari keyboard
494 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
495 void keyboard(int key, int x, int y)
496 {
497     float fraction = 0.1f;
498
499     switch (key)
500     {
501         // masukkan perintah disini bila tombol kiri ditekan
502         case GLUT_KEY_LEFT:
```

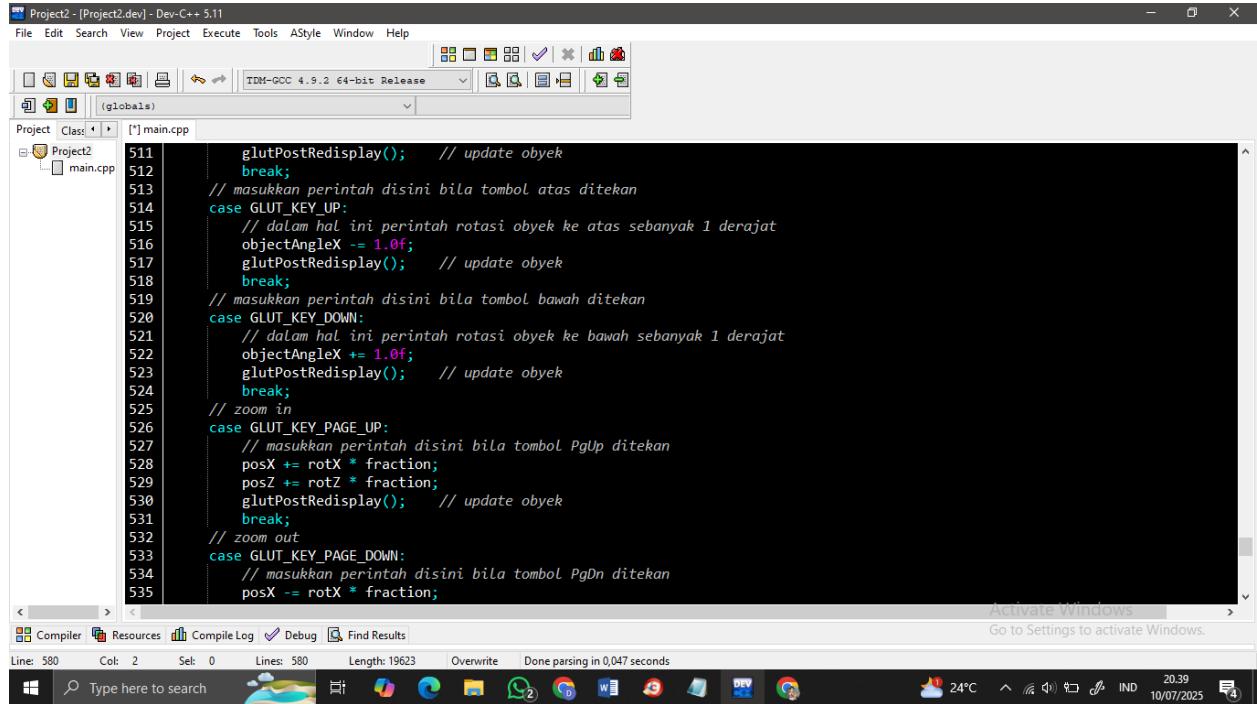
Gambar 25 laprak 7



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
493 // fungsi untuk mengatur masukan dari keyboard
494 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
495 void keyboard(int key, int x, int y)
496 {
497     float fraction = 0.1f;
498
499     switch (key)
500     {
501         // masukkan perintah disini bila tombol kiri ditekan
502         case GLUT_KEY_LEFT:
503             // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
504             objectAngleY -= 1.0f;
505             glutPostRedisplay(); // update obyek
506             break;
507         // masukkan perintah disini bila tombol kanan ditekan
508         case GLUT_KEY_RIGHT:
509             // dalam hal ini perintah rotasi obyek ke kanan sebanyak 1 derajat
510             objectAngleY += 1.0f;
511             glutPostRedisplay(); // update obyek
512             break;
513         // masukkan perintah disini bila tombol atas ditekan
514         case GLUT_KEY_UP:
515             // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
516             objectAngleX -= 1.0f;
517             glutPostRedisplay(); // update obyek
518             break;
```

Gambar 26 laprak 7



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
511     glutPostRedisplay(); // update obyek
512     break;
513     // masukkan perintah disini bila tombol atas ditekan
514     case GLUT_KEY_UP:
515         // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
516         objectAngleX -= 1.0f;
517         glutPostRedisplay(); // update obyek
518         break;
519     // masukkan perintah disini bila tombol bawah ditekan
520     case GLUT_KEY_DOWN:
521         // dalam hal ini perintah rotasi obyek ke bawah sebanyak 1 derajat
522         objectAngleX += 1.0f;
523         glutPostRedisplay(); // update obyek
524         break;
525     // zoom in
526     case GLUT_KEY_PAGE_UP:
527         // masukkan perintah disini bila tombol PgUp ditekan
528         posX += rotX * fraction;
529         posZ += rotZ * fraction;
530         glutPostRedisplay(); // update obyek
531         break;
532     // zoom out
533     case GLUT_KEY_PAGE_DOWN:
534         // masukkan perintah disini bila tombol PgDn ditekan
535         posX -= rotX * fraction;
```

Gambar 27 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays the following C++ code:

```
// zoom out
case GLUT_KEY_PAGE_DOWN:
    // masukkan perintah disini bila tombol PgDn ditekan
    posX -= rotX * fraction;
    posY -= rotY * fraction;
    posZ -= rotZ * fraction;
    glutPostRedisplay(); // update obyek
    break;
}

// timer untuk animasi (gunakan bila perlu)
void timer(int value)
{
    glutPostRedisplay();
    glutTimerFunc(5, timer, 0);
}

// program utama
int main(int argc, char** argv)
{
    // inisialisasi jendela OpenGL
    // GLUT_SINGLE berarti memakai single buffer
    // GLUT_DOUBLE berarti memakai double buffer
    // GLUT_RGB berarti mode tampilan yang dipakai RGB
    // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
}
```

Gambar 28 laprak 7

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 580 Col: 2 Sel: 0 Lines: 580 Length: 19623 Overwrite Done parsing in 0,047 seconds". The code editor displays the following C++ code:

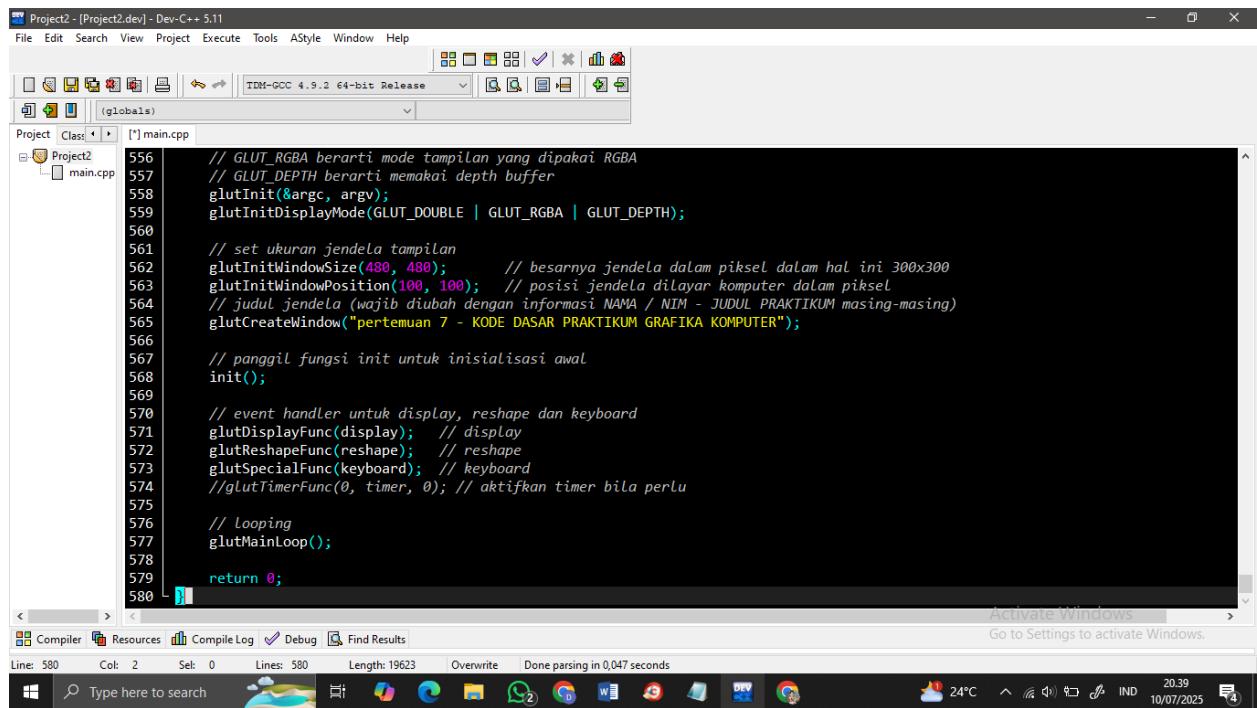
```
int main(int argc, char** argv)
{
    // inisialisasi jendela OpenGL
    // GLUT_SINGLE berarti memakai single buffer
    // GLUT_DOUBLE berarti memakai double buffer
    // GLUT_RGB berarti mode tampilan yang dipakai RGB
    // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
    // GLUT_DEPTH berarti memakai depth buffer
    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGBA | GLUT_DEPTH);

    // set ukuran jendela tampilan
    glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
    glutInitWindowPosition(100, 100); // posisi jendela di layar komputer dalam piksel
    // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
    glutCreateWindow("pertemuan 7 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");

    // panggil fungsi init untuk inisialisasi awal
    init();

    // event handler untuk display, reshape dan keyboard
    glutDisplayFunc(display); // display
    glutReshapeFunc(reshape); // reshape
    glutSpecialFunc(keyboard); // keyboard
    //glutTimerFunc(0, timer, 0); // aktifkan timer bila perlu
}
```

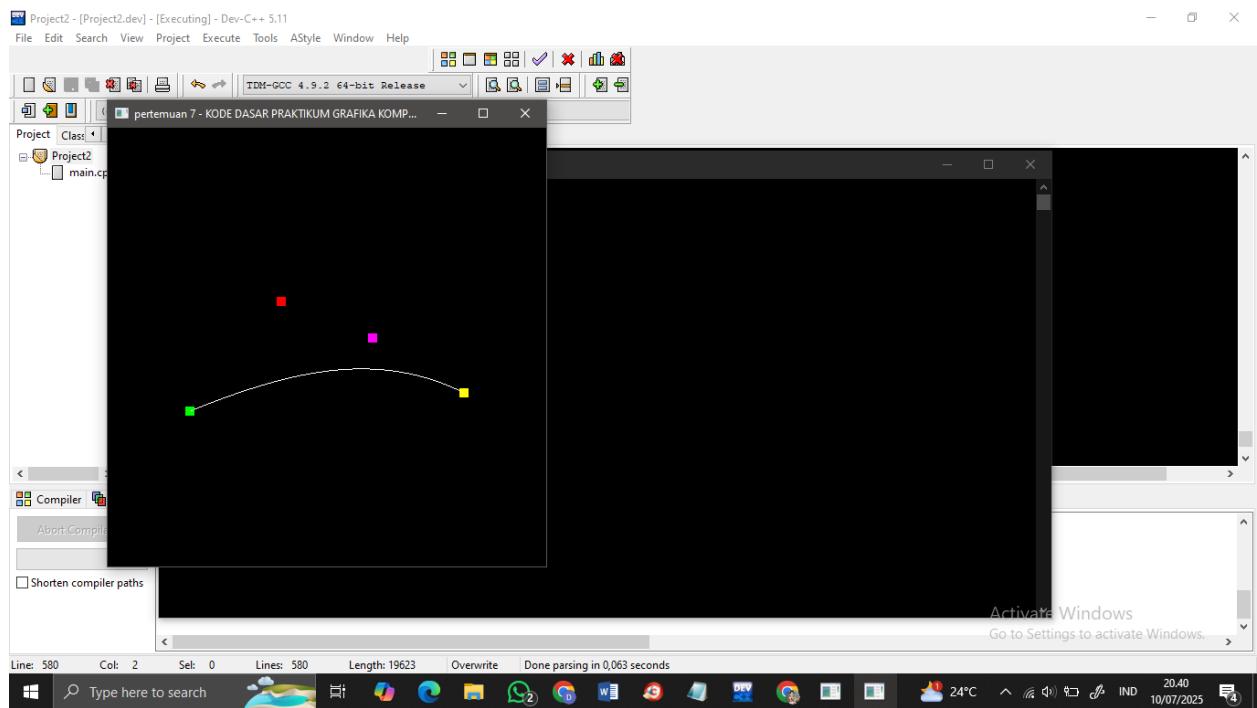
Gambar 29 laprak 7



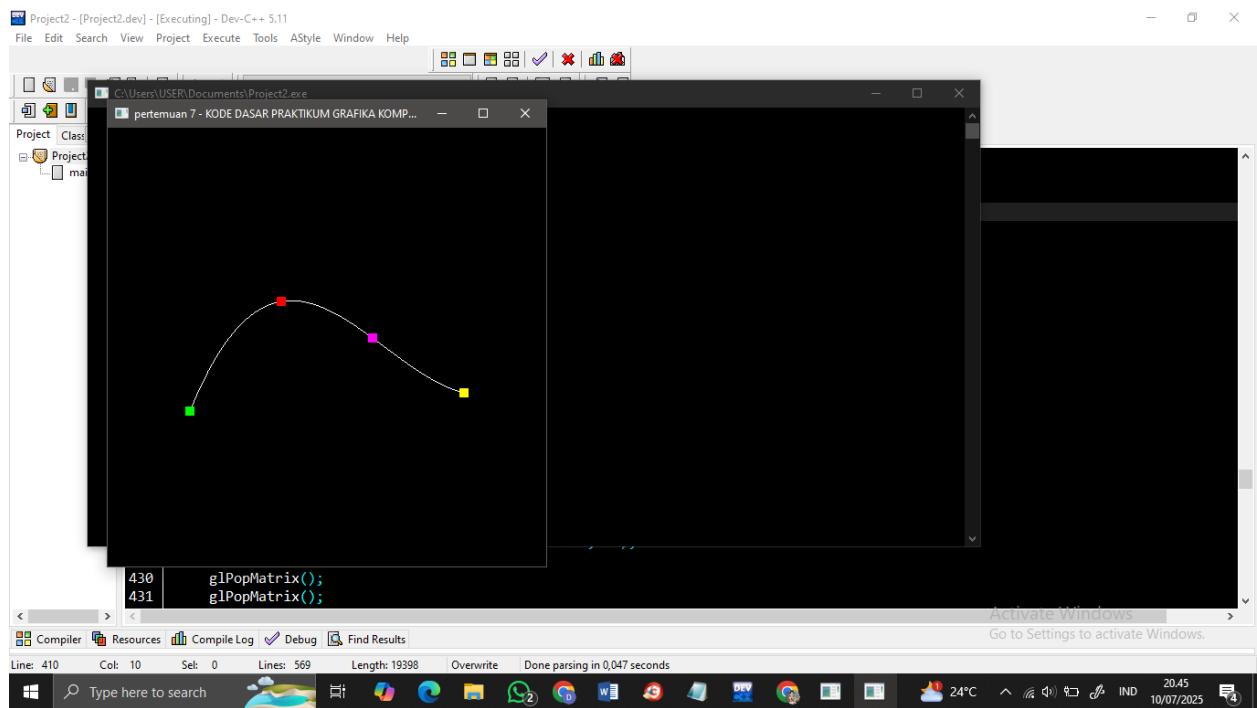
The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has various icons for file operations. The main window displays the code for "main.cpp" under the "Project2" project. The code initializes OpenGL for an RGBA depth buffer, sets the window size to 480x480 at position 100, 100, and creates a window titled "pertemuan 7 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER". It then calls the init() function and sets up event handlers for display, reshape, and keyboard. The glutMainLoop() is called to start the loop. The status bar at the bottom shows the line number (Line: 580), column (Col: 2), selection (Sel: 0), lines (Lines: 580), length (Length: 19623), and parsing time (Done parsing in 0,047 seconds). The taskbar at the bottom shows various application icons.

```
556 // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
557 // GLUT_DEPTH berarti memakai depth buffer
558 glutInit(&argc, argv);
559 glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGBA | GLUT_DEPTH);
560
561 // set ukuran jendela tampilan
562 glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
563 glutInitWindowPosition(100, 100); // posisi jendela di layar komputer dalam piksel
564 // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
565 glutCreateWindow("pertemuan 7 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");
566
567 // panggil fungsi init untukinisialisasi awal
568 init();
569
570 // event handler untuk display, reshape dan keyboard
571 glutDisplayFunc(display); // display
572 glutReshapeFunc(reshape); // reshape
573 glutSpecialFunc(keyboard); // keyboard
574 //glutTimerFunc(0, timer, 0); // aktifkan timer bila perlu
575
576 // Looping
577 glutMainLoop();
578
579 return 0;
580
```

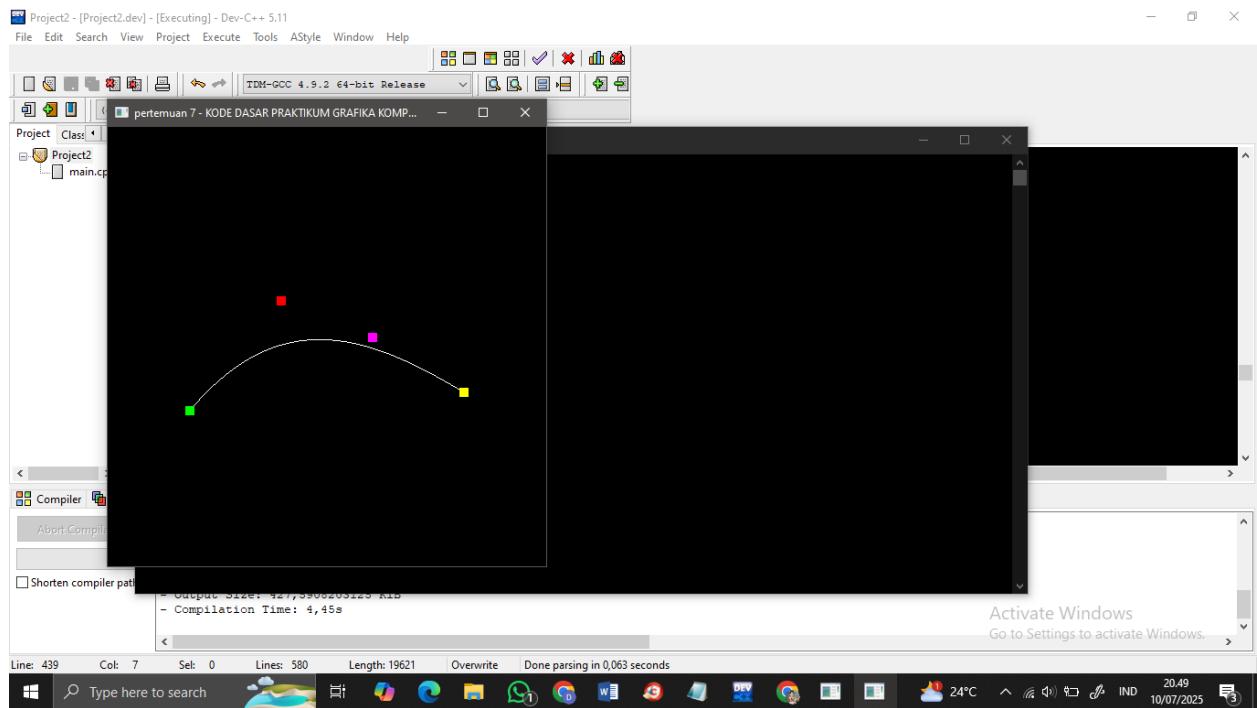
Output 1 laprak 7



Output 2 laprak 7

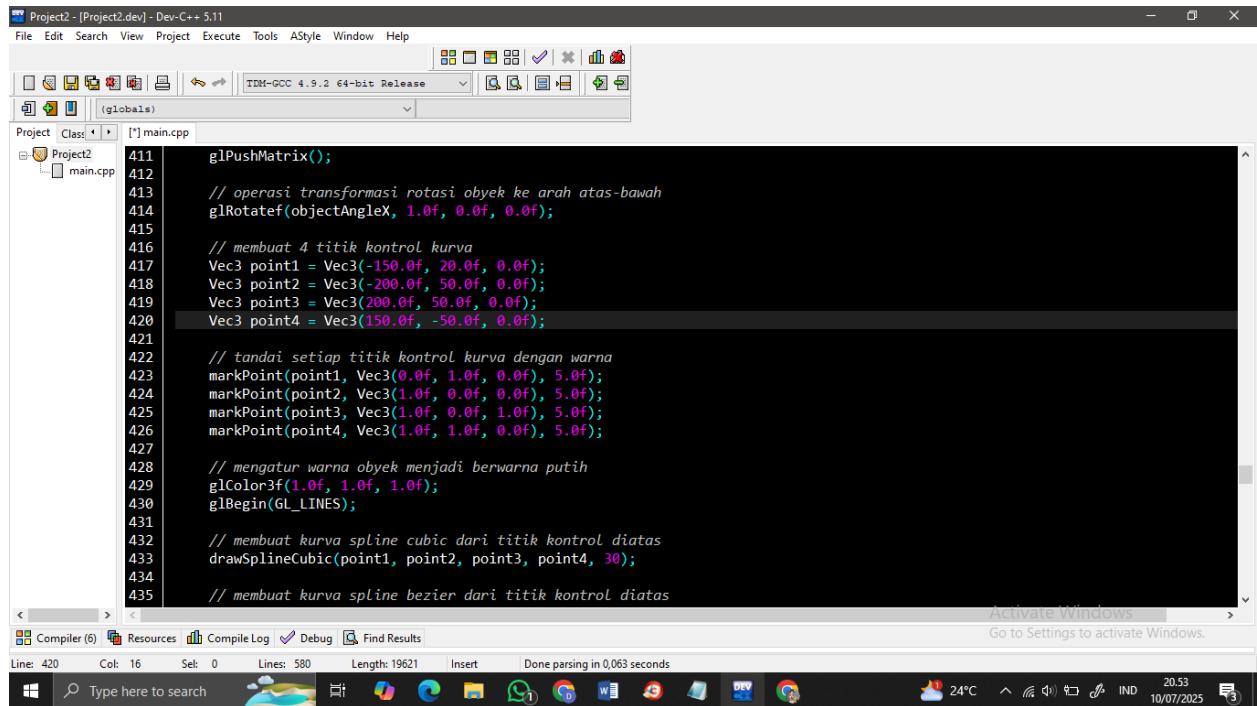


Output 3 laprak 7



Posttest 7

Gambar 8 posttest 7

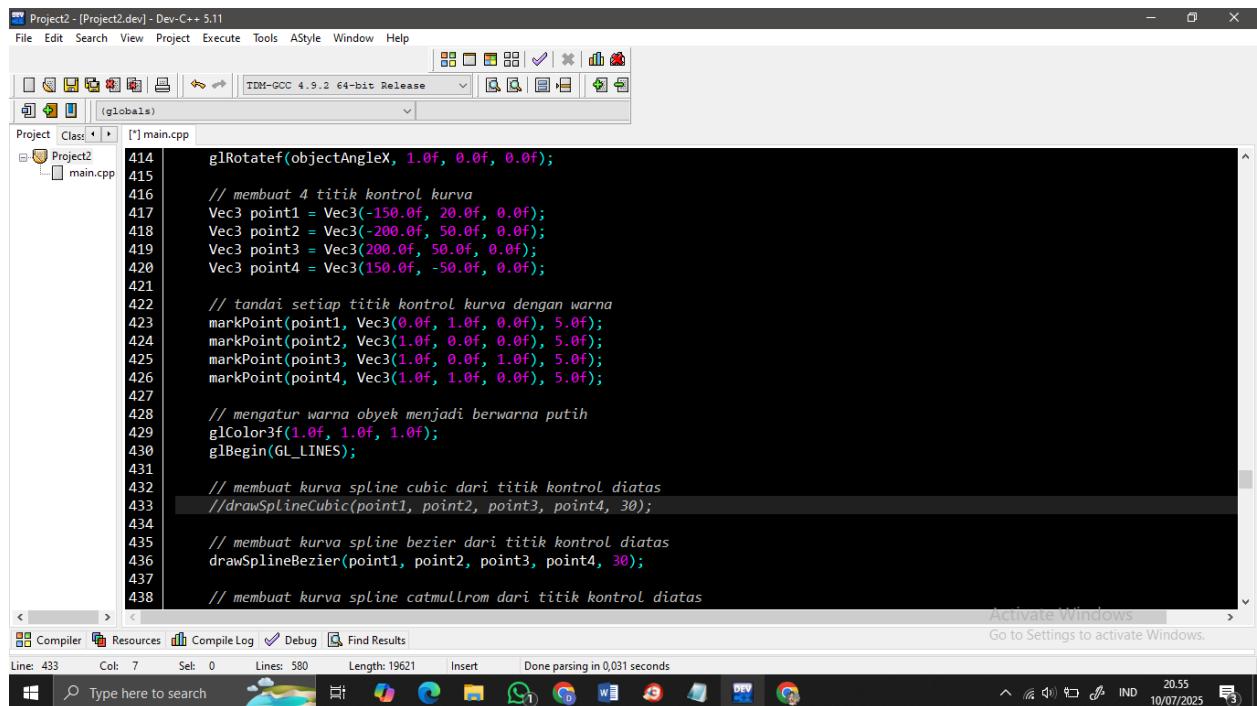


The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has various icons for file operations. The status bar at the bottom shows "Line: 420 Col: 16 Sel: 0 Lines: 580 Length: 19621 Insert Done parsing in 0.063 seconds". The code editor displays main.cpp with the following content:

