Introduction to MS Visual C/C++ under .NET

0. Introduction:

Part 1 of this tutorial gives a simple introduction to MS Visual Studio .NET with an emphasis on OpenGL graphics application. Part 2 introduces the basics of C/C++. At the end of this tutorial you should be able to write a simple console application using the graphics libraries OpenGL, GLU, and GLUT. The tutorial gives an introduction to the C/C++ programming language but does not attempt to explain the above mentioned graphics libraries (which is done in the 372 lecture). Please note that these notes only introduce a very limited subset of the C/C++ language and you are expected to consult the *372 Resources* web page for more information. Finally please remember that 'learning by doing' is the best recipe for mastering C/C++. I recommend that you do all examples on a computer. Also it is a good idea to experiment with the code (e.g. change parameters) and to introduce intentionally little syntax errors into the example programs in order to get familiar with the resulting error messages (if any) from the compiler.

1. Getting started with Microsoft Visual Studio .NET:

1.1. Creating a Solution

The first step to doing anything in VS.NET is creating a solution. A VS.NET solution can be made up of a number of different projects. In order to create a solution we start VS.NET and choose 'New', 'Blank Solution' in the 'File' menu. In the resulting pop-up menu click on the 'Visual Studio Solutions' folder and the item 'Blank Solution'. In this example we name the solution 'Ass1' and specify where it should be stored, as shown in the figure below.

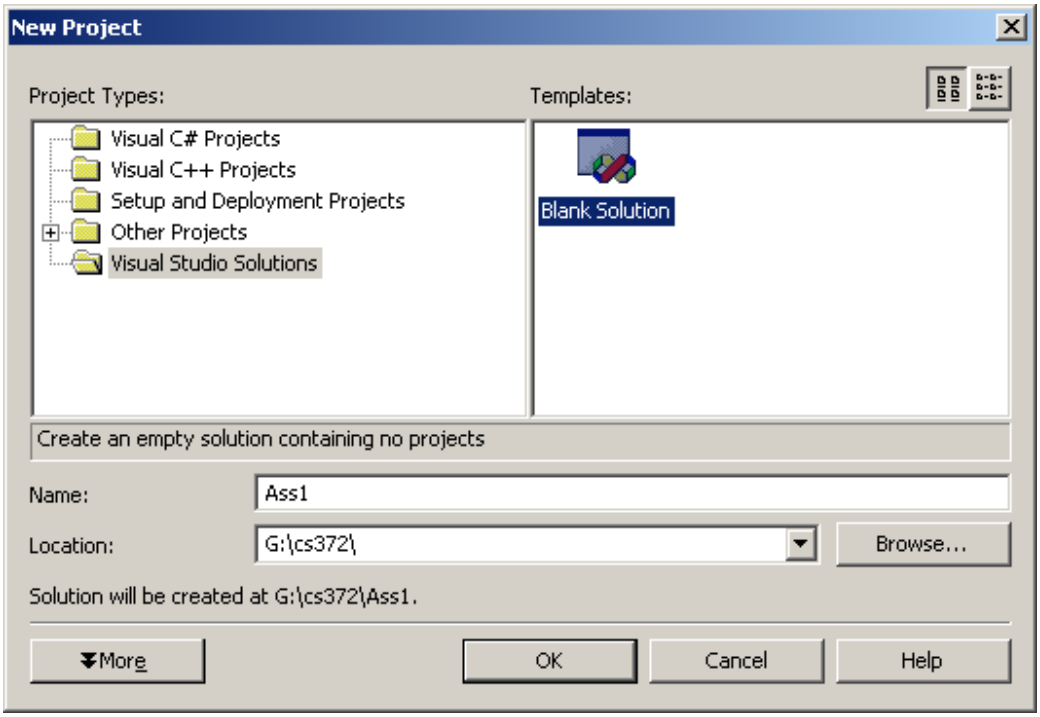


Figure 1 - Creating a blank solution

Click ‘OK’ and click on the ‘Solution Explorer’ tab, you should see something similar to the figure below.

