The GL Utility Toolkit (GLUT)

The GL Utility Toolkit (GLUT) serves two major purposes:

1. It interfaces with your operating system and window system
2. It provides various application utilities, such as drawing 3D shapes for you

You can find GLUT (actually freeGLUT) at:
http://freeglut.sourceforge.net/

although we will give you some binaries that are ready-to-use.
Using GLUT to Setup the Window

All the GLUT_XXX constants are #defined in glut.h

```c
glutInitDisplayMode( GLUT_RGBA | GLUT_DOUBLE | GLUT_DEPTH );
// set the initial window configuration:

glutInitWindowPosition( 0, 0 );
glutInitWindowSize(INIT_WINDOW_SIZE, INIT_WINDOW_SIZE);
// open the window and set its title:

MainWindow = glutCreateWindow( WINDOWTITLE );
glutSetWindowTitle( WINDOWTITLE );
```

Constants not beginning with GL_ or GLUT_ are user-defined

Using GLUT to Specify Event-driven Callback Functions

```c
glutSetWindow( MainWindow );
glutDisplayFunc( Display );
glutReshapeFunc( Resize );
glutKeyboardFunc( Keyboard );
glutMouseFunc( MouseButton );
glutMotionFunc( MouseMotion );

glutPassiveMotionFunc( NULL );
glutVisibilityFunc( Visibility );
glutEntryFunc( NULL );
glutSpecialFunc( NULL );
glutSpaceballMotionFunc( NULL );
glutSpaceballRotateFunc( NULL );
glutSpaceballButtonFunc( NULL );
glutButtonBoxFunc( NULL );
glutDialsFunc( NULL );
glutTabletMotionFunc( NULL );
glutTabletButtonFunc( NULL );
glutMenuStateFunc( NULL );
glutTimerFunc( -1, NULL, 0 );
glutIdleFunc( NULL );
```

For example, the Keyboard() function gets called when a keyboard key is hit

A NULL callback function means that this event will be ignored
The **Keyboard** Callback Function

```c
void Keyboard( unsigned char c, int x, int y )
{
    if( DebugOn != 0 )
        fprintf( stderr, "Keyboard: '%c' (0x%0x)\n", c, c );
    switch( c )
    {
        case 'o':  case 'O':
            WhichProjection = ORTHO;
            break;
        case 'p':  case 'P':
            WhichProjection = PERSP;
            break;
        case 'q':  case 'Q':
            case ESCAPE:
                DoMainMenu( QUIT );  // will not return here
                break;  // happy compiler
        default:
            fprintf( stderr, "Don't know what to do with keyboard hit: '%c' (0x%0x)\n", c, c );
    }
    // force a call to Display( ) :
    glutSetWindow( MainWindow );
    glutPostRedisplay();
}
```

Where the mouse was when the key was hit
The key that was hit

---

The **MouseButton** Callback Function

```c
void MouseButton( int button, int state, int x, int y )
{
    int b = 0;  // LEFT, MIDDLE, or RIGHT
    if( DebugOn != 0 )
        fprintf( stderr, "MouseButton: %d, %d, %d, %d\n", button, state, x, y );
    // get the proper button bit mask:
    switch( button )
    {
        case GLUT_LEFT_BUTTON:
            b = LEFT;  break;
        case GLUT_MIDDLE_BUTTON:
            b = MIDDLE;  break;
        case GLUT_RIGHT_BUTTON:
            b = RIGHT;  break;
        default:
            b = 0;  fprintf(stderr, "Unknown mouse button: %d\n", button );
    }
    // button down sets the bit, up clears the bit:
    if( state == GLUT_DOWN )
    {
        Xmouse = x;
        Ymouse = y;
        ActiveButton |= b;  // set the proper bit
    }
    else
    {
        ActiveButton &= ~b;  // clear the proper bit
    }
```