```
411     glPushMatrix();
412
413     // operasi transformasi rotasi obyek ke arah atas-bawah
414     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
415
416     // membuat 4 titik kontrol kurva
417     Vec3 point1 = Vec3(-150.0f, 20.0f, 0.0f);
418     Vec3 point2 = Vec3(-200.0f, 50.0f, 0.0f);
419     Vec3 point3 = Vec3(200.0f, 50.0f, 0.0f);
420     Vec3 point4 = Vec3(150.0f, -50.0f, 0.0f);
421
422     // tandai setiap titik kontrol kurva dengan warna
423     markPoint(point1, Vec3(0.0f, 1.0f, 0.0f), 5.0f);
424     markPoint(point2, Vec3(1.0f, 0.0f, 0.0f), 5.0f);
425     markPoint(point3, Vec3(1.0f, 0.0f, 1.0f), 5.0f);
426     markPoint(point4, Vec3(1.0f, 1.0f, 0.0f), 5.0f);
427
428     // mengatur warna obyek menjadi berwarna putih
429     glColor3f(1.0f, 1.0f, 1.0f);
430     glBegin(GL_LINES);
431
432     // membuat kurva spline cubic dari titik kontrol diatas
433     drawSplineCubic(point1, point2, point3, point4, 30);
434
435     // membuat kurva spline bezier dari titik kontrol diatas
436     drawSplineBezier(point1, point2, point3, point4, 30);
437
438     // membuat kurva spline catmullrom dari titik kontrol diatas
```

The code uses OpenGL functions like glPushMatrix, glRotatef, Vec3, markPoint, glColor3f, glBegin, drawSplineCubic, drawSplineBezier, and drawSplineCatmullRom.

Gambar 2 posttest 7



The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has various icons for file operations. The status bar at the bottom shows "Line: 433 Col: 7 Sel: 0 Lines: 580 Length: 19621 Insert Done parsing in 0.031 seconds". The code editor displays main.cpp with the following content:

```
414     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
415
416     // membuat 4 titik kontrol kurva
417     Vec3 point1 = Vec3(-150.0f, 20.0f, 0.0f);
418     Vec3 point2 = Vec3(-200.0f, 50.0f, 0.0f);
419     Vec3 point3 = Vec3(200.0f, 50.0f, 0.0f);
420     Vec3 point4 = Vec3(150.0f, -50.0f, 0.0f);
421
422     // tandai setiap titik kontrol kurva dengan warna
423     markPoint(point1, Vec3(0.0f, 1.0f, 0.0f), 5.0f);
424     markPoint(point2, Vec3(1.0f, 0.0f, 0.0f), 5.0f);
425     markPoint(point3, Vec3(1.0f, 0.0f, 1.0f), 5.0f);
426     markPoint(point4, Vec3(1.0f, 1.0f, 0.0f), 5.0f);
427
428     // mengatur warna obyek menjadi berwarna putih
429     glColor3f(1.0f, 1.0f, 1.0f);
430     glBegin(GL_LINES);
431
432     // membuat kurva spline cubic dari titik kontrol diatas
433     //drawSplineCubic(point1, point2, point3, point4, 30);
434
435     // membuat kurva spline bezier dari titik kontrol diatas
436     drawSplineBezier(point1, point2, point3, point4, 30);
437
438     // membuat kurva spline catmullrom dari titik kontrol diatas
```

The code uses OpenGL functions like glPushMatrix, glRotatef, Vec3, markPoint, glColor3f, glBegin, drawSplineCubic, drawSplineBezier, and drawSplineCatmullRom.

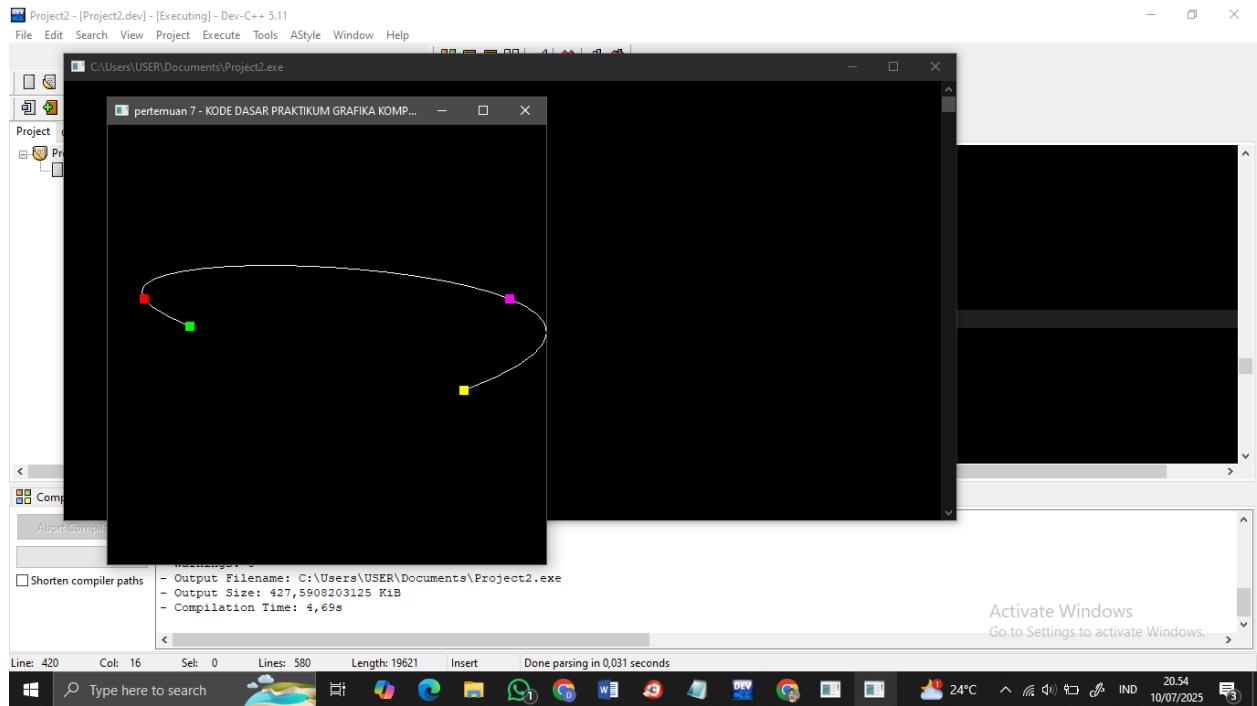
Gambar 2 postest 7

The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has various icons for file operations. The main window displays the code for "main.cpp". The code is as follows:

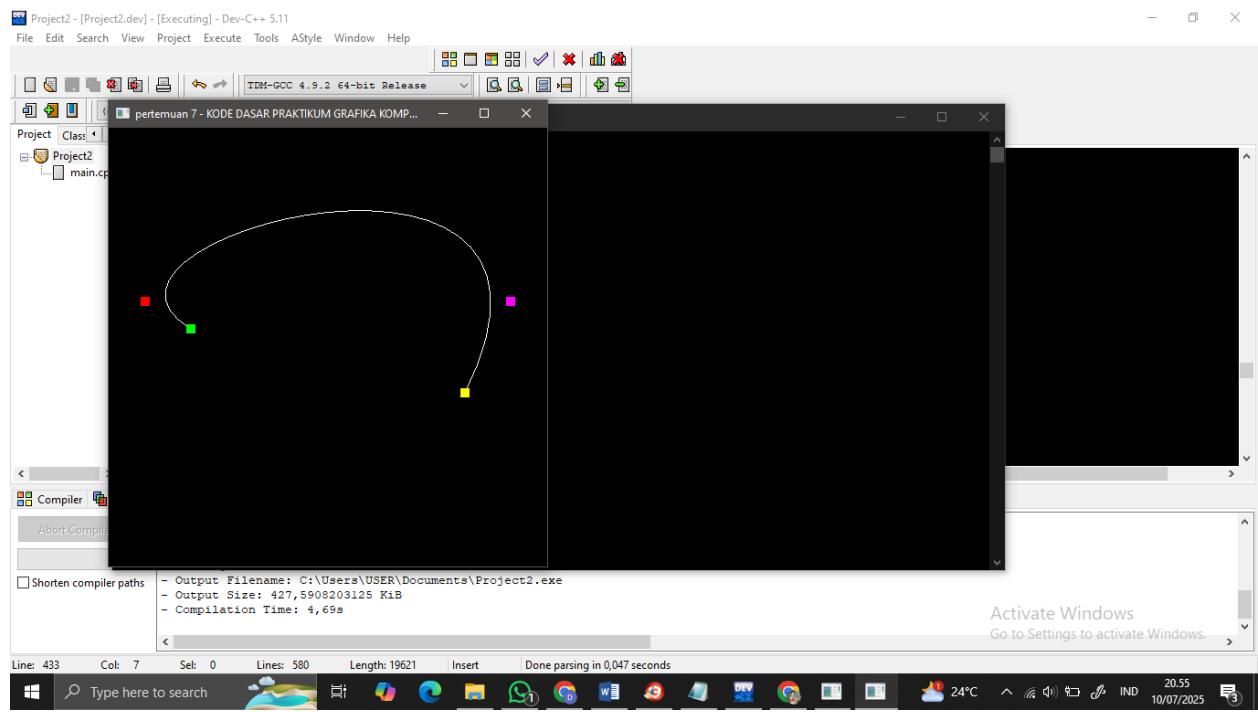
```
415 // membuat 4 titik kontrol kurva
416 Vec3 point1 = Vec3(-150.0f, 20.0f, 0.0f);
417 Vec3 point2 = Vec3(-200.0f, 50.0f, 0.0f);
418 Vec3 point3 = Vec3(200.0f, 50.0f, 0.0f);
419 Vec3 point4 = Vec3(150.0f, -50.0f, 0.0f);
420
421 // tandai setiap titik kontrol kurva dengan warna
422 markPoint(point1, Vec3(0.0f, 1.0f, 0.0f), 5.0f);
423 markPoint(point2, Vec3(1.0f, 0.0f, 0.0f), 5.0f);
424 markPoint(point3, Vec3(1.0f, 0.0f, 1.0f), 5.0f);
425 markPoint(point4, Vec3(1.0f, 1.0f, 0.0f), 5.0f);
426
427 // mengatur warna obyek menjadi berwarna putih
428 glColor3f(1.0f, 1.0f, 1.0f);
429 glBegin(GL_LINES);
430
431 // membuat kurva spline cubic dari titik kontrol diatas
432 //drawSplineCubic(point1, point2, point3, point4, 30);
433
434 // membuat kurva spline bezier dari titik kontrol diatas
435 //drawSplineBezier(point1, point2, point3, point4, 30);
436
437 // membuat kurva spline catmullRom dari titik kontrol diatas
438 drawSplineCatmullRom(point1, point2, point3, point4, 30);
439
```

The status bar at the bottom shows "Line: 439 Col: 5 Sel: 0 Lines: 580 Length: 19623 Insert Done parsing in 0,047 seconds". The taskbar at the bottom right includes icons for File Explorer, Edge, Google Chrome, Word, Excel, Dev-C++, and others, along with system status like 24°C, 10/07/2025, and battery level.

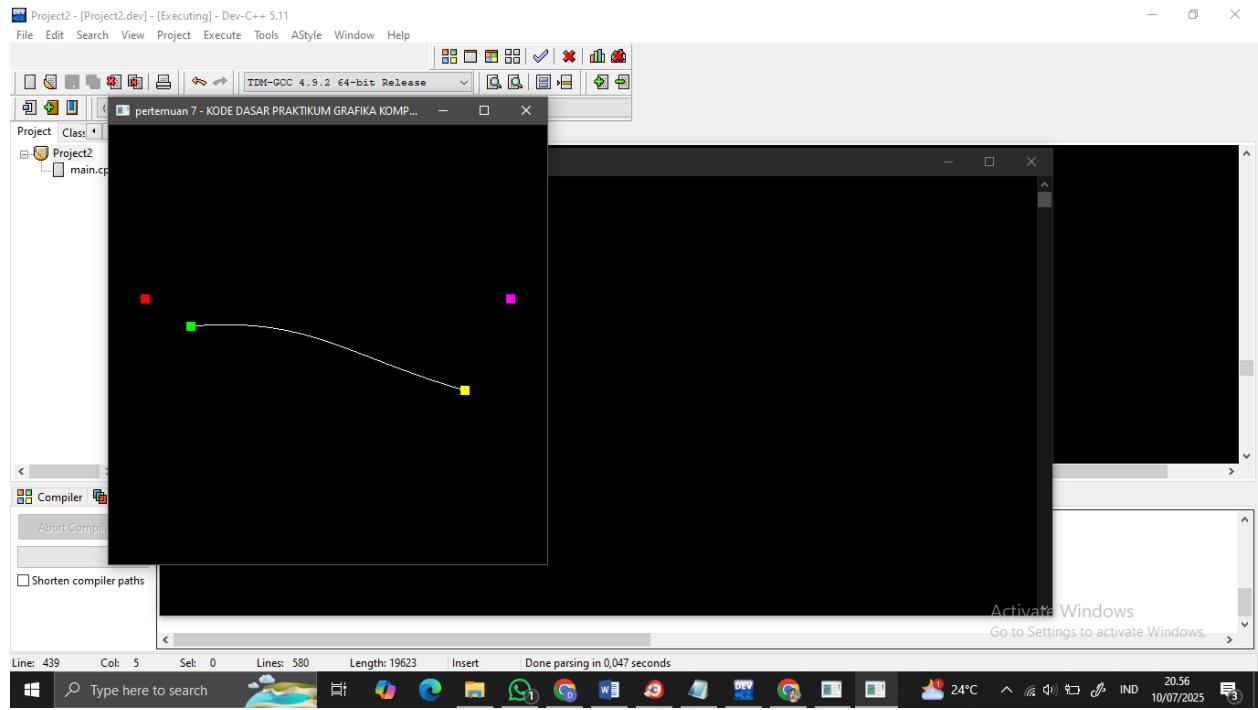
Output 1 postest 7



Output 2 postest 7



Output 2 postest 7



BAB VIII. TEKNIK REPRESENTASI PERMUKAAN

Pretest 8

Pertanyaan:

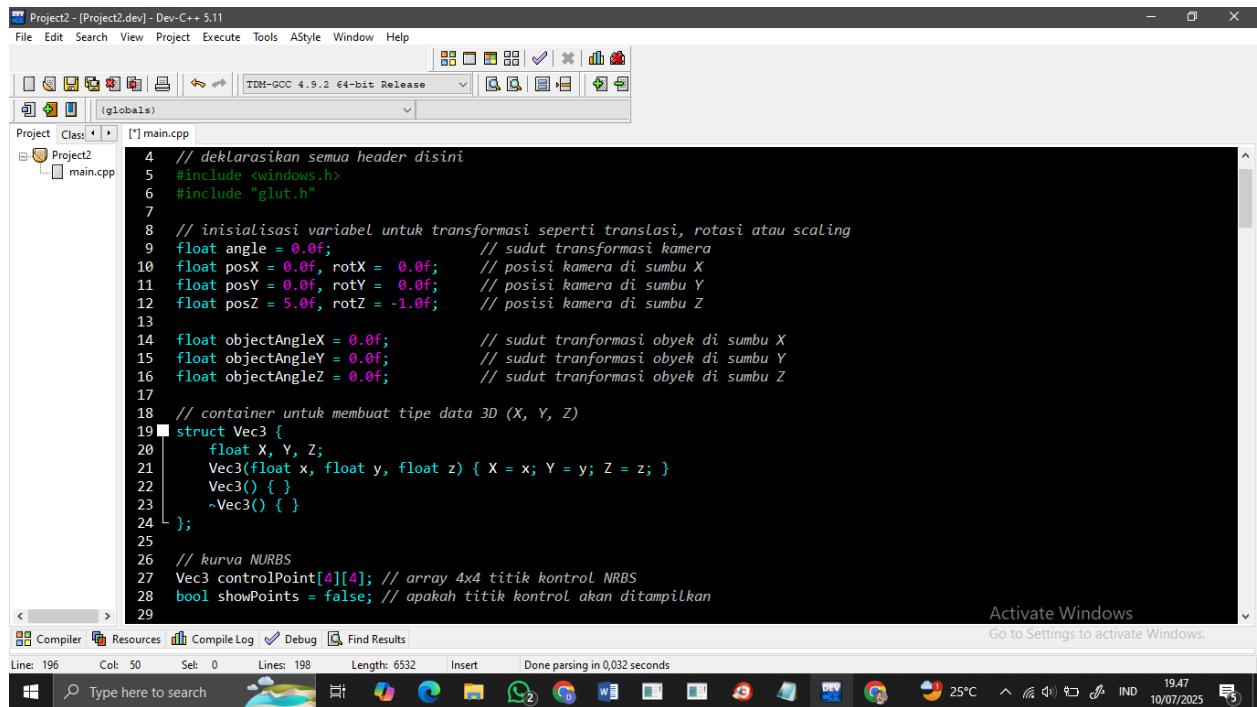
1. Sebutkan teknik representasi permukaan yang anda ketahui
2. Jelaskan setiap teknik representasi permukaan yang anda sebutkan di soal nomer 1

Jawaban:

1. Polygon mesh, b-spline, voxels, NURBS, dan bezier.
2. Polygon adalah kumpulan poligon yang menyusun permukaan 3D, b-spline adalah menggunakan basis b-spline untuk permukaan halus lebih fleksibel daripada bezier, NURBS adalah kurva dan permukaan halus berbasis persamaan sangat presisi untuk desain industri, voxels adalah 3D grid kubus kecil yang menyimpan nilai material, bisa merepresentasikan permukaan dengan volume, dan bezier adalah permukaan dibentuk dari kontrol titik lebih sederhana daripada NURBS.

Langkah Praktikum 8

Gambar 1 laprak 8



The screenshot shows the Dev-C++ IDE interface with the following details:

- Title Bar:** Project2 - [Project2.dev] - Dev-C++ 5.11
- Menu Bar:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help
- Toolbar:** Includes icons for file operations like Open, Save, Build, and Run.
- Toolbox:** Includes icons for Project, Class, and Global.
- Compiler Status:** TDM-GCC 4.9.2 64-bit Release
- Code Editor:** The main window displays C++ code for a NURBS implementation. The code includes declarations for camera variables, a Vec3 struct, and control points for a NURBS curve.