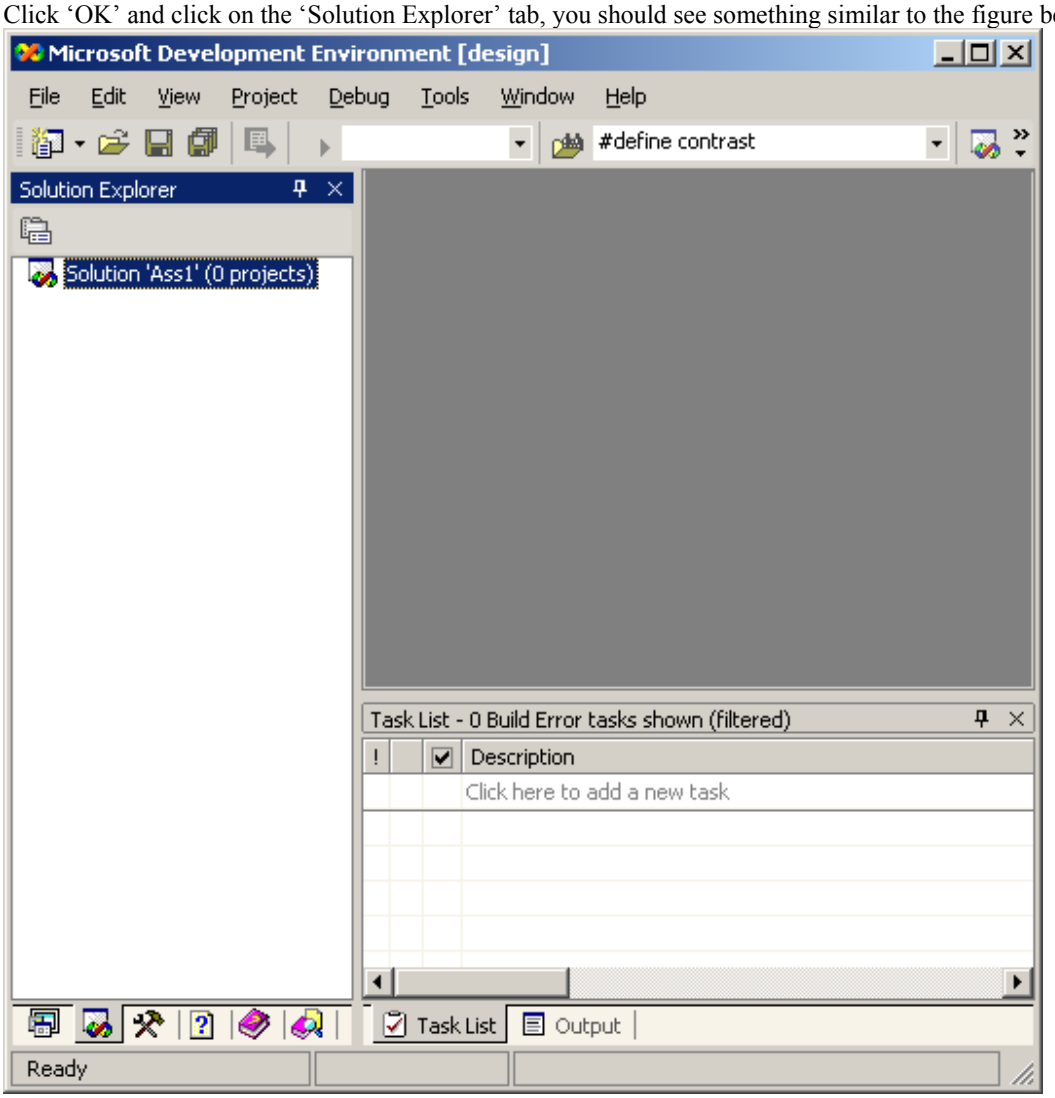


Figure 2 - A blank solution

1.2. Creating a Console Application

This section explains how to create a simple console application using MS VS .NET. A console application is run from a console window, which is used to perform standard output and standard input. The behavior of a console application is similar to a Java application executed from a console window using JDK. If you are running a different IDE at home please consult your documentation about how to use it.