Or
The **MouseMotion Callback Function**

```c
void MouseMotion( int x, int y )
{
    if( DebugOn != 0 )
        fprintf( stderr, "MouseMotion: %d, %d \n", x, y );
    int dx = x - Xmouse;            // change in mouse coords
    int dy = y - Ymouse;
    if( ( ActiveButton & LEFT ) != 0 )
    {
        Xrot += ( ANGFACT*dy );
        Yrot += ( ANGFACT*dx );
    }
    if( ( ActiveButton & MIDDLE ) != 0 )
    {
        Scale += SCLFACT * (float) ( dx - dy );
        // keep object from turning inside-out or disappearing:
        if( Scale < MINSIZE )
            Scale = MINSIZE;
    }
    Xmouse = x;                     // new current position
    Ymouse = y;
    glutSetWindow( MainWindow );
    glutPostRedisplay( );
}
```

The **Animate Idle Callback Function**

```c
void Animate() {
    int ms = glutGet( GLUT_ELAPSED_TIME );        // milliseconds
    ms %= MS_IN_THE_ANIMATION_CYCLE;
    Time = (float)ms / (float)MS_IN_THE_ANIMATION_CYCLE;    // [ 0., 1. ]
    // put animation stuff in here -- change some global variables
    // for Display( ) to find:
    // force GLUT to do a call to Display( ) next time it is convenient:
    glutSetWindow( MainWindow );
    glutPostRedisplay( );
}
```

The Idle Function gets called when the GLUT event handler has nothing else to do.

To set it up:

```c
glutSetWindow( MainWindow );
glutIdleFunc( Animate );
```

We’ll talk about this later. This is a good way to control your animations!
void InitMenus( ) {
    glutSetWindow( MainWindow );
    int numColors = sizeof( Colors ) / ( 3*sizeof(int) );
    int colormenu = glutCreateMenu( DoColorMenu);
    for( int i = 0; i < numColors; i++ )
    {
        glutAddMenuEntry( ColorNames[i], i);
    }
    int axesmenu = glutCreateMenu( DoAxesMenu);
    glutAddMenuEntry( "Off", 0 );
    glutAddMenuEntry( "On", 1 );
    int depthcuemenu = glutCreateMenu( DoDepthMenu);
    glutAddMenuEntry( "Off", 0 );
    glutAddMenuEntry( "On", 1 );
    int debugmenu = glutCreateMenu( DoDebugMenu);
    glutAddMenuEntry( "Off", 0 );
    glutAddMenuEntry( "On", 1 );
    int projmenu = glutCreateMenu( DoProjMenu);
    glutAddMenuEntry( "Orthographic", ORTHO );
    glutAddMenuEntry( "Perspective", PERSP );
    int mainmenu = glutCreateMenu( DoMainMenu);
    glutAddSubMenu( "Axes", axesmenu);
    glutAddSubMenu( "Colors", colormenu);
    glutAddSubMenu( "Depth Cue", depthcuemenu);
    glutAddSubMenu( "Projection", projmenu);
    glutAddMenuEntry( "Reset", RESET );
    glutAddSubMenu( "Debug", debugmenu);
    glutAddMenuEntry( "Quit", QUIT );
    // attach the pop-up menu to the right mouse button:
    glutAttachMenu( GLUT_RIGHT_BUTTON );
}

This is the color menu’s callback function. When the user selects from this pop-up menu, its callback function gets executed. Its argument is the integer ID of the menu item that was selected. You specify that integer ID in glutAddMenuEntry().

This is how you create hierarchical sub-menus

Finally, tell GLUT which mouse button activates the entire menu hierarchy

The GLUT 3D Objects

- glutSolidSphere( radius, slices, stacks );
- glutWireSphere( radius, slices, stacks );
- glutSolidCube( size );
- glutWireCube( size );
- glutSolidCone( base, height, slices, stacks );
- glutWireCone( base, height, slices, stacks );
- glutSolidTorus( innerRadius, outerRadius, nsides, nrings );
- glutWireTorus( innerRadius, outerRadius, nsides, nrings );
- glutSolidDodecahedron();
- glutWireDodecahedron();
- glutSolidOctahedron();
- glutWireOctahedron();
- glutSolidTetrahedron();
- glutWireTetrahedron();
- glutSolidIcosahedron();
- glutWireIcosahedron();
- glutSolidTeapot( size );
- glutWireTeapot( size );

In case you have a hard time remembering which direction “slices” are, think of this:
Without *lighting*, the GLUT solids don’t look very cool. I’d recommend you stick with the wireframe versions of the GLUT 3D Objects for now! We will get to lighting soon.