```
4 // deklarasikan semua header disini
5 #include <windows.h>
6 #include "glut.h"
7
8 // inisialisasi variabel untuk transformasi seperti translasi, rotasi atau scaling
9 float angle = 0.0f; // sudut transformasi kamera
10 float posX = 0.0f, rotX = 0.0f; // posisi kamera di sumbu X
11 float posY = 0.0f, rotY = 0.0f; // posisi kamera di sumbu Y
12 float posZ = 5.0f, rotZ = -1.0f; // posisi kamera di sumbu Z
13
14 float objectAngleX = 0.0f; // sudut transformasi obyek di sumbu X
15 float objectAngleY = 0.0f; // sudut transformasi obyek di sumbu Y
16 float objectAngleZ = 0.0f; // sudut transformasi obyek di sumbu Z
17
18 // container untuk membuat tipe data 3D (X, Y, Z)
19 struct Vec3 {
20     float X, Y, Z;
21     Vec3(float x, float y, float z) { X = x; Y = y; Z = z; }
22     Vec3() {}
23     ~Vec3() {}
24 };
25
26 // kurva NURBS
27 Vec3 controlPoint[4][4]; // array 4x4 titik kontrol NRBS
28 bool showPoints = false; // apakah titik kontrol akan ditampilkan
29
```

- Compiler Tab:** Shows the compiler status: Line: 196, Col: 50, Sel: 0, Lines: 198, Length: 6532, Insert, Done parsing in 0,032 seconds.
- Resources Tab:** Shows various system resources and settings.
- System Taskbar:** Shows the Windows taskbar with the Start button, search bar, and various pinned application icons.
- System Icons:** Shows battery level, signal strength, and system status icons.

Gambar 2 laprak 8

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 196 Col: 50 Sel: 0 Lines: 198 Length: 6532 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code:

```
28     bool showPoints = false; // apakah titik kontrol akan ditampilkan
29
30     // properti material untuk pencahayaan
31     GLfloat mat_diffuse[] = { 0.7, 0.7, 0.7, 0.0 };
32     GLfloat mat_specular[] = { 1.0, 1.0, 1.0, 1.0 };
33     GLfloat mat_shininess[] = { 100.0 };
34
35     GLUnurbsObj *theNurb; // pointer ke objek NURBS OpenGL
36
37     // fungsi untuk menggambar obyek
38     void drawObject() {
39         glPushMatrix();
40         glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f); // rotasi kanan-kiri
41
42         glPushMatrix();
43         glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f); // rotasi atas-bawah
44         glScalef(0.5, 0.5, 0.5); // skala obyek jadi setengah ukuran
45         glColor3f(0.0f, 1.0f, 0.0f); // warna hijau
46
47         GLfloat knots[8] = { 0.0, 0.0, 0.0, 0.0, 1.0, 1.0, 1.0, 1.0 };
48         gluBeginSurface(theNurb);
49         gluNurbsSurface(theNurb, 8, knots, 8, knots, 4 * 3, 3, &controlPoint[0][0].X, 4, 4, GL_MAP2_VERTEX_3);
50         gluEndSurface(theNurb);
51
52         if (showPoints) {
53             glPointSize(5.0);
```

Gambar 3 laprak 8

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 196 Col: 50 Sel: 0 Lines: 198 Length: 6532 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code:

```
52         if (showPoints) {
53             glPointSize(5.0);
54             glDisable(GL_LIGHTING); // supaya titik terlihat jelas
55             glColor3f(1.0, 1.0, 0.0); // warna kuning
56             glBegin(GL_POINTS);
57             for (int i = 0; i < 4; i++) {
58                 for (int j = 0; j < 4; j++) {
59                     glVertex3f(controlPoint[i][j].X, controlPoint[i][j].Y, controlPoint[i][j].Z);
60                 }
61             }
62             glEnd();
63             glEnable(GL_LIGHTING);
64         }
65
66         glPopMatrix(); // kembalikan transformasi rotasi X
67         glPopMatrix(); // kembalikan transformasi rotasi Y
68     }
69
70     // taruh semua obyek yang akan digambar di fungsi display()
71     void display() {
72         glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
73         glLoadIdentity(); // reset transformasi
74
75         // atur kamera
76         gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
77     }
```

Gambar 4 laprak 8

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 196 Col: 50 Sel: 0 Lines: 198 Length: 6532 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code:

```
70 // taruh semua obyek yang akan digambar di fungsi display()
71 void display() {
72     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
73     glLoadIdentity(); // reset transformasi
74
75     // atur kamera
76     gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
77
78     drawObject(); // panggil gambar obyek
79
80
81     glutSwapBuffers(); // tampilkan hasil di layar
82 }
83
84 // inisialisasi
85 void init(void) {
86     glClearColor(1.0, 1.0, 1.0, 0.0); // Latar belakang putih
87     glEnable(GL_DEPTH_TEST);
88     glMatrixMode(GL_PROJECTION); // ubah ke mode proyeksi
89     glLoadIdentity();
90     gluPerspective(45.0, 1.0, 1.0, 100.0);
91     glMatrixMode(GL_MODELVIEW);
92     glLoadIdentity();
93     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
94
95 // atur titik-titik kontrol permukaan
```

Gambar 5 laprak 8

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 196 Col: 50 Sel: 0 Lines: 198 Length: 6532 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code, which includes the code from Gambar 4 and adds more control point calculations:

```
85 void init(void) {
86     glClearColor(1.0, 1.0, 1.0, 0.0); // Latar belakang putih
87     glEnable(GL_DEPTH_TEST);
88     glMatrixMode(GL_PROJECTION); // ubah ke mode proyeksi
89     glLoadIdentity();
90     gluPerspective(45.0, 1.0, 1.0, 100.0);
91     glMatrixMode(GL_MODELVIEW);
92     glLoadIdentity();
93     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
94
95 // atur titik-titik kontrol permukaan
96 for (int u = 0; u < 4; u++) {
97     for (int v = 0; v < 4; v++) {
98         controlPoint[u][v].X = 2.0 * ((GLfloat)u - 1.5);
99         controlPoint[u][v].Y = 2.0 * ((GLfloat)v - 1.5);
100
101         // Mengatur posisi Z (ketinggian) dari titik kontrol
102         // Jika titik berada di bagian tengah (u = 1 atau 2 dan v = 1 atau 2)
103         // maka diberi nilai Z = 3.0 ? permukaan menonjol di tengah (cembung)
104         if ((u == 1 || u == 2) && (v == 1 || v == 2))
105             controlPoint[u][v].Z = 3.0;
106         else
107             // Selain titik tengah, diberi Z = -3.0 ? permukaan turun di pinggir
108             controlPoint[u][v].Z = -3.0;
109     }
110 }
```

Gambar 6 laprak 8

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 196 Col: 50 Sel: 0 Lines: 198 Length: 6532 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code:

```
112 // pengaturan pencahayaan dan material
113 glClearColor(0.0, 0.0, 0.0, 0.0); // Latar belakang hitam
114 glMaterialfv(GL_FRONT, GL_DIFFUSE, mat_diffuse);
115 glMaterialfv(GL_FRONT, GL_SPECULAR, mat_specular);
116 glMaterialfv(GL_FRONT, GL_SHININESS, mat_shininess);
117 glEnable(GL_LIGHTING);
118 glEnable(GL_LIGHT0);
119 glEnable(GL_DEPTH_TEST);
120 glEnable(GL_AUTO_NORMAL);
121 glEnable(GL_NORMALIZE);
122
123 // buat renderer NURBS
124 theNurb = gluNewNurbsRenderer();
125 gluNurbsProperty(theNurb, GLU_SAMPLING_TOLERANCE, 25.0); // tingkat kelengkungan
126 gluNurbsProperty(theNurb, GLU_DISPLAY_MODE, GLU_FILL); // isi permukaan
127 }
128
129 // fungsi ini digunakan bila layar akan diresize (default)
130 void reshape(int w, int h) {
131     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
132     glMatrixMode(GL_PROJECTION);
133     glLoadIdentity();
134     gluPerspective(45, (GLfloat)w / (GLfloat)h, 1.0, 100.0);
135     glMatrixMode(GL_MODELVIEW);
136 }
137
```

The code is annotated with comments explaining the setup of lighting and material properties, creation of a NURBS renderer, and handling window resize events.

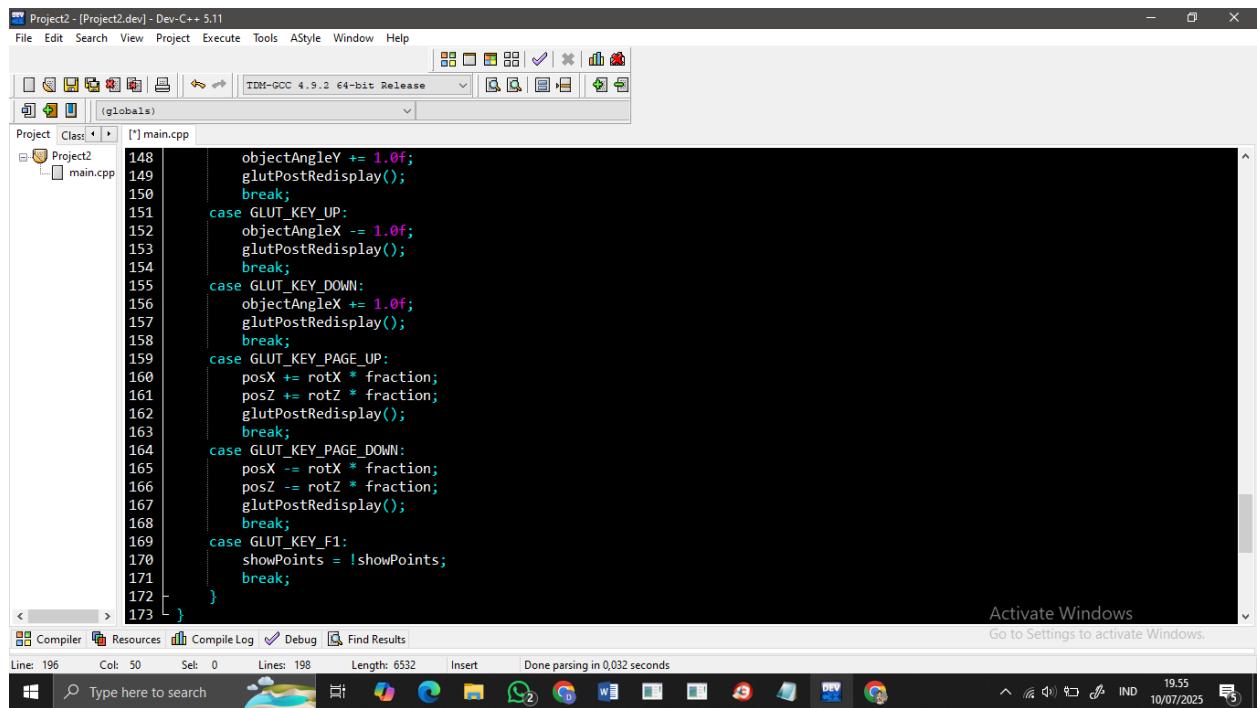
Gambar 7 laprak 8

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 196 Col: 50 Sel: 0 Lines: 198 Length: 6532 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code:

```
136 }
137
138 // fungsi untuk mengatur masukan dari keyboard
139 void keyboard(int key, int x, int y) {
140     float fraction = 0.1f;
141
142     switch (key) {
143     case GLUT_KEY_LEFT:
144         objectAngleY -= 1.0f;
145         glutPostRedisplay();
146         break;
147     case GLUT_KEY_RIGHT:
148         objectAngleY += 1.0f;
149         glutPostRedisplay();
150         break;
151     case GLUT_KEY_UP:
152         objectAngleX -= 1.0f;
153         glutPostRedisplay();
154         break;
155     case GLUT_KEY_DOWN:
156         objectAngleX += 1.0f;
157         glutPostRedisplay();
158         break;
159     case GLUT_KEY_PAGE_UP:
160         posX += rotX * fraction;
161         posY += rotY * fraction;
162         posZ += rotZ * fraction;
```

The code handles keyboard input for movement and rotation of a 3D object using glutPostRedisplay() to update the display.

Gambar 8 laprak 8

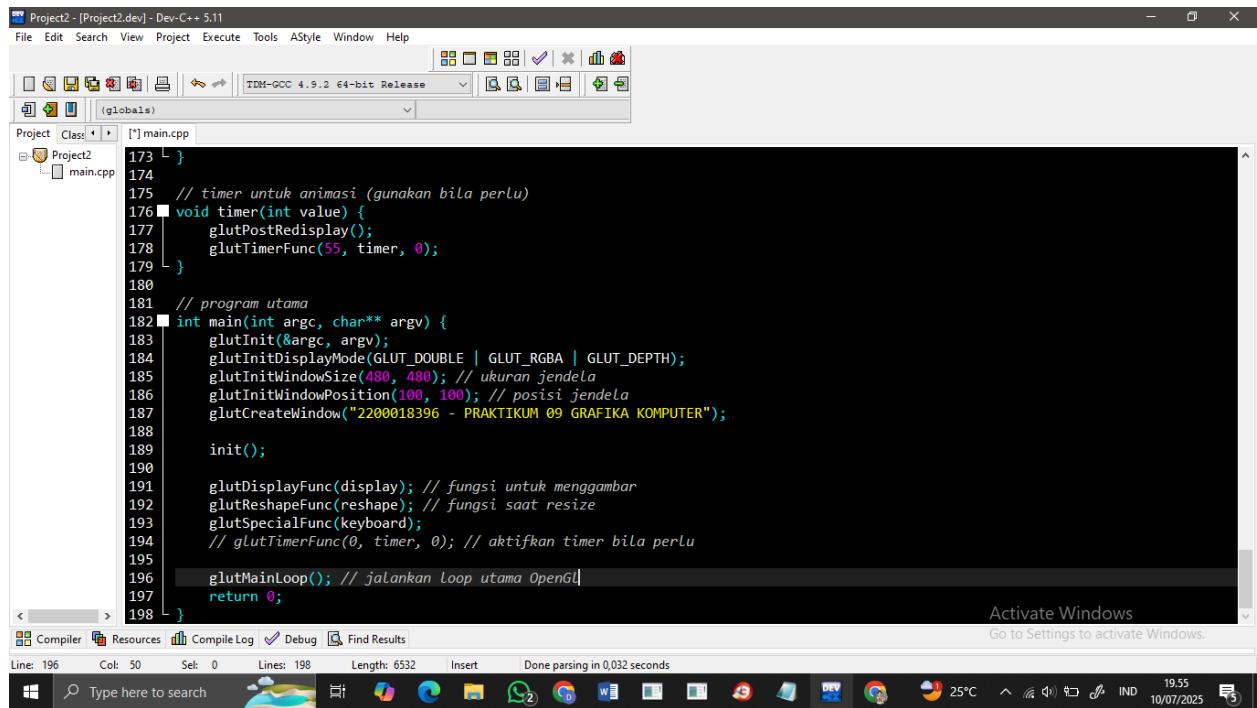


The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 196 Col: 50 Sel: 0 Lines: 198 Length: 6532 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code:

```
148     objectAngleY += 1.0f;
149     glutPostRedisplay();
150     break;
151     case GLUT_KEY_UP:
152         objectAngleX -= 1.0f;
153         glutPostRedisplay();
154         break;
155     case GLUT_KEY_DOWN:
156         objectAngleX += 1.0f;
157         glutPostRedisplay();
158         break;
159     case GLUT_KEY_PAGE_UP:
160         posX += rotX * fraction;
161         posY += rotZ * fraction;
162         glutPostRedisplay();
163         break;
164     case GLUT_KEY_PAGE_DOWN:
165         posX -= rotX * fraction;
166         posY -= rotZ * fraction;
167         glutPostRedisplay();
168         break;
169     case GLUT_KEY_F1:
170         showPoints = !showPoints;
171         break;
172     }
173 }
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 19:55 on 10/07/2025.

Gambar 9 laprak 8

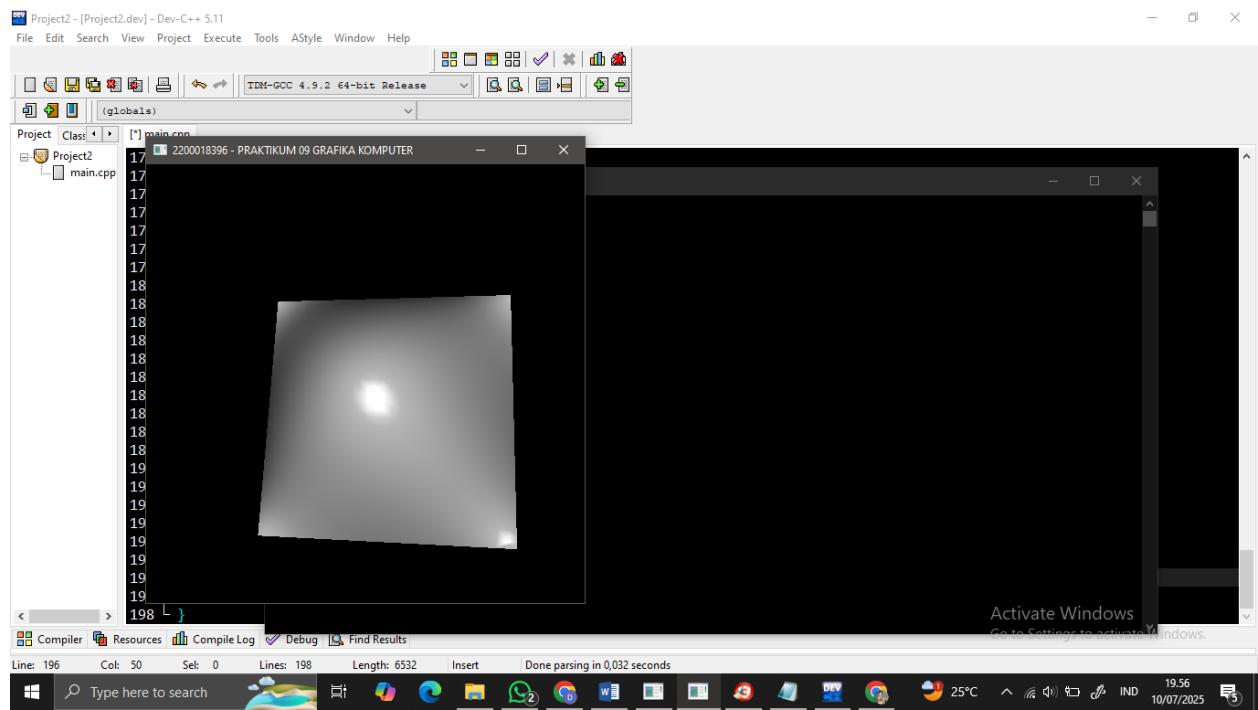


The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 196 Col: 50 Sel: 0 Lines: 198 Length: 6532 Insert Done parsing in 0,032 seconds". The code editor displays the following C++ code with comments:

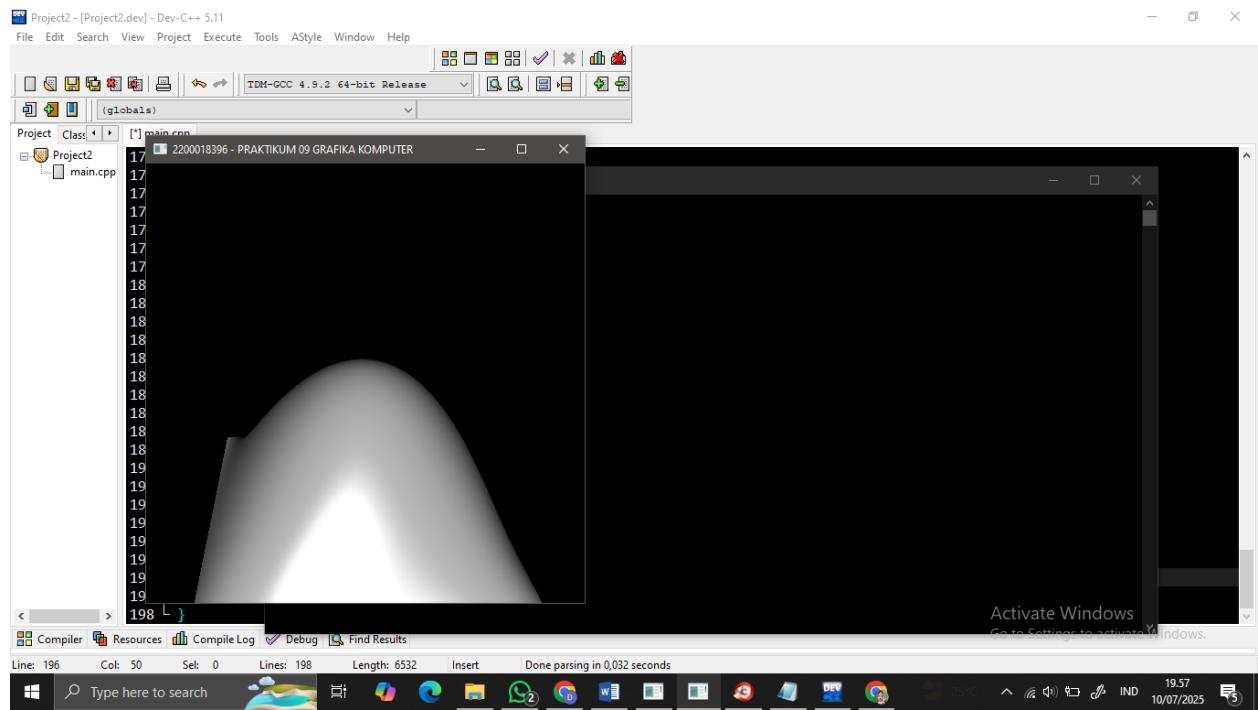
```
173 L }
174
175 // timer untuk animasi (gunakan bila perlu)
176 void timer(int value) {
177     glutPostRedisplay();
178     glutTimerFunc(55, timer, 0);
179 }
180
181 // program utama
182 int main(int argc, char** argv) {
183     glutInit(&argc, argv);
184     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
185     glutInitWindowSize(480, 480); // ukuran jendela
186     glutInitWindowPosition(100, 100); // posisi jendela
187     glutCreateWindow("2200018396 - PRAKTIKUM 09 GRAFIKA KOMPUTER");
188
189     init();
190
191     glutDisplayFunc(display); // fungsi untuk menggambar
192     glutReshapeFunc(reshape); // fungsi saat resize
193     glutSpecialFunc(keyboard);
194     // glutTimerFunc(0, timer, 0); // aktifkan timer bila perlu
195
196     glutMainLoop(); // jalankan Loop utama OpenGL
197     return 0;
198 }
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 25°C on 10/07/2025.

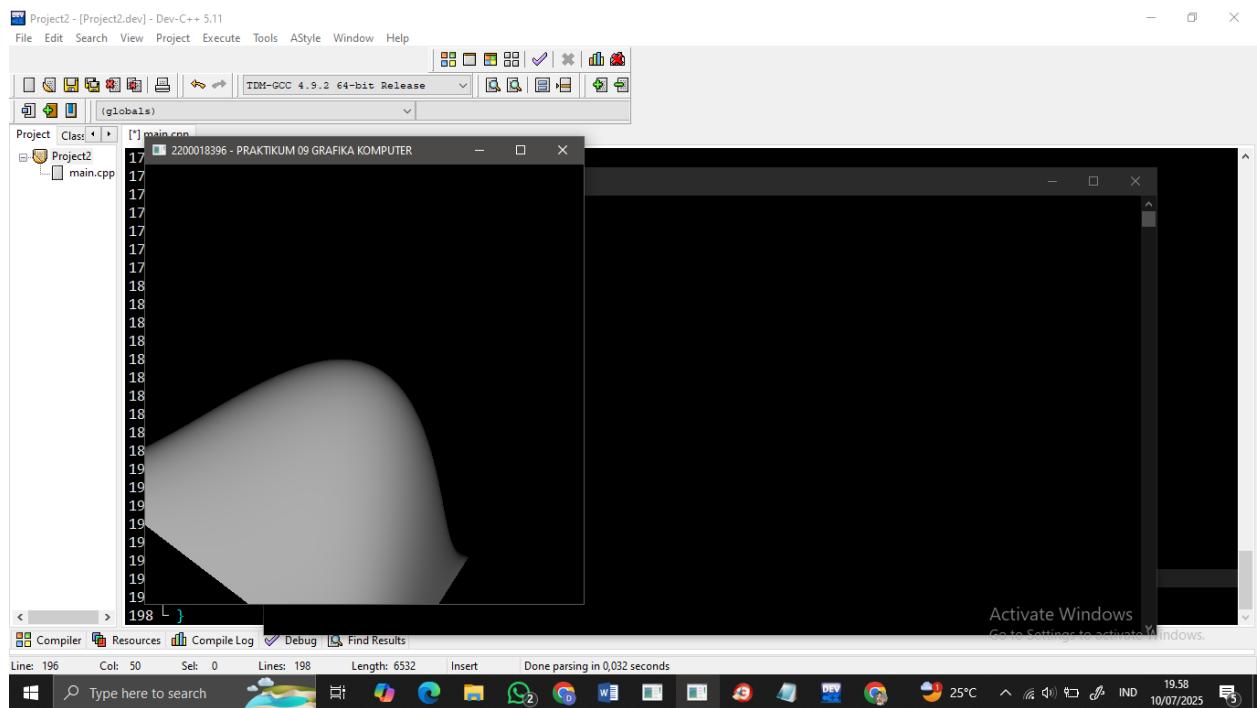
Output 9 posttest 8



Output 2 posttest 8



Output 3 posttest 8



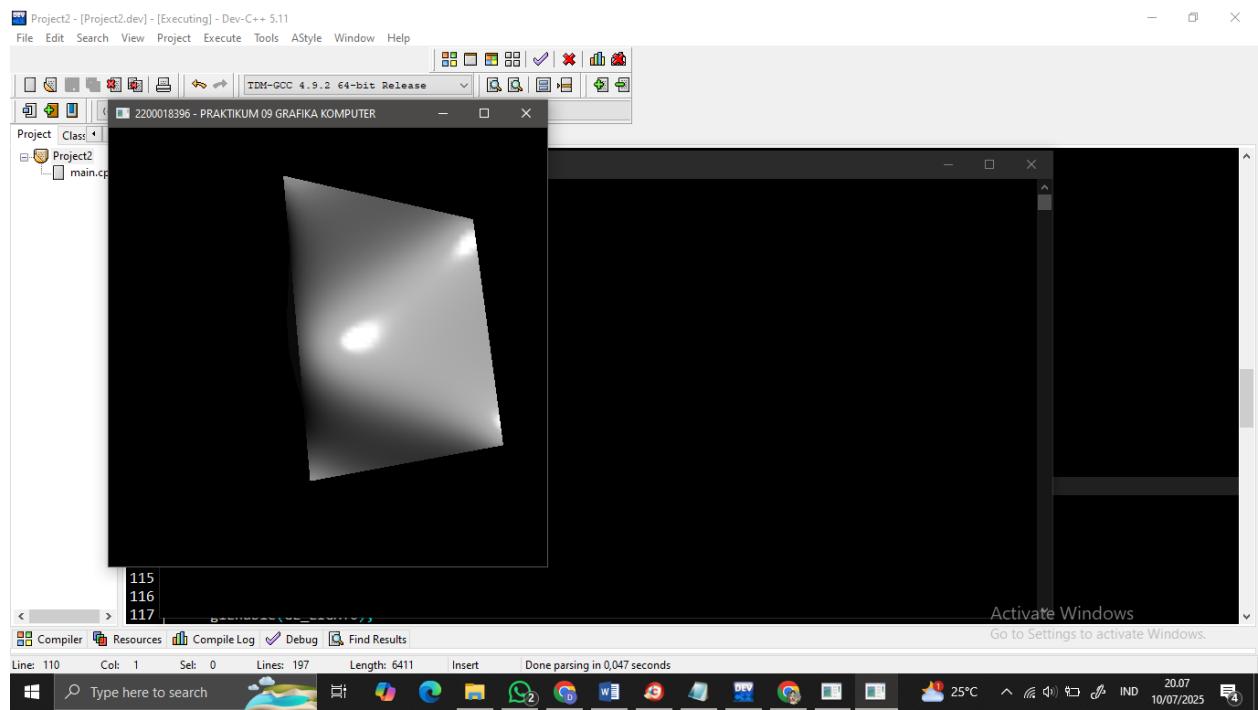
Posttest 8

Gambar 10 posttest 8

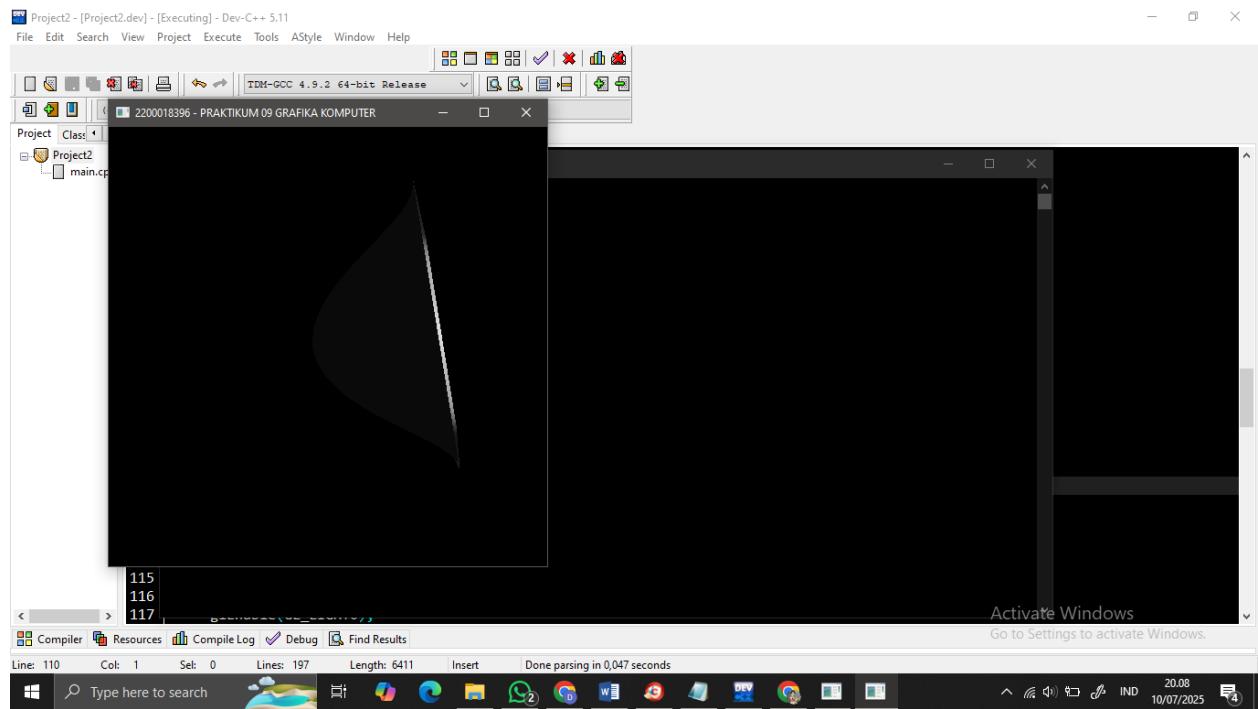
```
94
95 // atur titik-titik kontrol permukaan
96 for (int u = 0; u < 4; u++) {
97     for (int v = 0; v < 4; v++) {
98         controlPoint[u][v].X = 2.0 * ((GLfloat)u - 1.5);
99         controlPoint[u][v].Y = 2.0 * ((GLfloat)v - 1.5);

100
101     // Membuat permukaan menjorok ke dalam:
102     // Titik tengah ditarik ke bawah (Z = -3), pinggiran lebih tinggi (Z = 3)
103     if ((u == 1 || u == 2) && (v == 1 || v == 2))
104         controlPoint[u][v].Z = -3.0; // tengah cekung ke bawah
105     else
106         controlPoint[u][v].Z = 3.0; // pinggiran naik
107     }
108 }
109
```

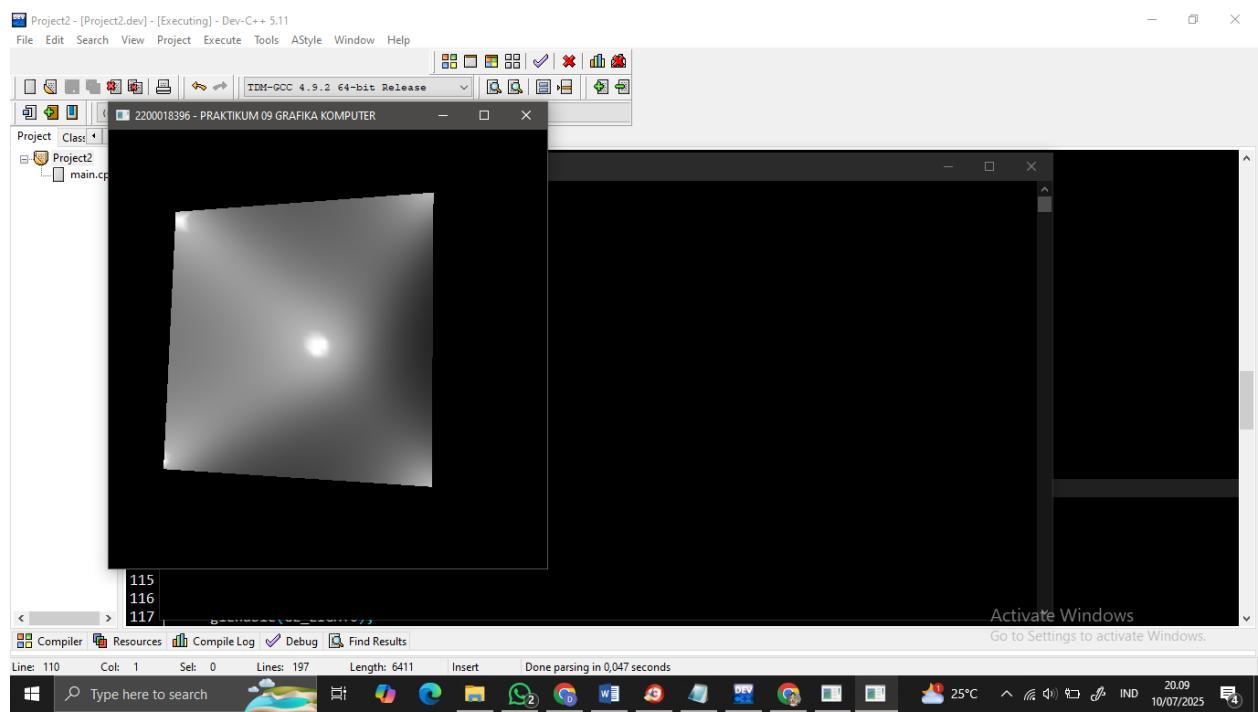
Output 1 postest 8



Output 2 postest 8



Output 3 postest 8



BAB IX. TEKNIK PEMODELAN OBYEK 3D

Pretest 9

Pertanyaan:

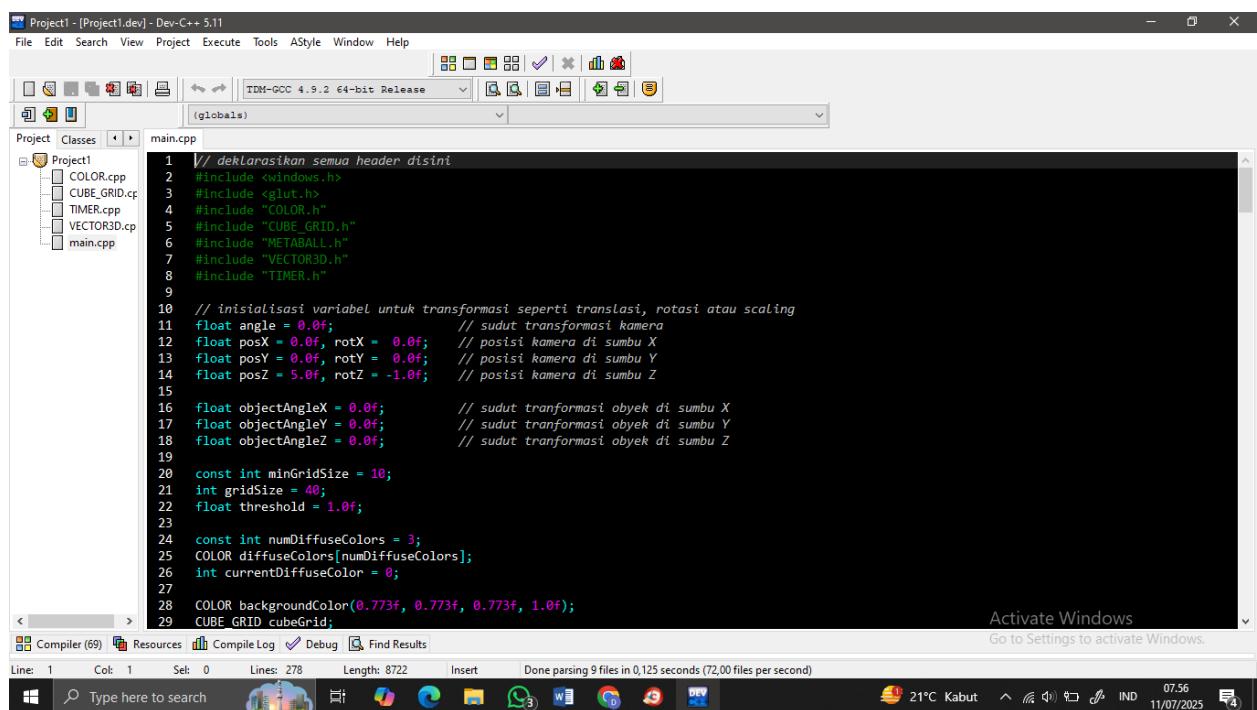
3. Sebutkan teknik pemodelan 3D yang anda ketahui
4. Jelaskan setiap teknik pemodelan 3D yang anda sebutkan di soal nomer 1

Jawaban:

1. Polygonal, NURBS, subdivision surface, box, procedural.
2. Polygonal adalah membangun objek dari poligon/segitiga/segiempat yang disusun membentuk permukaan, NURBS adalah pemodelan menggunakan kurva untuk permukaan halus (desain mobil/produk industri), subdivision surface adalah pemodelan yang memperhalus bentuk poligonal dengan membaginya menjadi poligon lebih kecil sehingga bentuk terlihat lebih mulus, box adalah pemodelan yang memulai dari bnetuk dasar lalu diekstrusi, discale, dipotong untuk membentuk detail, dan procedural adalah pemodelan yang menghasilkan bentuk dengan algoritma atau aturan (pohon, kota).

Langkah Praktikum 9

Gambar 1 laprak 9



```
// deklarasikan semua header disini
#include <windows.h>
#include <glut.h>
#include "COLOR.h"
#include "CUBE_GRID.h"
#include "METABALL.h"
#include "VECTOR3D.h"
#include "TIMER.h"

// inisialisasi variabel untuk transformasi seperti translasi, rotasi atau scaling
float angle = 0.0f; // sudut transformasi kamera
float posX = 0.0f, rotX = 0.0f; // posisi kamera di sumbu X
float posY = 0.0f, rotY = 0.0f; // posisi kamera di sumbu Y
float posZ = 5.0f, rotZ = -1.0f; // posisi kamera di sumbu Z

float objectAngleX = 0.0f; // sudut transformasi objek di sumbu X
float objectAngleY = 0.0f; // sudut transformasi objek di sumbu Y
float objectAngleZ = 0.0f; // sudut transformasi objek di sumbu Z

const int minGridSize = 10;
int gridSize = 40;
float threshold = 1.0f;

const int numDiffuseColors = 3;
COLOR diffuseColors[numDiffuseColors];
int currentDiffuseColor = 0;

COLOR backgroundColor(0.773f, 0.773f, 0.773f, 1.0f);
CUBE_GRID cubeGrid;
```

Gambar 2 laprak 9

The screenshot shows the Dev-C++ IDE interface with the title bar "Project1 - [Project1.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 16 Col: 29 Sel: 0 Lines: 278 Length: 8722 Insert Done parsing 9 files in 0,125 seconds (72,00 files per second)". The code editor displays main.cpp with the following content:

```
25 COLOR diffuseColors[numDiffuseColors];
26 int currentDiffuseColor = 0;
27
28 COLOR backgroundColor(0.773f, 0.773f, 0.773f, 1.0f);
29 CUBE_GRID cubeGrid;
30
31 const int numMetaballs = 3;
32 METABALL metaballs[numMetaballs];
33 TIMER timers;
34
35 //set up Lighting
36 float shininess = 32.0f;
37 float ambient[] = { 0.0f, 0.0f, 0.2f, 1.0f };
38 float position[] = { -1.0f, 1.0f, 1.0f, 0.0f };
39 float specular[] = { 1.0f, 1.0f, 1.0f, 1.0f };
40
41 // fungsi ini digunakan untuk menggambar objek
42 void drawObject()
43 {
44     glPushMatrix();
45
46     // glRotatef(objectAngle, objectRotation.X, objectRotation.Y,
47     //           objectRotation.Z);
48     glRotatef(objectAngleY, 0.0, 1.0f, 0.0f);
49
50     // dinormalisasi dulu
51     glEnable(GL_NORMALIZE);
52     glEnable(GL_CULL_FACE);
53 }
```

The code implements basic OpenGL rendering logic, including setting up lighting, defining a cube grid, and managing metaballs. It uses GL functions like glEnable, glPushMatrix, and glRotatef.

Gambar 3 laprak 9

The screenshot shows the Dev-C++ IDE interface with the title bar "Project1 - [Project1.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 16 Col: 29 Sel: 0 Lines: 278 Length: 8722 Insert Done parsing 9 files in 0,125 seconds (72,00 files per second)". The code editor displays main.cpp with the following content:

```
52     glEnable(GL_CULL_FACE);
53
54     gllightfv(GL_LIGHT1, GL_AMBIENT, ambient);
55     gllightfv(GL_LIGHT1, GL_DIFFUSE, diffuseColors[currentDiffuseColor]);
56     gllightfv(GL_LIGHT1, GL_POSITION, position);
57     gllightfv(GL_LIGHT1, GL_SPECULAR, specular);
58     glEnable(GL_LIGHT1);
59
60     // set pencahayaan
61     glMaterialfv(GL_FRONT, GL_AMBIENT_AND_DIFFUSE, white);
62     glMaterialfv(GL_FRONT, GL_SPECULAR, white);
63     glMaterialfv(GL_FRONT, GL_SHININESS, &shininess);
64
65     // update posisi metaball
66     float c = 2.0f*(float)cos(timers.GetTime() / 600);
67
68     metaballs[0].position.x = -4.0f*(float)cos(timers.GetTime()/700) - c;
69     metaballs[0].position.y = 4.0f*(float)sin(timers.GetTime()/600) - c;
70
71     metaballs[1].position.x = 5.0f*(float)sin(timers.GetTime()/400) + c;
72     metaballs[1].position.y = 5.0f*(float)cos(timers.GetTime()/400) - c;
73
74     metaballs[2].position.x = -5.0f*(float)cos(timers.GetTime()/600) -
75     0.2f*(float)sin(timers.GetTime() / 600);
76     metaballs[2].position.y = 5.0f*(float)sin(timers.GetTime()/500) -
77     0.2f*(float)sin(timers.GetTime() / 400);
78
79     // bersihkan layar
80     for (int i = 0; i < cubeGrid.numVertices; i++)
```

This version of the code adds lighting and metaball movement. It sets up a light source (GL_LIGHT1), defines materials for the front face, and updates the position of three metaballs over time using trigonometric functions.

Gambar 4 laprak 9

The screenshot shows the Dev-C++ IDE interface with the title bar "Project1 - [Project1.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 16 Col: 29 Sel: 0 Lines: 278 Length: 8722 Insert Done parsing 9 files in 0,125 seconds (72,00 files per second)". The code editor displays main.cpp with the following C++ code:

```
76     metaballs[2].position.y = 5.0f*(float)sin(timers.GetTime()/500) -
77     | 0.2f*(float)sin(timers.GetTime() / 400);
78     // bersihkan Layar
79     for (int i = 0; i < cubeGrid.numVertices; i++)
80     {
81         cubeGrid.vertices[i].value = 0.0f;
82         cubeGrid.vertices[i].normal.LoadZero();
83     }
84
85     // hitung jarak skalar disetiap titik
86     VECTOR3D ballToPoint;
87     float squaredRadius;
88     VECTOR3D ballPosition;
89     float normalScale;
90     for (int i = 0; i < numMetaballs; i++)
91     {
92         squaredRadius = metaballs[i].squaredRadius;
93         ballPosition = metaballs[i].position;
94         for (int j = 0; j < cubeGrid.numVertices; j++)
95         {
96             ballToPoint.x = cubeGrid.vertices[j].position.x -
97             | ballPosition.x;
98             ballToPoint.y = cubeGrid.vertices[j].position.y -
99             | ballPosition.y;
100            ballToPoint.z = cubeGrid.vertices[j].position.z -
101            | ballPosition.z;
102            // hitung jarak bola ke titik
103            float squaredDistance = ballToPoint.x*ballToPoint.x +
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
```

The code continues with calculations involving ball positions, squared distances, and normal scaling.

Gambar 5 laprak 9

The screenshot shows the Dev-C++ IDE interface with the title bar "Project1 - [Project1.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 16 Col: 29 Sel: 0 Lines: 278 Length: 8722 Insert Done parsing 9 files in 0,125 seconds (72,00 files per second)". The code editor displays main.cpp with the following C++ code:

```
97             ballToPoint.x = cubeGrid.vertices[j].position.x -
98             | ballPosition.x;
99             ballToPoint.y = cubeGrid.vertices[j].position.y -
100             | ballPosition.y;
101             ballToPoint.z = cubeGrid.vertices[j].position.z -
102             | ballPosition.z;
103             // hitung jarak bola ke titik
104             float squaredDistance = ballToPoint.x*ballToPoint.x +
105             | ballToPoint.y*ballToPoint.y + ballToPoint.z*ballToPoint.z;
106             if (squaredDistance == 0.0f)
107                 squaredDistance = 0.0001f;
108             // value = r^2/d^2
109             cubeGrid.vertices[j].value += squaredRadius / squaredDistance;
110             // normal = (r^2 * v)/d^4
111             normalScale = squaredRadius / (squaredDistance*squaredDistance);
112             cubeGrid.vertices[j].normal.x += ballToPoint.x*normalScale;
113             cubeGrid.vertices[j].normal.y += ballToPoint.y*normalScale;
114             cubeGrid.vertices[j].normal.z += ballToPoint.z*normalScale;
115         }
116     }
117     glPopMatrix();
118 }
119
120     // taruh semua fungsi obyek yang akan digambar di fungsi display()
121 void display()
122 {
123     // bersihkan dan reset Layar dan buffer
124     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
125     glLoadIdentity();
```

The code continues with the implementation of the display function, including clearing the buffer and setting the identity matrix.

Gambar 6 laprak 9

The screenshot shows the Dev-C++ IDE interface with the title bar "Project1 - [Project1.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 16 Col: 29 Sel: 0 Lines: 278 Length: 8722 Insert Done parsing 9 files in 0,125 seconds (72,00 files per second)". The code editor displays main.cpp with the following content:

```
118 L }
119
120 // taruh semua fungsi obyek yang akan digambar di fungsi display()
121 void display()
122 {
123     // bersihkan dan reset layar dan buffer
124     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
125     glLoadIdentity();
126
127     gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
128
129     glShadeModel(GL_SMOOTH);
130
131     // panggil fungsi untuk menggambar objek
132     drawObject();
133
134     glEnable(GL_LIGHTING);
135     glTranslatef(0.0f, 0.0f, -30.0f);
136     glRotatef((float)timers.getTime() / 30, 1.0f, 0.0f, 1.0f);
137     cubeGrid.DrawSurface(threshold);
138     glDisable(GL_LIGHTING);
139
140     cubeGrid.DrawSurface(threshold);
141
142     glutSwapBuffers();
143
144 // inisialisasikan variabel, pencahayaan, tekstur,
145 // pengaturan pandangan kamera dan sebagainya di fungsi init()
146 void init(void)
```

Gambar 7 laprak 9

The screenshot shows the Dev-C++ IDE interface with the title bar "Project1 - [Project1.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 16 Col: 29 Sel: 0 Lines: 278 Length: 8722 Insert Done parsing 9 files in 0,125 seconds (72,00 files per second)". The code editor displays main.cpp with the following content:

```
142     glutSwapBuffers();
143 }
144 // inisialisasikan variabel, pencahayaan, tekstur,
145 // pengaturan pandangan kamera dan sebagainya di fungsi init()
146 void init(void)
147 {
148     // inisialisasi warna latar belakang layar
149     // dalam hal ini warna putih warna putih (1.0, 1.0, 1.0, 0.0)
150     glClearColor(1.0, 1.0, 1.0, 0.0);
151     // mengaktifkan depth buffer
152     glEnable(GL_DEPTH_TEST);
153     glMatrixMode(GL_PROJECTION);
154     glLoadIdentity();
155     // set proyeksi ke proyeksi perspektif
156     gluPerspective(45.0, 1.0, 1.0, 100.0);
157     glMatrixMode(GL_MODELVIEW);
158     glLoadIdentity();
159     // inisialisasi kamera pandang
160     // kamera berada di posisi (0.0f, 0.0f, 0.0f)
161     gluLookAt(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
162
163     // set up grid
164     if (!cubeGrid.CreateMemory())
165     {
166         return;
167     }
168     if (!cubeGrid.Init(gridSize))
169     {
170         return;
171
172         // set up metaballs
173         for (int i = 0; i < numMetaballs; i++)
```

Gambar 8 laprak 9

The screenshot shows the Dev-C++ IDE interface with the title bar "Project1 - [Project1.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 16 Col: 29 Sel: 0 Lines: 278 Length: 8722 Insert Done parsing 9 files in 0,125 seconds (72,00 files per second)". The code editor displays main.cpp with the following content:

```
169     //set up metaballs
170     for (int i = 0; i < numMetaballs; i++)
171         metaballs[i].Init(VECTOR3D(0.0f, 0.0f, 0.0f), 5.0f + float(i));
172
173     //Set Up Colors
174     diffuseColors[0].Set(0.345f, 0.843f, 0.902f, 1.0f);
175     diffuseColors[1].Set(0.047f, 0.839f, 0.271f, 1.0f);
176     diffuseColors[2].Set(0.976f, 0.213f, 0.847f, 1.0f);
177
178     timers.Reset();
179 }
180
181 // fungsi ini digunakan bila Layar akan diresize (default)
182 void reshape(int w, int h)
183 {
184     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
185     glMatrixMode(GL_PROJECTION);
186     glLoadIdentity();
187     gluPerspective(45, (GLfloat)w / (GLfloat)h, 1.0, 100.0);
188     glMatrixMode(GL_MODELVIEW);
189 }
190
191 // fungsi untuk mengatur masukan dari keyboard
192 // untuk arah kiri, kanan, atas, bawah, PgUp, dan PgDn
193 void keyboard(int key, int x, int y)
194 {
195     float fraction = 0.1f;
196
197     switch (key)
198     {
199         // masukkan perintah disini bila tombol kiri ditekan
200         case GLUT_KEY_LEFT:
201             // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
202             objectAngleY -= 1.0f;
203             glutPostRedisplay(); // update obyek
204             break;
205         // masukkan perintah disini bila tombol kanan ditekan
206         case GLUT_KEY_RIGHT:
207             // dalam hal ini perintah rotasi obyek ke kanan sebanyak 1 derajat
208             objectAngleY += 1.0f;
209             glutPostRedisplay(); // update obyek
210             break;
211         // masukkan perintah disini bila tombol atas ditekan
212         case GLUT_KEY_UP:
213             // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
214             objectAngleX -= 1.0f;
215             glutPostRedisplay(); // update obyek
216             break;
217         // masukkan perintah disini bila tombol bawah ditekan
218         case GLUT_KEY_DOWN:
219             // dalam hal ini perintah rotasi obyek ke bawah sebanyak 1 derajat
220             objectAngleX += 1.0f;
221             glutPostRedisplay(); // update obyek
222     }
223 }
```

Gambar 9 laprak 9

The screenshot shows the Dev-C++ IDE interface with the title bar "Project1 - [Project1.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 16 Col: 29 Sel: 0 Lines: 278 Length: 8722 Insert Done parsing 9 files in 0,125 seconds (72,00 files per second)". The code editor displays main.cpp with the following content:

```
193 void keyboard(int key, int x, int y)
194 {
195     float fraction = 0.1f;
196
197     switch (key)
198     {
199         // masukkan perintah disini bila tombol kiri ditekan
200         case GLUT_KEY_LEFT:
201             // dalam hal ini perintah rotasi obyek ke kiri sebanyak 1 derajat
202             objectAngleY -= 1.0f;
203             glutPostRedisplay(); // update obyek
204             break;
205         // masukkan perintah disini bila tombol kanan ditekan
206         case GLUT_KEY_RIGHT:
207             // dalam hal ini perintah rotasi obyek ke kanan sebanyak 1 derajat
208             objectAngleY += 1.0f;
209             glutPostRedisplay(); // update obyek
210             break;
211         // masukkan perintah disini bila tombol atas ditekan
212         case GLUT_KEY_UP:
213             // dalam hal ini perintah rotasi obyek ke atas sebanyak 1 derajat
214             objectAngleX -= 1.0f;
215             glutPostRedisplay(); // update obyek
216             break;
217         // masukkan perintah disini bila tombol bawah ditekan
218         case GLUT_KEY_DOWN:
219             // dalam hal ini perintah rotasi obyek ke bawah sebanyak 1 derajat
220             objectAngleX += 1.0f;
221             glutPostRedisplay(); // update obyek
222     }
223 }
```

Gambar 10 laprak 9

The screenshot shows the Dev-C++ IDE interface with the title bar "Project1 - [Project1.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has various icons for file operations. The status bar at the bottom shows "Line: 16 Col: 29 Sel: 0 Lines: 278 Length: 8722 Insert Done parsing 9 files in 0,125 seconds (72,00 files per second)". The code editor displays main.cpp with the following content:

```
214     objectAngleX -= 1.0f;
215     glutPostRedisplay(); // update obyek
216     break;
217 // masukkan perintah disini bila tombol bawah ditekan
218 case GLUT_KEY_DOWN:
219     // dalam hal ini perintah rotasi obyek ke bawah sebanyak 1 derajat
220     objectAngleX += 1.0f;
221     glutPostRedisplay(); // update obyek
222     break;
223 // zoom in
224 case GLUT_KEY_PAGE_UP:
225     // masukkan perintah disini bila tombol PgUp ditekan
226     posx += rotX * fraction;
227     posz += rotZ * fraction;
228     glutPostRedisplay(); // update obyek
229     break;
230 // zoom out
231 case GLUT_KEY_PAGE_DOWN:
232     // masukkan perintah disini bila tombol PgDn ditekan
233     posx -= rotX * fraction;
234     posz -= rotZ * fraction;
235     glutPostRedisplay(); // update obyek
236     break;
237 }
238 }
239
240 // timer untuk animasi (gunakan bila perlu)
241 void timer(int value)
242 {

```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray with icons for weather (21°C), battery (07.59), and date (11/07/2025).

Gambar 12 laprak 9

The screenshot shows the Dev-C++ IDE interface with the title bar "Project1 - [Project1.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has various icons for file operations. The status bar at the bottom shows "Line: 252 Col: 49 Sel: 0 Lines: 278 Length: 8722 Insert Done parsing 9 files in 0,125 seconds (72,00 files per second)". The code editor displays main.cpp with the following content:

```
238 }
239
240 // timer untuk animasi (gunakan bila perlu)
241 void timer(int value)
242 {
243     glutPostRedisplay();
244     glutTimerFunc(55, timer, 0);
245 }
246
247 // program utama
248 int main(int argc, char** argv)
249 {
250     // inisialisasi jendela OpenGL
251     // GLUT_SINGLE berarti memakai single buffer
252     // GLUT_DOUBLE berarti memakai double buffer
253     // GLUT_RGB berarti mode tampilan yang dipakai RGB
254     // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
255     // GLUT_DEPTH berarti memakai depth buffer
256     glutInit(&argc, argv);
257     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
258
259     // set ukuran jendela tampilan
260     glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
261     glutInitWindowPosition(100, 100); // posisi jendela dilayar komputer dalam piksel
262     // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
263     glutCreateWindow("Dyah / 154 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");
264
265     // panggil fungsi init untuk inisialisasi awal
266     init();

```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray with icons for weather (21°C), battery (07.59), and date (11/07/2025).

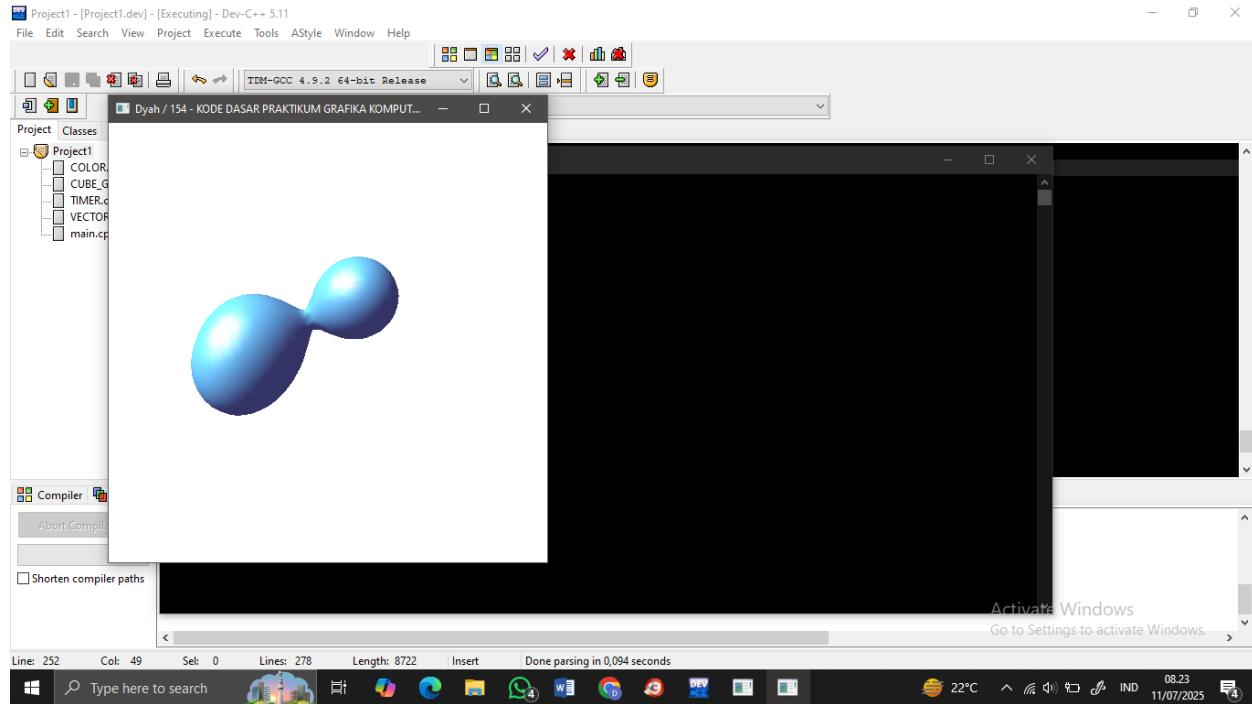
Gambar 13 laprak 9

The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project1 - [Project1.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has various icons for file operations. The status bar at the bottom shows "Line: 252 Col: 49 Sek 0 Lines: 278 Length: 8722 Insert Done parsing 9 files in 0,125 seconds (72,00 files per second)". The bottom right shows system information: 21°C Kabut 08.00 11/07/2025.

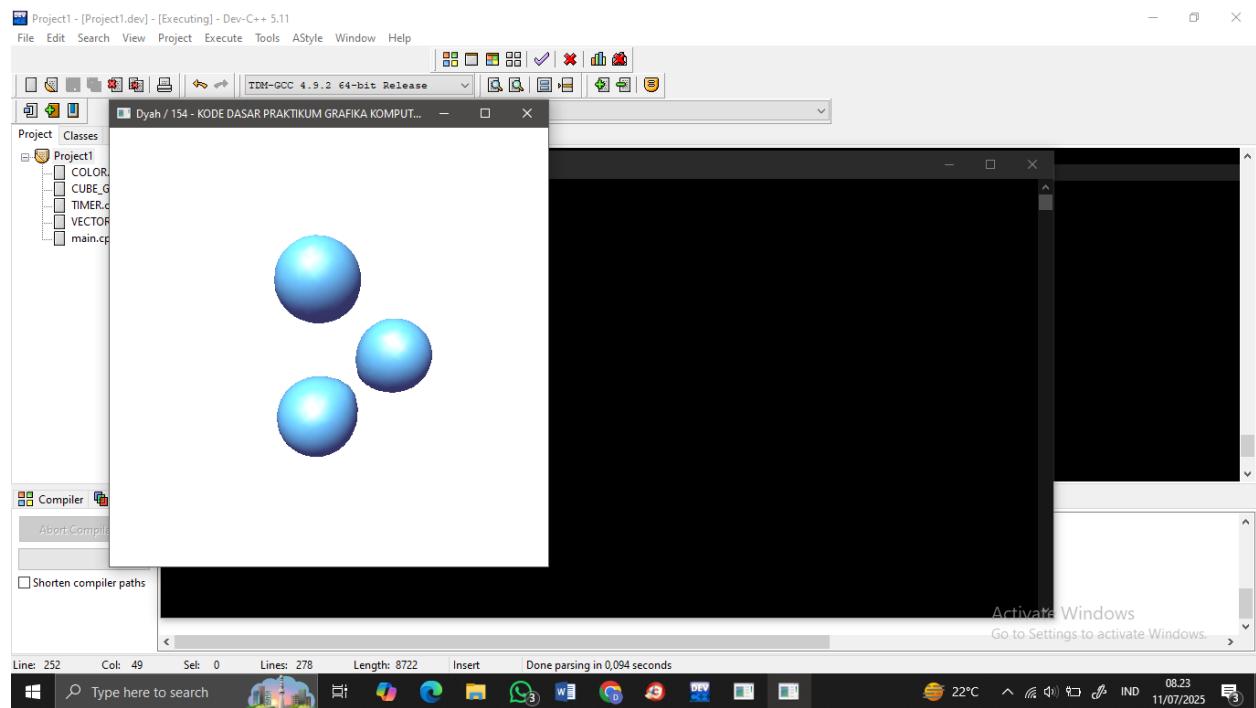
```
251 // GLUT_SINGLE berarti memakai single buffer
252 // GLUT_DOUBLE berarti memakai double buffer
253 // GLUT_RGB berarti mode tampilan yang dipakai RGB
254 // GLUT_RGBA berarti mode tampilan yang dipakai RGBA
255 // GLUT_DEPTH berarti memakai depth buffer
256 glutInit(&argc, &argv);
257 glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGBA | GLUT_DEPTH);