In order to create a project for our application we start by creating a solution as described in the previous section. Then we choose 'New', 'Project' in the 'File' menu. In the resulting pop-up menu click the 'Visual C++ Projects' folder and the item 'Win32 Project'. In this example we name the project 'Ass1a' and add it to our previously created solution as shown in the figure below.

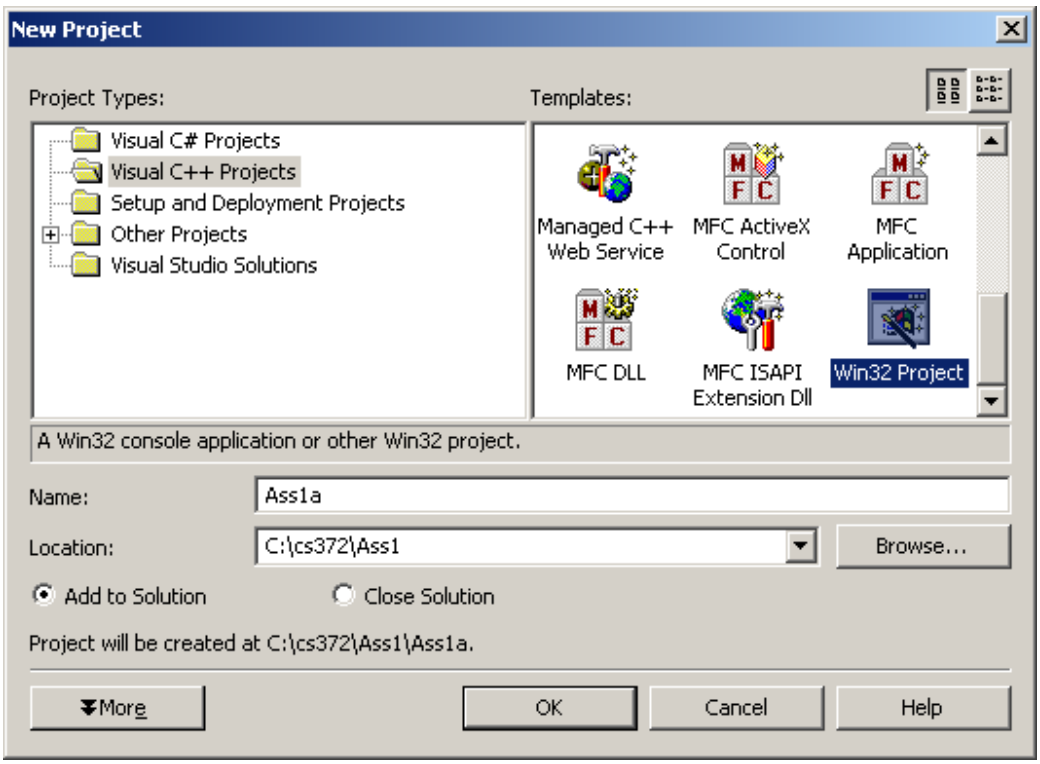


Figure 3 - Creating a new project

Click ‘OK’ and the ‘Win32 Application Wizard’ window should pop-up, now you can specify the type of project you want. Click on ‘Application Settings’, select ‘Console Application’ and ‘Empty Project’, and click ‘Finish’.

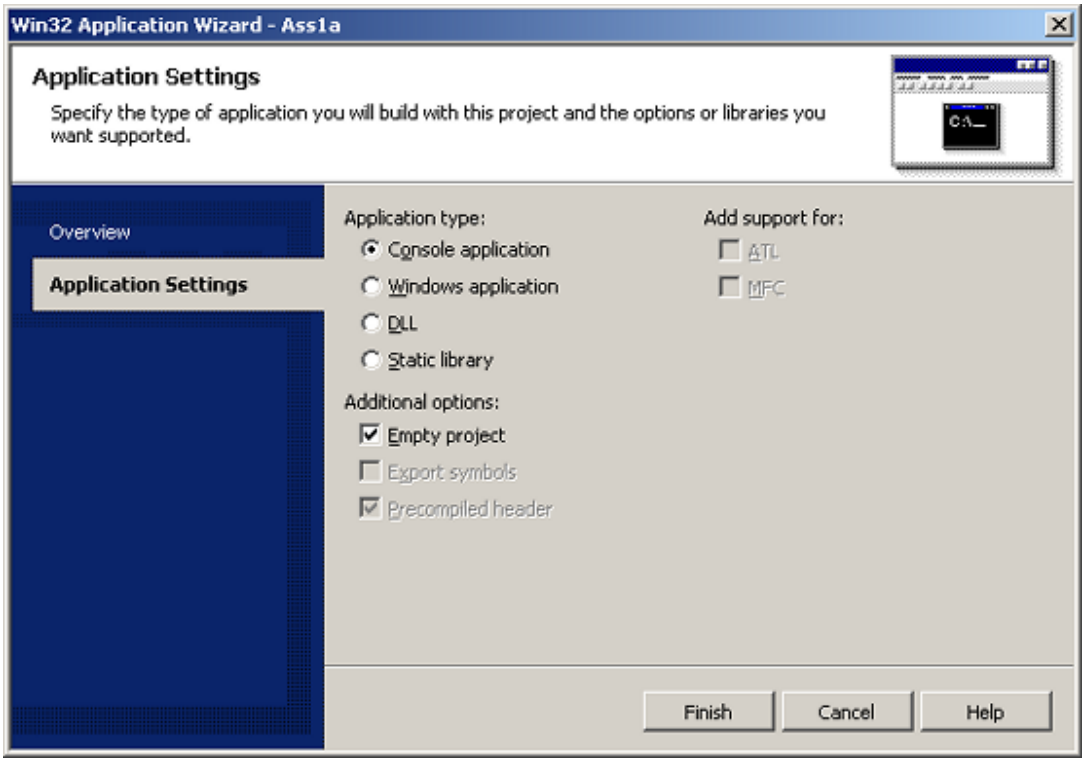


Figure 4 - Creating a new console application

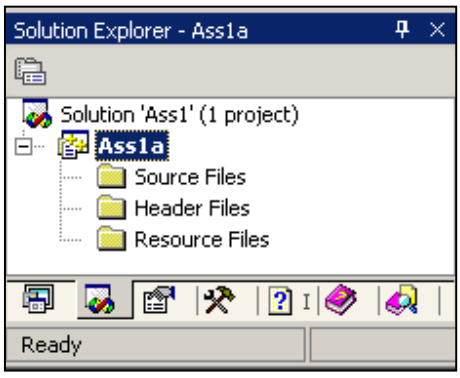


Figure 5 - Empty project

You now have an empty project without any classes or files. Click on the ‘Solution Explorer’ tab to see the project contents. If you want to open your project next time you load VS.NET you can either choose ‘Open’, ‘Project’ in the ‘File’ menu of VS .NET or you can double click on the solution file Ass1.sln (or project file Ass1a.vcproj) on the disk.

Next we want to create a file containing the main program. In order to do this, right click on 'Ass1a' in the 'Solution Explorer' tab, and select 'Add', 'Add New Item'. In the resulting pop-up window click the 'Visual C++' folder and select 'C++ File'. In the text box titled 'Name:' input the name of the file, in this example 'ass1a.cpp', then click 'Open'.