258 // set ukuran jendela tampilan
259 glutInitWindowSize(480, 480); // besarnya jendela dalam piksel dalam hal ini 300x300
260 glutInitWindowPosition(100, 100); // posisi jendela di layar komputer dalam piksel
261 // judul jendela (wajib diubah dengan informasi NAMA / NIM - JUDUL PRAKTIKUM masing-masing)
262 glutCreateWindow("Dyah / 154 - KODE DASAR PRAKTIKUM GRAFIKA KOMPUTER");
263
264 // panggil fungsi init untuk inisialisasi awal
265 init();
266
267 // event handler untuk display, reshape dan keyboard
268 glutDisplayFunc(display); // display
269 glutReshapeFunc(reshape); // reshape
270 glutSpecialFunc(keyboard); // keyboard
271 //glutTimerFunc(0, timer, 0); // aktifkan timer bila perlu
272
273 // Looping
274 glutMainLoop();
275
276
277
278 }
```

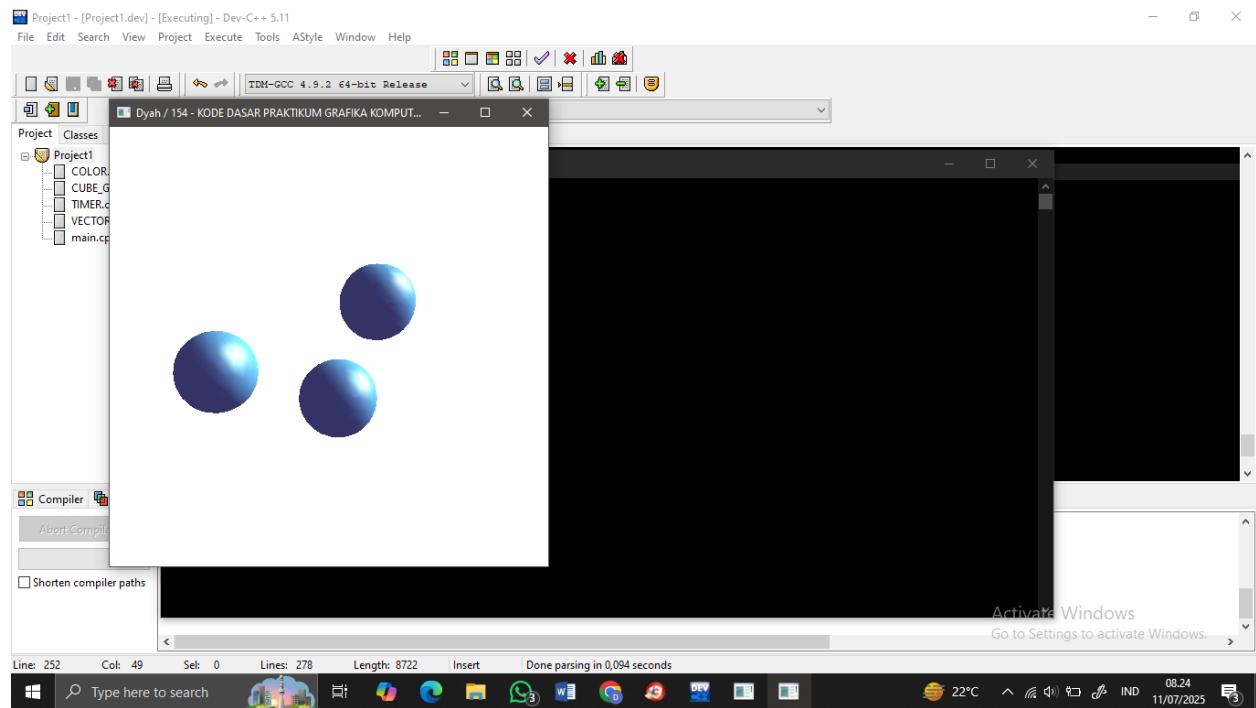
Output 1 laprak 9



Output 2 laprak 9

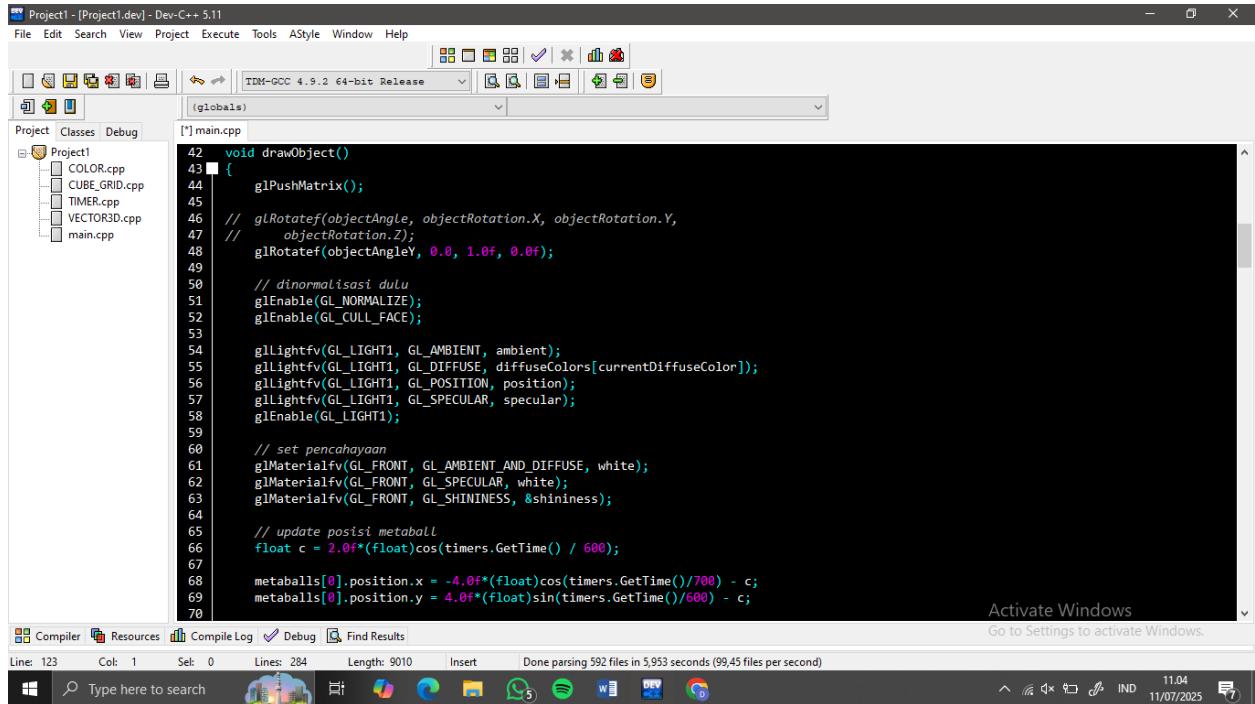


Output 3 laprak 9



Posttest 9

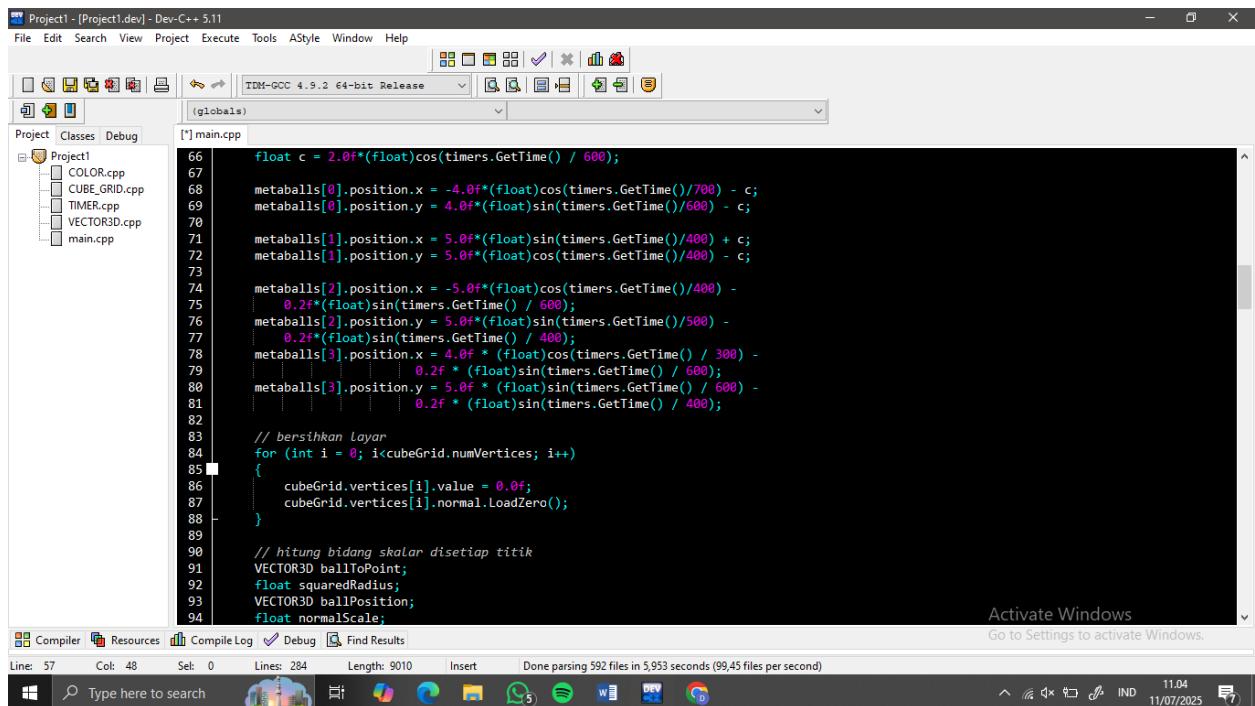
Gambar 11 posttest 9



The screenshot shows the Dev-C++ IDE interface with the following details:

- File Menu:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help.
- Toolbars:** Standard toolbar with icons for file operations, build, and search.
- Compiler:** TDM-GCC 4.9.2 64-bit Release.
- Project:** Project1 with files COLOR.cpp, CUBE_GRID.cpp, TIMER.cpp, VECTOR3D.cpp, and main.cpp.
- Code Editor:** The main window displays the content of main.cpp. The code defines a drawObject() function that sets up OpenGL states like matrix push/pop, lighting, and material properties for a front-facing cube. It also updates the position of metaballs based on time.
- Status Bar:** Shows Line: 123, Col: 1, Sel: 0, Lines: 284, Length: 9010, Insert, Done parsing 592 files in 5,953 seconds (99,45 files per second).
- Taskbar:** Shows the Windows Start button, a search bar, and various pinned application icons.
- System Tray:** Shows the date and time (11/07/2025) and other system icons.

Gambar 2 posttest 9



The screenshot shows the Dev-C++ IDE interface with the following details:

- File Menu:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help.
- Toolbars:** Standard toolbar with icons for file operations, build, and search.
- Compiler:** TDM-GCC 4.9.2 64-bit Release.
- Project:** Project1 with files COLOR.cpp, CUBE_GRID.cpp, TIMER.cpp, VECTOR3D.cpp, and main.cpp.
- Code Editor:** The main window displays the content of main.cpp. The code defines a drawObject() function that renders multiple metaballs (up to index 3) with periodic sine/cosine position updates. It also includes logic to clear the screen and calculate surface normals for each vertex.
- Status Bar:** Shows Line: 57, Col: 48, Sel: 0, Lines: 284, Length: 9010, Insert, Done parsing 592 files in 5,953 seconds (99,45 files per second).
- Taskbar:** Shows the Windows Start button, a search bar, and various pinned application icons.
- System Tray:** Shows the date and time (11/07/2025) and other system icons.

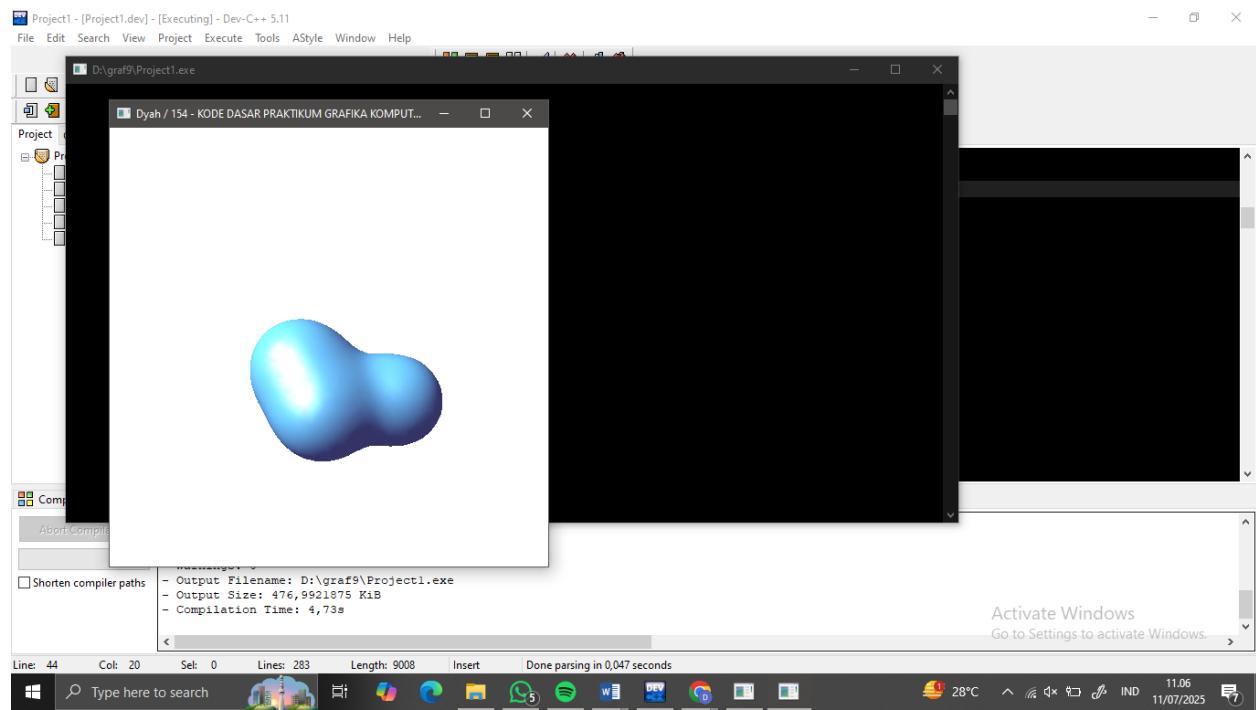
Gambar 3 postest 9

```
Project1 - [Project1.dev] - Dev-C++ 5.11
File Edit Search View Project Execute Tools AStyle Window Help
TDM-GCC 4.9.2 64-bit Release
(globals)
[*]main.cpp
Project Classes Debug
Project1
  COLOR.cpp
  CUBE_GRID.cpp
  TIMER.cpp
  VECTOR3D.cpp
  main.cpp
90 // hitung bidang skalar disetiap titik
91 VECTOR3D ballToPoint;
92 float squaredRadius;
93 VECTOR3D ballPosition;
94 float normalScale;
95 for (int i = 0; i<numMetaballs; i++)
96 {
97     squaredRadius = metaballs[i].squaredRadius;
98     ballPosition = metaballs[i].position;
99     for (int j = 0; j<cubeGrid.numVertices; j++)
100    {
101        ballToPoint.x = cubeGrid.vertices[j].position.x -
102            ballPosition.x;
103        ballToPoint.y = cubeGrid.vertices[j].position.y -
104            ballPosition.y;
105        ballToPoint.z = cubeGrid.vertices[j].position.z -
106            ballPosition.z;
107        // hitung jarak bola ke titik
108        float squaredDistance = ballToPoint.x*ballToPoint.x +
109            ballToPoint.y*ballToPoint.y + ballToPoint.z*ballToPoint.z;
110        if (squaredDistance == 0.0f)
111            squaredDistance = 0.0001f;
112        // value = r^2/d^2
113        cubeGrid.vertices[j].value += squaredRadius / squaredDistance;
114        // normal = (r^2 * v)/d^4
115        normalScale = squaredRadius / (squaredDistance*squaredDistance);
116        cubeGrid.vertices[j].normal.x += ballToPoint.x*normalScale;
117        cubeGrid.vertices[j].normal.y += ballToPoint.y*normalScale;
118        cubeGrid.vertices[j].normal.z += ballToPoint.z*normalScale;
119    }
120 }
121 g1PopMatrix();
122 }
123
124
Activate Windows
Go to Settings to activate Windows.
Compiler Resources Compile Log Debug Find Results
Line: 89 Col: 5 Sel: 0 Lines: 284 Length: 9010 Insert Done parsing 592 files in 5,953 seconds (99,45 files per second)
11/07/2025 11:05
```

Gambar 4 postest 9

```
Project1 - [Project1.dev] - Dev-C++ 5.11
File Edit Search View Project Execute Tools AStyle Window Help
TDM-GCC 4.9.2 64-bit Release
(globals)
[*]main.cpp
Project Classes Debug
Project1
  COLOR.cpp
  CUBE_GRID.cpp
  TIMER.cpp
  VECTOR3D.cpp
  main.cpp
96 {
97     squaredRadius = metaballs[i].squaredRadius;
98     ballPosition = metaballs[i].position;
99     for (int j = 0; j<cubeGrid.numVertices; j++)
100    {
101        ballToPoint.x = cubeGrid.vertices[j].position.x -
102            ballPosition.x;
103        ballToPoint.y = cubeGrid.vertices[j].position.y -
104            ballPosition.y;
105        ballToPoint.z = cubeGrid.vertices[j].position.z -
106            ballPosition.z;
107        // hitung jarak bola ke titik
108        float squaredDistance = ballToPoint.x*ballToPoint.x +
109            ballToPoint.y*ballToPoint.y + ballToPoint.z*ballToPoint.z;
110        if (squaredDistance == 0.0f)
111            squaredDistance = 0.0001f;
112        // value = r^2/d^2
113        cubeGrid.vertices[j].value += squaredRadius / squaredDistance;
114        // normal = (r^2 * v)/d^4
115        normalScale = squaredRadius / (squaredDistance*squaredDistance);
116        cubeGrid.vertices[j].normal.x += ballToPoint.x*normalScale;
117        cubeGrid.vertices[j].normal.y += ballToPoint.y*normalScale;
118        cubeGrid.vertices[j].normal.z += ballToPoint.z*normalScale;
119    }
120 }
121 g1PopMatrix();
122 }
123
124
Activate Windows
Go to Settings to activate Windows.
Compiler Resources Compile Log Debug Find Results
Line: 111 Col: 41 Sel: 0 Lines: 284 Length: 9010 Insert Done parsing 592 files in 5,953 seconds (99,45 files per second)
11/07/2025 11:05
```

Output 1 postest 9



BAB X. TEKNIK SUBDIVISI

Pretest 10

Pertanyaan:

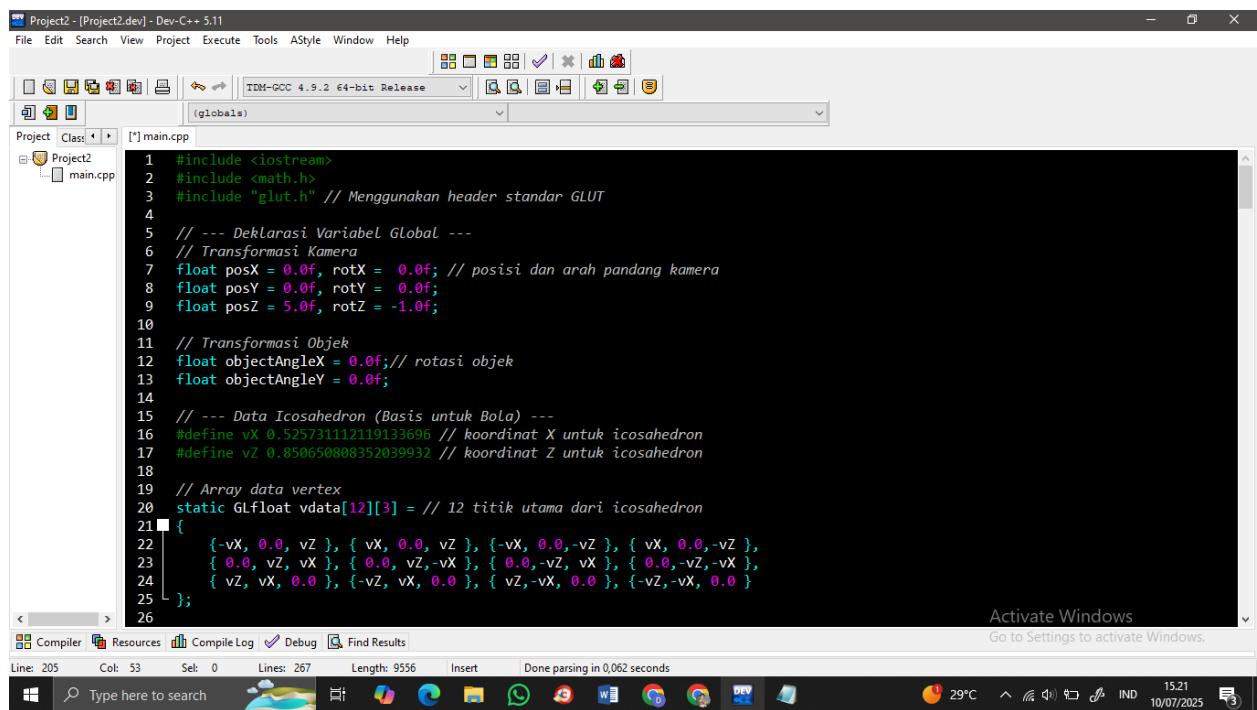
1. Bagaimana cara menerapkan subdivisi 2x pada permukaan segitiga?

Jawaban:

1. Cara menerapkan subdivisi 2x pada permukaan segitiga
 - Mencari titik tengah dari segitiga tersebut, kemudian bagi menjadi 4 sub bagian
 - Lakukan hal yang sama pada pembagian sub untuk subdivisi 2x, total dari segitiga tersebut adalah 16 segitiga

Langkah Praktikum 10

Gambar 12 pretest 10



```
#include <iostream>
#include <math.h>
#include "glut.h" // Menggunakan header standar GLUT
// --- Deklarasi Variabel Global ---
// Transformasi Kamera
float posX = 0.0f, rotX = 0.0f; // posisi dan arah pandang kamera
float posY = 0.0f, rotY = 0.0f;
float posZ = 5.0f, rotZ = -1.0f;
// Transformasi Objek
float objectAngleX = 0.0f; // rotasi objek
float objectAngleY = 0.0f;
// --- Data Icosahedron (Basis untuk Bola) ---
#define vX 0.525731112119133696 // koordinat X untuk icosahedron
#define vZ 0.850650808352039932 // koordinat Z untuk icosahedron
// Array data vertex
static GLfloat vdata[12][3] = // 12 titik utama dari icosahedron
{
    {-vX, 0.0, vZ}, { vX, 0.0, vZ }, {-vX, 0.0, -vZ }, { vX, 0.0, -vZ },
    { 0.0, vZ, vX }, { 0.0, vZ, -vX }, { 0.0, -vZ, vX }, { 0.0, -vZ, -vX },
    { vZ, vX, 0.0 }, { -vZ, vX, 0.0 }, { vZ, -vX, 0.0 }, { -vZ, -vX, 0.0 }
```

Gambar 2 pretest 10

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 14 Col: 1 Sel: 0 Lines: 267 Length: 9556 Insert Done parsing in 0,062 seconds". The code editor displays main.cpp with the following content:

```
25 L };
26
27 // Indeks untuk membentuk 20 segitiga dari 12 vertex
28 static int tindices[20][3] = {
29     {1,4,0}, {4,9,0}, {4,5,9}, {8,5,4}, {1,8,4},
30     {1,10,8}, {10,3,8}, {8,3,5}, {3,2,5}, {3,7,2},
31     {3,10,7}, {10,6,7}, {6,11,7}, {6,0,11}, {6,1,0},
32     {10,1,6}, {11,0,9}, {2,11,9}, {5,2,9}, {11,2,7}
33 };
34
35 // --- Properti Material dan Cahaya ---
36 GLfloat mat_specular[] = { 0.0, 0.0, 0.0, 1.0 }; // properti material (specular, diffuse, ambient)
37 GLfloat mat_diffuse[] = { 0.8, 0.6, 0.4, 1.0 };
38 GLfloat mat_ambient[] = { 0.8, 0.6, 0.4, 1.0 };
39 GLfloat mat_shininess = 100.0;
40
41 GLfloat light_ambient[] = { 0.2, 0.2, 0.2, 1.0 }; // properti cahaya (ambient, diffuse, specular)
42 GLfloat light_diffuse[] = { 1.0, 1.0, 1.0, 1.0 };
43 GLfloat light_specular[] = { 0.0, 0.0, 0.0, 1.0 };
44
45 GLfloat light_position1[] = { 1.5, 1.0, -2.0, 0.0 }; // Cahaya dari satu arah
46 GLfloat light_position2[] = { 1.5, 1.0, 2.0, 0.0 }; // Cahaya dari arah lain
47
48 int flat = 1;      // 1 = flat shading, 0 = smooth shading
49 int subdiv = 0;    // Level subdivisi (detail bola)
50
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 29°C, 15.23, and the date is 10/07/2025.