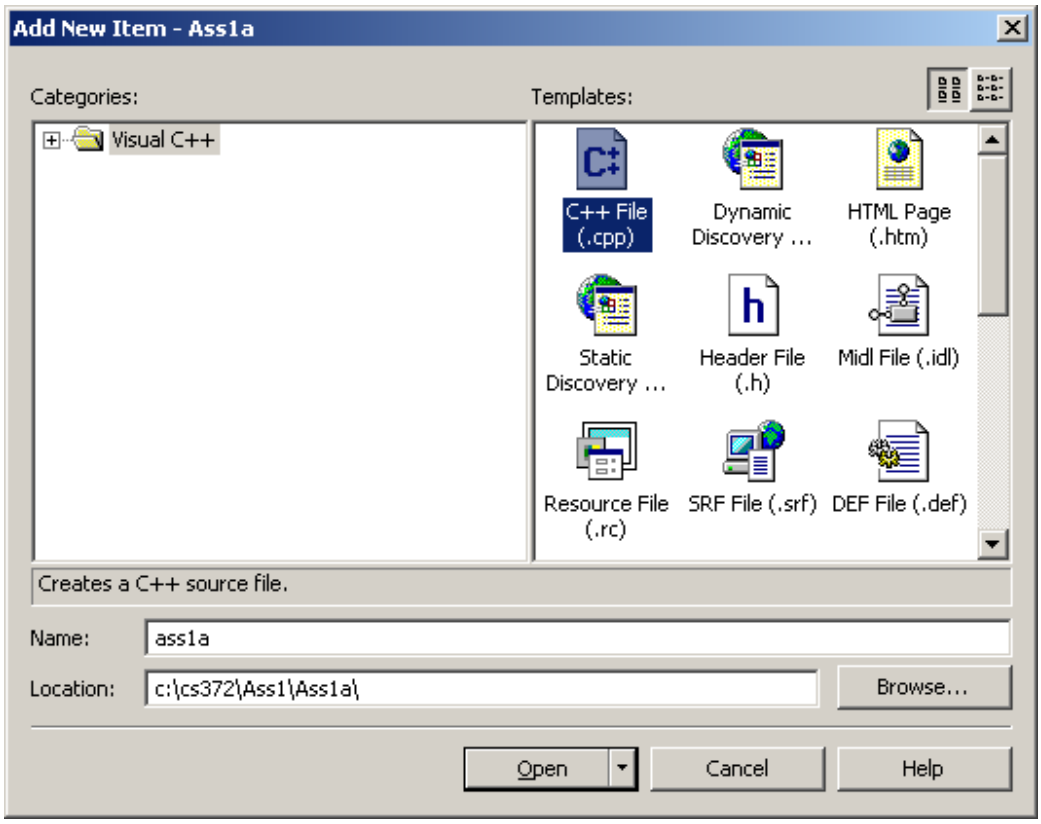


Figure 6 - Creating a new source file

Notice that your project now contains the ass1.cpp file.

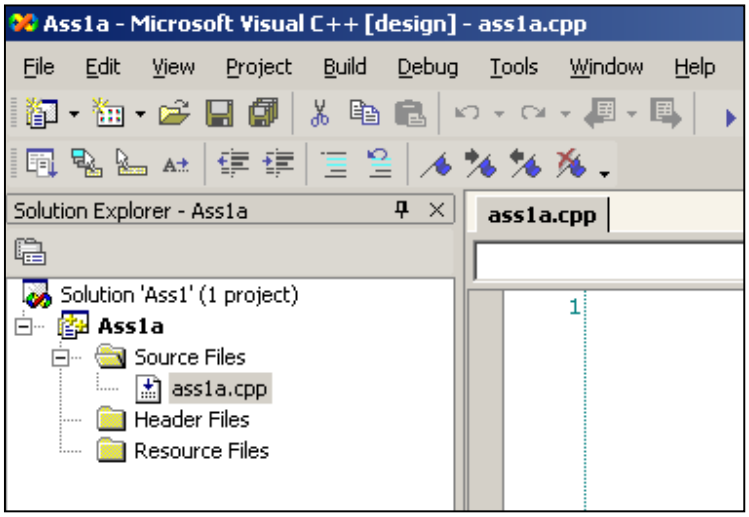


Figure 7 - Project with the new source file

We now have a project without classes and with one source file. If the source file (ass1a.cpp) is not shown in the main window choose the 'Solution Explorer' tab in the left hand frame. Expand first the folder 'Ass1a' and then the folder 'Source Files' by clicking on the box next to it. If the folder is expanded the plus sign inside the box changes to a minus sign. Open the file 'ass1a.cpp' by double clicking on it. Your workspace should now look similar to the figure on the left.

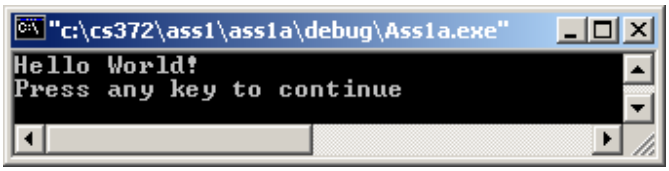
You can now create your first program by typing into the file 'ass1a.cpp' the following code (or cut/paste):

```
// My first C-program

#include <stdio.h>

int main( int argc, char* argv[] )
{
   printf( "Hello World!\n" );
   return 0;
}
```

The code will be explained in the lecture. Save the file (using 'Save' in the 'File' menu or by using the keyboard shortcut 'CTRL+S'), build the project (choose 'Build Ass1a.exe' in the 'Build') and run it (choose 'Start Without Debugging' in the 'Debug' menu or press 'CTRL+F5').
You should get something like this:



Note that the output is written into a console window. The line 'Press any key to continue' occurs because you are currently executing the application in debug-mode.

We can also execute the application directly. In order to do this, change into the 'Debug' directory of the directory containing your project and double click the file 'ass1a.exe'. Note that the application exits immediately after execution. If you want the console window to stay open you have modify the code accordingly, e.g.

```
// My second C-program

#include <stdio.h>

int main( int argc, char* argv[] )
{
   printf( "Hello World!\n" );
   printf( "Press 'Enter' to quit\t" );
   while ( getchar() != '\n' );   // loop until ENTER is pressed
   return 0;
}
```

1.2 Using OpenGL

For many programming tasks it is convenient to use a software interface to the hardware or the underlying operating system that offers high-level functionality. Such a software interface is called an *application programming interface* (API). The arguably most common graphics API in use today is OpenGL. OpenGL was originally introduced by SGI (Silicon Graphics) and is now available for most platforms. Even though the OpenGL commands are standardized different implementations of the OpenGL library may exist for the same platform. The two main versions of the OpenGL library for the Windows operating system are from Microsoft and from SGI. In this lecture we use the Microsoft version, which consists of the files `gl.h`, `opengl32.lib` and `opengl32.dll`. The SGI version consists of the files `gl.h`, `opengl.lib` and `opengl.dll` and is **not** used in this lecture.

The file `gl.h` contains function prototypes and constants whereas the file `opengl32.lib` contains the precompiled object code with the implementations of the function. Therefore, when writing an OpenGL program, we have to include `gl.h` at the beginning of each file, which uses OpenGL commands. In addition we have to link the project with the library `opengl32.lib`. Further explanation of this topic is found in section 1.4.

Nowadays many windows applications (e.g. computer games) use OpenGL. Rather than including the complete OpenGL object code with each application it is more convenient to have the OpenGL library code stored in one place on your machine and to use it for all OpenGL applications. This is achieved by using *dynamic link libraries*. The Microsoft OpenGL dynamic link library is called `opengl32.dll` and comes by default with all recent versions of the Windows operating system[1]. Note that some applications might require the SGI version. In this case you have to download the file `opengl.dll` from the web and put it into the 'system32' folder.

On top of OpenGL we use two utility libraries called GLU and GLUT. The corresponding files are `glu.h`, `glu32.lib`, `glu32.dll`, and `glut.h`, `glut32.lib`, `glut32.dll`, respectively. They are used analogously to the corresponding OpenGL files. The files `glu.lib`, `glu.dll`, `glut.lib`, and `glut.dll` are the SGI versions and are **not** used in this lecture.

1.3 Downloads:

The Microsoft versions of the above OpenGL and GLU files are available from the *372 Resources* page or from: http://www.opengl.org/users/downloads/index.html

GLUT for windows (Microsoft version) is also on the *372 Resources* page or at:
http://www.xmission.com/~nate/glut.html

A useful site for installing OpenGL drivers (assuming you have an OpenGL video card) is:
http://www.glsetup.com/

After downloading OpenGL/GLU and GLUT put all `.dll` files into the 'system32' directory (or 'system' for Windows95/98) and the `.h` and `.lib` files into a convenient directory from which you will add them to your project (more on this in the next section).

[1] In Windows NT / 2000 / XP the file is in the folder 'system32' which is inside the folder 'WINNT' (or wherever you installed your operating system). In Windows 98 it is *probably* in the 'system' folder.