Gambar 3 pretest 10

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 38 Col: 37 Sel: 0 Lines: 267 Length: 9556 Insert Done parsing in 0,062 seconds". The code editor displays main.cpp with the following content:

```
49 int subdiv = 0;    // Level subdivisi (detail bola)
50
51 // --- Definisi Struktur dan Fungsi Utilitas ---
52 // Container untuk membuat tipe data 3D (X, Y, Z)
53 struct Vec3 {
54     float X, Y, Z;
55     Vec3(float x = 0, float y = 0, float z = 0) : X(x), Y(y), Z(z) {}
56 };
57
58 // Fungsi untuk melakukan normalisasi vektor (membuat panjangnya menjadi 1)
59 Vec3 normalize(Vec3 value) {
60     Vec3 result;
61     float length = sqrt((value.X * value.X) + (value.Y * value.Y) + (value.Z * value.Z));
62     if (length == 0.0f) return Vec3(0, 0, 0); // Mencegah pembagian dengan nol
63     result.X = value.X / length;
64     result.Y = value.Y / length;
65     result.Z = value.Z / length;
66     return result;
67 }
68
69 // Fungsi untuk operasi perkalian silang (cross product)
70 Vec3 cross(Vec3 value1, Vec3 value2) {
71     Vec3 result;
72     result.X = value1.Y * value2.Z - value2.Y * value1.Z;
73     result.Y = value1.Z * value2.X - value2.Z * value1.X;
74     result.Z = value1.X * value2.Y - value2.X * value1.Y;
75 }
```

The status bar also shows "Activate Windows Go to Settings to activate Windows." and the system tray indicates it's 29°C, 15.23, and the date is 10/07/2025.

Gambar 4 pretest 10

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 64 Col: 33 Sel: 0 Lines: 267 Length: 9556 Insert Done parsing in 0,062 seconds". The code editor displays C++ code for calculating cross products and drawing triangles with flat shading:

```
70 Vec3 cross(Vec3 value1, Vec3 value2) {
71     Vec3 result;
72     result.X = value1.Y * value2.Z - value2.Y * value1.Z;
73     result.Y = value1.Z * value2.X - value2.Z * value1.X;
74     result.Z = value1.X * value2.Y - value2.X * value1.Y;
75     return result;
76 }
77
78 // --- Fungsi Penggambaran ---
79
80 // Menghitung normal untuk satu permukaan segitiga (untuk flat shading)
81 void normface(Vec3 v1, Vec3 v2, Vec3 v3) {
82     Vec3 d1, d2;
83     d1.X = v1.X - v2.X; d1.Y = v1.Y - v2.Y; d1.Z = v1.Z - v2.Z;
84     d2.X = v2.X - v3.X; d2.Y = v2.Y - v3.Y; d2.Z = v2.Z - v3.Z;
85     Vec3 tn = cross(d1, d2);
86     tn = normalize(tn);
87     glNormal3f(tn.X, tn.Y, tn.Z);
88 }
89
90 // Menggambar segitiga dengan flat shading
91 void drawTriangleFlat(Vec3 v1, Vec3 v2, Vec3 v3) {
92     glBegin(GL_TRIANGLES);
93     normface(v1, v2, v3);
94     glVertex3f(v1.X, v1.Y, v1.Z);
95     glVertex3f(v2.X, v2.Y, v2.Z);
96     glVertex3f(v3.X, v3.Y, v3.Z);
97 }
98
99
100 // Menggambar segitiga dengan smooth shading
101 void drawTriangleSmooth(Vec3 v1, Vec3 v2, Vec3 v3) { // interpolasi normal tiap vertex
102     glBegin(GL_TRIANGLES);
103     glNormal3f(v1.X, v1.Y, v1.Z);
104     glVertex3f(v1.X, v1.Y, v1.Z);
105     glNormal3f(v2.X, v2.Y, v2.Z);
106     glVertex3f(v2.X, v2.Y, v2.Z);
107     glNormal3f(v3.X, v3.Y, v3.Z);
108     glVertex3f(v3.X, v3.Y, v3.Z);
109 }
110
111
112 // Fungsi rekursif untuk membagi segitiga menjadi 4 segitiga yang lebih kecil
113 void subdivide(Vec3 v1, Vec3 v2, Vec3 v3, int depth) {
114     Vec3 v12, v23, v31;
115     if (depth == 0) {
116         if (flat == 1)
```

Gambar 5 pretest 10

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 85 Col: 29 Sel: 0 Lines: 267 Length: 9556 Insert Done parsing in 0,062 seconds". The code editor displays C++ code for drawing triangles with smooth shading and recursive subdivision:

```
91 void drawTriangleFlat(Vec3 v1, Vec3 v2, Vec3 v3) {
92     glBegin(GL_TRIANGLES);
93     normface(v1, v2, v3);
94     glVertex3f(v1.X, v1.Y, v1.Z);
95     glVertex3f(v2.X, v2.Y, v2.Z);
96     glVertex3f(v3.X, v3.Y, v3.Z);
97 }
98
99
100 // Menggambar segitiga dengan smooth shading
101 void drawTriangleSmooth(Vec3 v1, Vec3 v2, Vec3 v3) { // interpolasi normal tiap vertex
102     glBegin(GL_TRIANGLES);
103     glNormal3f(v1.X, v1.Y, v1.Z);
104     glVertex3f(v1.X, v1.Y, v1.Z);
105     glNormal3f(v2.X, v2.Y, v2.Z);
106     glVertex3f(v2.X, v2.Y, v2.Z);
107     glNormal3f(v3.X, v3.Y, v3.Z);
108     glVertex3f(v3.X, v3.Y, v3.Z);
109 }
110
111
112 // Fungsi rekursif untuk membagi segitiga menjadi 4 segitiga yang lebih kecil
113 void subdivide(Vec3 v1, Vec3 v2, Vec3 v3, int depth) {
114     Vec3 v12, v23, v31;
115     if (depth == 0) {
116         if (flat == 1)
```

Gambar 6 pretest 10

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 105 Col: 34 Sel: 0 Lines: 267 Length: 9556 Insert Done parsing in 0,062 seconds". The code editor displays the following C++ code:

```
109     glEnd();
110 }
111
112 // Fungsi rekursif untuk membagi segitiga menjadi 4 segitiga yang lebih kecil
113 void subdivide(Vec3 v1, Vec3 v2, Vec3 v3, int depth) {
114     Vec3 v12, v23, v31;
115     if (depth == 0) {
116         if (flat == 1)
117             drawTriangleFlat(v1, v2, v3);
118         else
119             drawTriangleSmooth(v1, v2, v3);
120         return;
121     }
122     // Hitung titik tengah setiap sisi segitiga
123     v12.X = (v1.X + v2.X) / 2.0f; v12.Y = (v1.Y + v2.Y) / 2.0f; v12.Z = (v1.Z + v2.Z) / 2.0f;
124     v23.X = (v2.X + v3.X) / 2.0f; v23.Y = (v2.Y + v3.Y) / 2.0f; v23.Z = (v2.Z + v3.Z) / 2.0f;
125     v31.X = (v3.X + v1.X) / 2.0f; v31.Y = (v3.Y + v1.Y) / 2.0f; v31.Z = (v3.Z + v1.Z) / 2.0f;
126
127     // Normalisasi titik tengah agar berada di permukaan bola satuan
128     v12 = normalize(v12);
129     v23 = normalize(v23);
130     v31 = normalize(v31);
131
132     // Panggil subdivide lagi untuk 4 segitiga baru
133     subdivide(v1, v12, v31, depth - 1);
134     subdivide(v2, v23, v12, depth - 1);
135 }
```

Gambar 7 pretest 10

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has icons for file operations like Open, Save, and Build. The status bar at the bottom shows "Line: 141 Col: 20 Sel: 0 Lines: 267 Length: 9556 Insert Done parsing in 0,062 seconds". The code editor displays the following C++ code:

```
130     v31 = normalize(v31);
131
132     // Panggil subdivide lagi untuk 4 segitiga baru
133     subdivide(v1, v12, v31, depth - 1);
134     subdivide(v2, v23, v12, depth - 1);
135     subdivide(v3, v31, v23, depth - 1);
136     subdivide(v12, v23, v31, depth - 1);
137 }
138
139 // Fungsi untuk menggambar objek utama
140 void drawObject() {
141     glPushMatrix();
142
143     // Atur posisi cahaya
144     glLightfv(GL_LIGHT0, GL_POSITION, light_position1);
145     glLightfv(GL_LIGHT1, GL_POSITION, light_position2);
146
147     // Rotasi objek berdasarkan input keyboard
148     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f); // Kanan-kiri
149     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f); // Atas-bawah
150
151     // Gambar 20 segitiga dasar dari icosahedron
152     for (int i = 0; i < 20; i++) {
153         Vec3 v1(vdata[tindices[i][0][0]], vdata[tindices[i][0][1]], vdata[tindices[i][0][2]]);
154         Vec3 v2(vdata[tindices[i][1][0]], vdata[tindices[i][1][1]], vdata[tindices[i][1][2]]);
155         Vec3 v3(vdata[tindices[i][2][0]], vdata[tindices[i][2][1]], vdata[tindices[i][2][2]]);
```

Gambar 8 pretest 10

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has icons for file operations like Open, Save, Build, and Run. The status bar at the bottom shows "Line: 144 Col: 43 Sel: 0 Lines: 267 Length: 9556 Insert Done parsing in 0,062 seconds". The code editor displays C++ code for rendering a icosahedron:

```
151 // Gambar 20 segitiga dasar dari icosahedron
152 for (int i = 0; i < 20; i++) {
153     Vec3 v1(vdata[tindices[i][0]][0], vdata[tindices[i][0]][1], vdata[tindices[i][0]][2]);
154     Vec3 v2(vdata[tindices[i][1]][0], vdata[tindices[i][1]][1], vdata[tindices[i][1]][2]);
155     Vec3 v3(vdata[tindices[i][2]][0], vdata[tindices[i][2]][1], vdata[tindices[i][2]][2]);
156     subdivide(v1, v2, v3, subdiv);
157     // Baris-baris yang memodifikasi 'vdata' global telah dihapus karena menyebabkan error Logika.
158 }
159
160 glPopMatrix(); // kembalikan transformasi
161 }
162
163 // --- Fungsi Callback GLUT ---
164
165 // Fungsi display utama, dipanggil setiap kali layar perlu digambar ulang
166 void display() {
167     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
168     glLoadIdentity();
169     // atur kamera menggunakan gluLookAt
170     gluLookAt(posX, posY, posZ, posX + rotX, posY + rotY, posZ + rotZ, 0.0f, 1.0f, 0.0f);
171     drawObject(); // gambar objek
172     glutSwapBuffers();
173 }
174
175 // Fungsi inisialisasi OpenGL
176 void init() {
```

Gambar 9 pretest 10

The screenshot shows the Dev-C++ IDE interface with the title bar "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help. The toolbar has icons for file operations like Open, Save, Build, and Run. The status bar at the bottom shows "Line: 170 Col: 27 Sel: 0 Lines: 267 Length: 9556 Insert Done parsing in 0,062 seconds". The code editor displays C++ code for initializing OpenGL settings:

```
175 // Fungsi inisialisasi OpenGL
176 void init() {
177     glClearColor(1.0, 1.0, 1.0, 1.0); // Latar belakang putih
178     glEnable(GL_DEPTH_TEST);
179
180     // Pengaturan Projeksi
181     glMatrixMode(GL_PROJECTION);
182     glLoadIdentity();
183     gluPerspective(45.0, 1.0, 1.0, 100.0);
184     glMatrixMode(GL_MODELVIEW);
185     glLoadIdentity();
186
187     // Inisialisasi Pencahaayaan dan Material
188     gllightfv(GL_LIGHT0, GL_AMBIENT, light_ambient);
189     gllightfv(GL_LIGHT0, GL_DIFFUSE, light_diffuse);
190     gllightfv(GL_LIGHT0, GL_SPECULAR, light_specular);
191     gllightfv(GL_LIGHT1, GL_AMBIENT, light_ambient);
192     gllightfv(GL_LIGHT1, GL_DIFFUSE, light_diffuse);
193     gllightfv(GL_LIGHT1, GL_SPECULAR, light_specular);
194
195     // properti material objek
196     gIMaterialfv(GL_FRONT, GL_SPECULAR, mat_specular);
197     gIMaterialfv(GL_FRONT, GL_AMBIENT, mat_ambient);
198     gIMaterialfv(GL_FRONT, GL_DIFFUSE, mat_diffuse);
199     // FIX: Shininess adalah properti material (GL_FRONT), bukan cahaya (GL_LIGHT0)
200     gIMaterialf(GL_FRONT, GL_SHININESS, mat_shininess);
```

Gambar 10 pretest 10

```
Project2 - [Project2.dev] - Dev-C++ 5.11
File Edit Search View Project Execute Tools AStyle Window Help
WINGDIAPI void APIENTRY gllightfv (GLenum light, GLenum pname, const GLfloat *params)
File Project Class[*] main.cpp
Project2 main.cpp
199 // FIX: Shininess adalah properti material (GL_FRONT), bukan cahaya (GL_LIGHT0)
200 glMaterialf(GL_FRONT, GL_SHININESS, mat_shininess);
201
202 glShadeModel(GL_SMOOTH); // model shading default: smooth
203 glEnable(GL_LIGHTING); // aktifkan pencahayaan
204 glEnable(GL_LIGHT0); // aktifkan sumber cahaya 1
205 glEnable(GL_LIGHT1); // aktifkan sumber cahaya 2
206 }
207
208 // Fungsi yang dipanggil saat ukuran jendela diubah
209 void reshape(int w, int h) {
210     if (h == 0) h = 1;
211     glViewport(0, 0, (GLsizei)w, (GLsizei)h);
212     glMatrixMode(GL_PROJECTION);
213     glLoadIdentity();
214     gluPerspective(45.0, (GLfloat)w / (GLfloat)h, 1.0, 100.0);
215     glMatrixMode(GL_MODELVIEW);
216 }
217
218 // Fungsi untuk menangani input keyboard (tombol khusus)
219 void keyboard(int key, int x, int y) {
220     float fraction = 0.1f;
221     switch (key) {
222         case GLUT_KEY_LEFT:
223             objectAngleY -= 5.0f;
224             break;
225         case GLUT_KEY_RIGHT:
226             objectAngleY += 5.0f;
227             break;
228         case GLUT_KEY_UP:
229             objectAngleX -= 5.0f;
230             break;
231         case GLUT_KEY_DOWN:
232             objectAngleX += 5.0f;
233             break;
234         case GLUT_KEY_PAGE_UP:
235             posZ -= fraction * 5;
236             break;
237         case GLUT_KEY_PAGE_DOWN:
238             posZ += fraction * 5;
239             break; // FIX: Menambahkan 'break' yang hilang
240         case GLUT_KEY_F1: // Menambah detail
241             subdiv++; // FIX: Menambah detail
242             break;
}
Activate Windows
Go to Settings to activate Windows.
Compiler Resources Compile Log Debug Find Results
Line: 193 Col: 47 Sel: 0 Lines: 267 Length: 9556 Insert Done parsing in 0,062 seconds
Windows Type here to search TPIA 15.26 10/07/2025 IND
```

Gambar 11 pretest 10

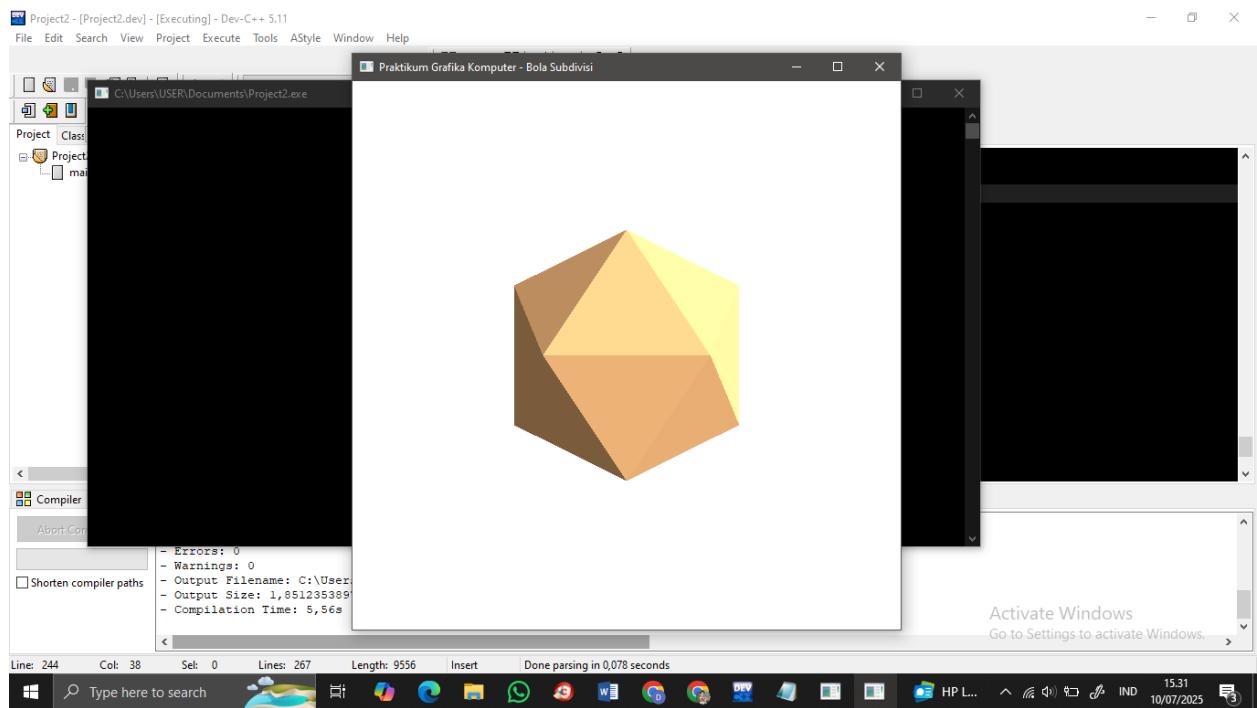
```
Project2 - [Project2.dev] - Dev-C++ 5.11
File Edit Search View Project Execute Tools AStyle Window Help
File Project Class[*] main.cpp
Project2 main.cpp
217
218 // Fungsi untuk menangani input keyboard (tombol khusus)
219 void keyboard(int key, int x, int y) {
220     float fraction = 0.1f;
221     switch (key) {
222         case GLUT_KEY_LEFT:
223             objectAngleY -= 5.0f;
224             break;
225         case GLUT_KEY_RIGHT:
226             objectAngleY += 5.0f;
227             break;
228         case GLUT_KEY_UP:
229             objectAngleX -= 5.0f;
230             break;
231         case GLUT_KEY_DOWN:
232             objectAngleX += 5.0f;
233             break;
234         case GLUT_KEY_PAGE_UP:
235             posZ -= fraction * 5;
236             break;
237         case GLUT_KEY_PAGE_DOWN:
238             posZ += fraction * 5;
239             break; // FIX: Menambahkan 'break' yang hilang
240         case GLUT_KEY_F1: // Menambah detail
241             subdiv++; // FIX: Menambah detail
242             break;
}
Activate Windows
Go to Settings to activate Windows.
Compiler Resources Compile Log Debug Find Results
Line: 214 Col: 44 Sel: 0 Lines: 267 Length: 9556 Insert Done parsing in 0,062 seconds
Windows Type here to search TPIA 15.26 10/07/2025 IND
```

Gambar 12 pretest 10

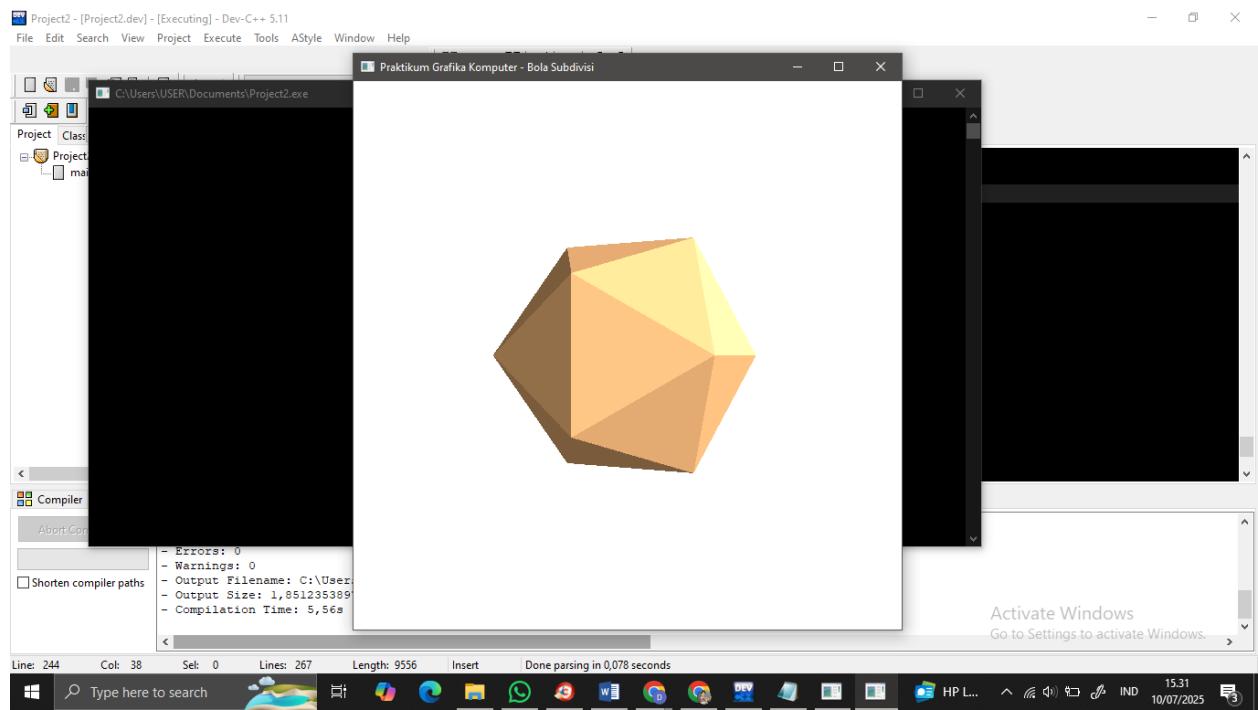
The screenshot shows the Dev-C++ IDE interface. The title bar reads "Project2 - [Project2.dev] - Dev-C++ 5.11". The menu bar includes File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, and Help. The toolbar has various icons for file operations. The main window displays the code for "main.cpp". The code implements a recursive subdivision of a sphere using GLUT library functions. It includes initialization, display, reshape, and keyboard callback functions. The code uses OpenGL functions like glutPostRedisplay and glutMainLoop. The status bar at the bottom shows the current line (Line: 240), column (Col: 38), selection (Sel: 0), lines (Lines: 267), length (Length: 9556), and the message "Done parsing in 0,062 seconds". The taskbar at the bottom shows the Windows Start button, a search bar, and several pinned application icons.

```
241     subdiv++;
242     break;
243     case GLUT_KEY_F2: // Mengurangi detail
244         if (subdiv > 0) subdiv--;
245         break;
246     }
247     glutPostRedisplay(); // Minta Layar digambar ulang setelah ada input
248 }
249
250 // --- Fungsi Utama Program ---
251 int main(int argc, char** argv) {
252     glutInit(&argc, argv);
253     glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
254     glutInitWindowSize(600, 600);
255     glutInitWindowPosition(100, 100);
256     glutCreateWindow("Praktikum Grafika Komputer - Bola Subdivisi");
257
258     init(); // Panggil fungsi inisialisasi
259
260     // Daftarkan fungsi callback
261     glutDisplayFunc(display);
262     glutReshapeFunc(reshape);
263     glutSpecialFunc(keyboard);
264
265     glutMainLoop(); // Mulai event Loop GLUT
266     return 0;
267 }
```

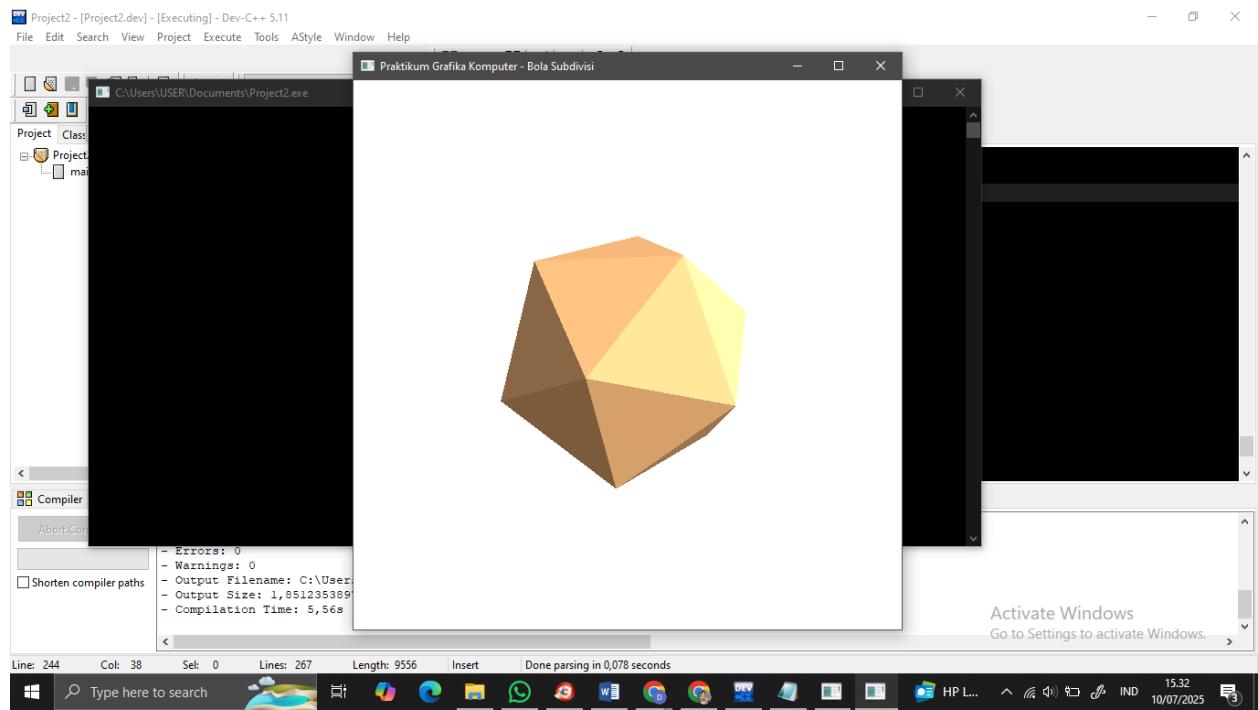
Output 13 pretest 10



Output 2 pretest 10



Output 3 pretest 10



Posttest 1

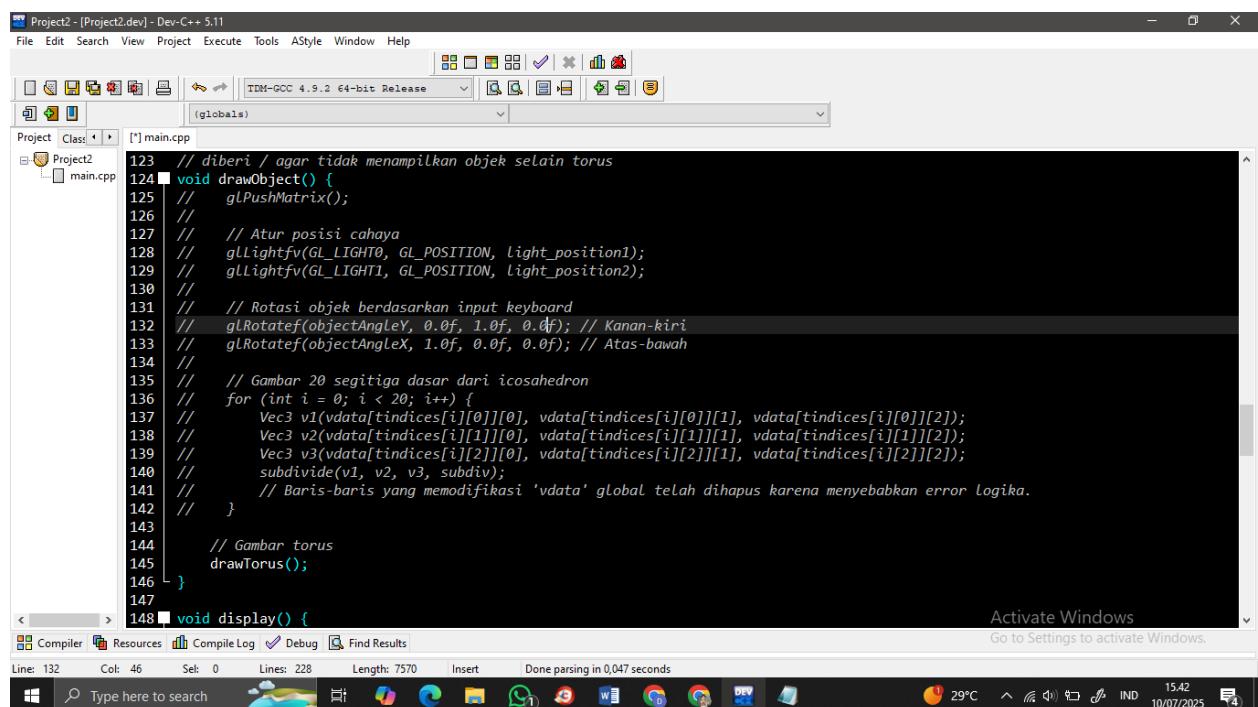
Gambar 14 posttest 10

```
43
44 // tambah subdivisi untuk torus
45 int torusRing = 20;
46 int torusSide = 20;
47
```

Gambar 2 posttest 10

```
112 // tambah fungsi menggambar torus
113 void drawTorus() {
114     glPushMatrix();
115     glLightfv(GL_LIGHT0, GL_POSITION, light_position1);
116     glLightfv(GL_LIGHT1, GL_POSITION, light_position2);
117     glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f);
118     glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f);
119     glutSolidTorus(0.2, 0.6, torusSide, torusRing);
120     glPopMatrix();
121 }
122
```

Gambar 3 posttest 10

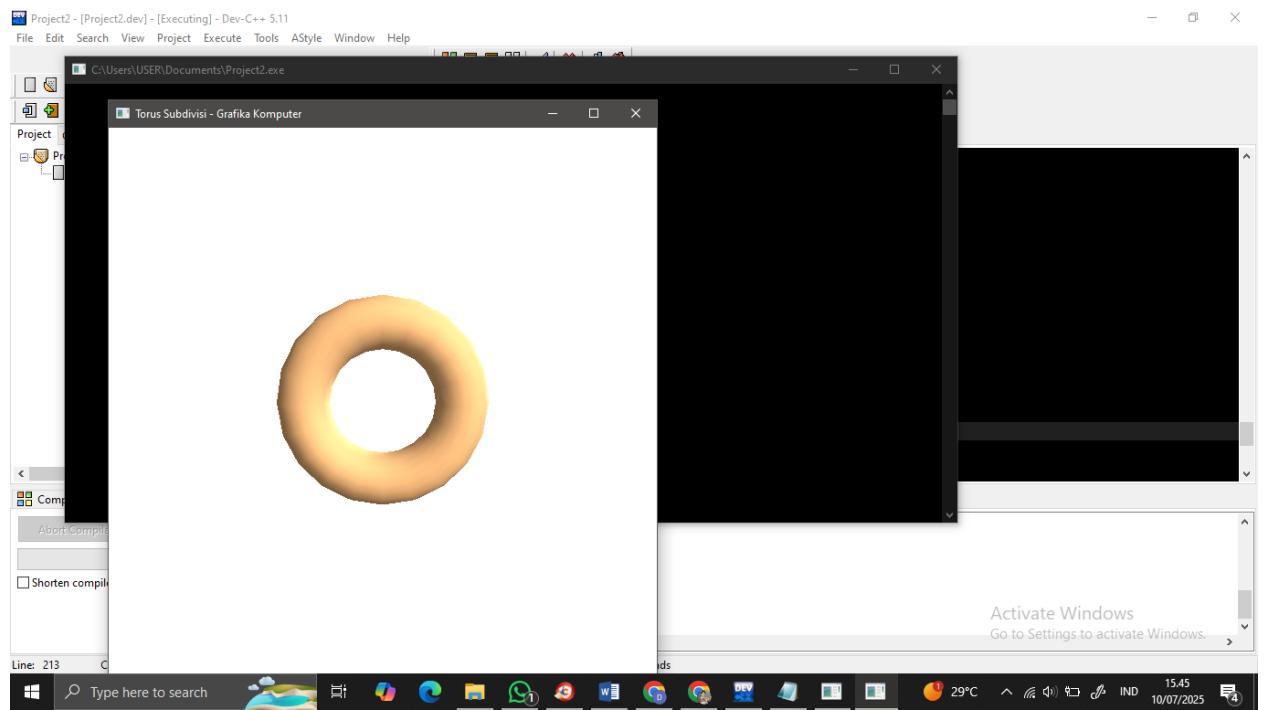


The screenshot shows the Dev-C++ IDE interface with the following details:

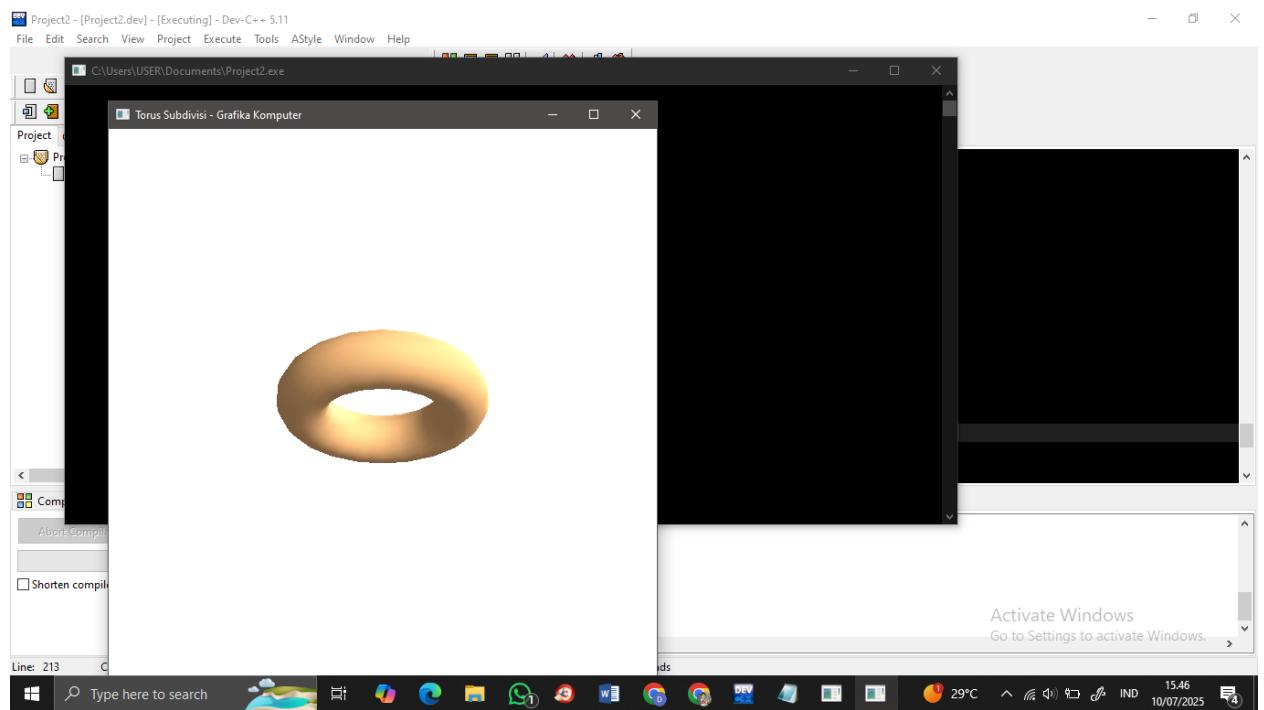
- File Menu:** File, Edit, Search, View, Project, Execute, Tools, AStyle, Window, Help.
- Toolbar:** Includes icons for New, Open, Save, Build, Run, and others.
- Project Explorer:** Shows "Project2" and "main.cpp".
- Code Editor:** Displays the following C++ code:

```
123 // diberi / agar tidak menampilkan objek selain torus
124 void drawObject() {
125     // glPushMatrix();
126     //
127     // Atur posisi cahaya
128     // glLightfv(GL_LIGHT0, GL_POSITION, light_position1);
129     // glLightfv(GL_LIGHT1, GL_POSITION, light_position2);
130     //
131     // Rotasi objek berdasarkan input keyboard
132     // glRotatef(objectAngleY, 0.0f, 1.0f, 0.0f); // Kanan-kiri
133     // glRotatef(objectAngleX, 1.0f, 0.0f, 0.0f); // Atas-bawah
134     //
135     // Gambar 20 segitiga dasar dari icosahedron
136     for (int i = 0; i < 20; i++) {
137         Vec3 v1(vdata[tindices[i][0]][0], vdata[tindices[i][0]][1], vdata[tindices[i][0]][2]);
138         Vec3 v2(vdata[tindices[i][1]][0], vdata[tindices[i][1]][1], vdata[tindices[i][1]][2]);
139         Vec3 v3(vdata[tindices[i][2]][0], vdata[tindices[i][2]][1], vdata[tindices[i][2]][2]);
140         subdivide(v1, v2, v3, subdiv);
141         // Baris-baris yang memodifikasi 'vdata' global telah dihapus karena menyebabkan error Logika.
142     }
143     //
144     // Gambar torus
145     drawTorus();
146 }
```
- Compiler Tab:** Shows "Compiler" selected.
- Status Bar:** Line: 132, Col: 46, Sel: 0, Lines: 228, Length: 7570, Insert, Done parsing in 0,047 seconds.
- System Tray:** Shows icons for Task View, Start, Taskbar, and system status (29°C, 10/07/2025).

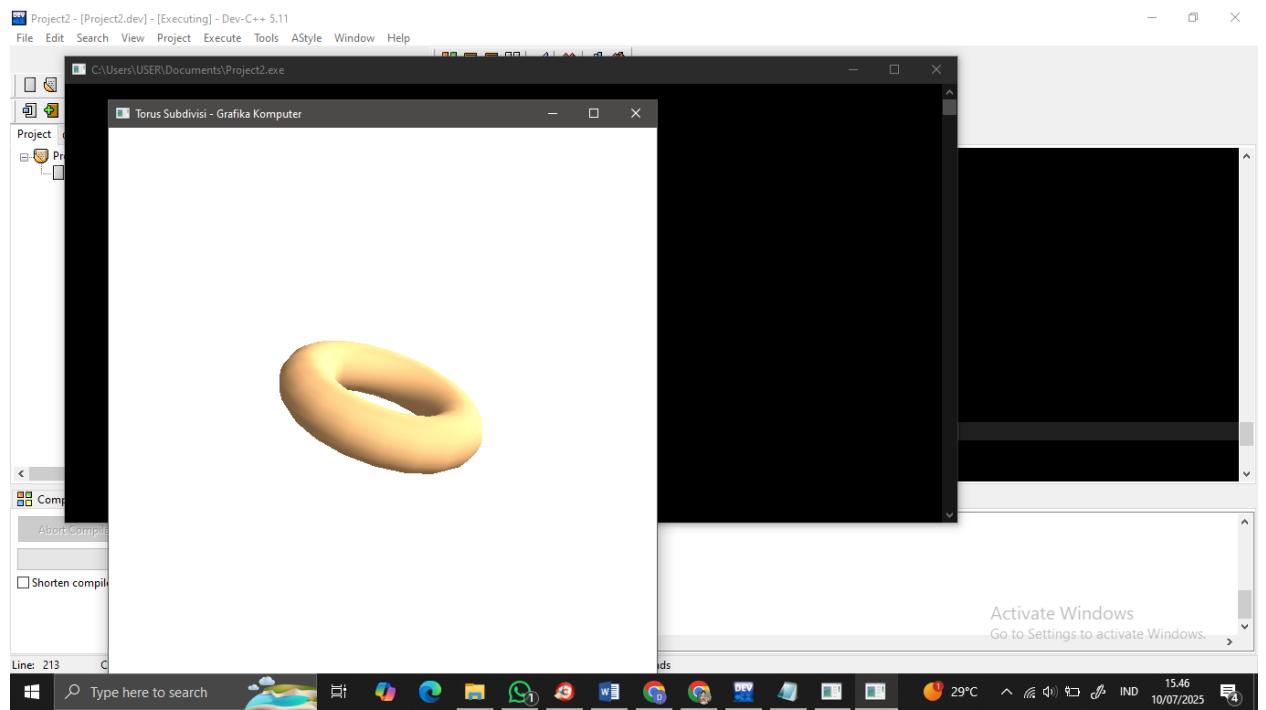
Output 1 postest 10



Output 2 postest 10



Output 3 postest 10



***Template Laporan belum semua sesuai dengan aturan penulisan silakan direvisi.**

Note :

Aturan Penulisan:

- a. Font : Times New Roman
- b. Ukuran Font:
 - i. Cover : 14
 - ii. Lainnya : 12
- c. Margin:
 - i. Top : 3
 - ii. Right : 3
 - iii. Left : 4
 - iv. Bottom : 3
 - v. Spacing : 1,5
- d. Cover Laporan
- e. Daftar isi (Halaman wajib otomatis terupdate).
- f. **Daftar Gambar (Halaman wajib otomatis terupdate & Setiap Gambar wajib memiliki foot note).**
- g. Penulisan nama Pertemuan diganti dengan BAB (Pertemuan 1 → BAB 1).
- h. Laporan minimal terdiri dari 50 halaman (exclude Cover, Daftar Isi, Daftar Gambar).

Objektif:

- **Pre-Test** (berisi pertanyaan dan jawaban pre-test yang ada di modul praktikum)
- **Praktikum** (berisi listing kode/*screenshot*) praktikum disertai penjelasannya)
- **Post-Test**(berisi listring kode/*screenshot*) pos-test disertai penjelasannya)
- **ScreenShot Ouput** (minimal 3 [disesuaikan dengan ketentuan])