1.4 An OpenGL Example:

1.4.1 An Example Program

The program below draws a red teapot (as a wireframe) into a 250x250 pixel window with white background.

```
#include <windows.h>
#include "gl.h"
#include "glu.h"    // not used in this program
#include "glut.h"

void display( void )
{
       // clear all pixels in frame buffer
       glClear( GL_COLOR_BUFFER_BIT );

       // draw a red wireframe teapot
       glColor3f( 1.0, 0.0, 0.0 ); // (red,green,blue) colour components
       glutWireTeapot( 0.6 );

       // start processing buffered OpenGL routines
       glFlush();
}

void init( void )
{
       // select clearing color (for glClear)
       glClearColor( 1.0, 1.0, 1.0, 0.0 ); // clear window in white

       // initialize view (simple orthographic projection)
       glMatrixMode( GL_PROJECTION );
       glLoadIdentity();
       glOrtho( -1.0, 1.0, -1.0, 1.0, -1.0, 1.0 );
}

// create a single buffered 250x250 pixel colour window
int main( int argc, char** argv )
{
   glutInit( &argc, argv );
   glutInitDisplayMode( GLUT_SINGLE | GLUT_RGB );
   glutInitWindowSize( 250, 250 );
   glutInitWindowPosition( 100, 100 );
   glutCreateWindow( "My first OpenGL program" );
   init();                        // initialise view
   glutDisplayFunc( display );    // draw scene
   glutMainLoop();
   return 0;                      // ANSI C requires main to return int
}
```

Figure 1.2: The file ‘drawObjects.cpp’.

1.4.1 Building a Project

In order to execute this OpenGL program we have to create a console application as shown in the previous section. Create a project named 'OpenGLExample' (you can name your solution the same), copy the source file 'drawObjects.cpp' into the project folder and then add the file to the project. You can add a file to the project by selecting the 'Solution Explorer' tab, right clicking on your project name, and selecting 'Add', 'Add Existing Item' from the pop-up menu.

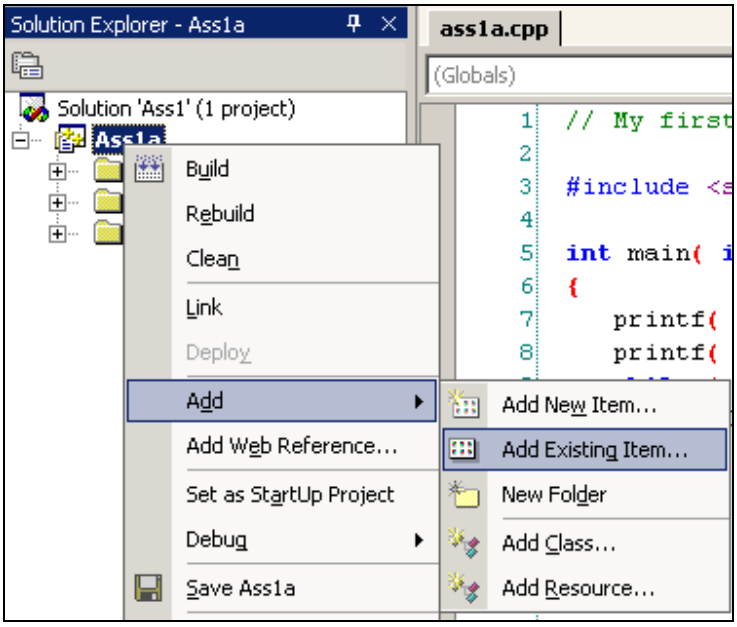


Figure 8 - Adding an existing source file

Alternatively you can download the complete solution with the project from the 372 Resources page: unzip the file 'OpenGLExample.zip', double click the solution 'OpenGLExample.sln' and type 'CTRL+F5' to build and run your application.

When building an application the following two steps are performed:

1. **Compilation**: First all include statements are replaced with the corresponding header files. As a result your program knows all constants and functions defined in the header files. Next your source files are compiled and any syntax errors are reported. If the compilation was successful object files (suffix '.obj') are created for each of your source files.
2. **Linking:** This step combines (links) your object code with any external libraries (such as opengl32.lib).

1.4.2 Including the OpenGL/GLU/GLUT libraries

Since the program in figure 1.2 makes use of OpenGL and GLUT commands, we have to tell our application about these functions. This is achieved by first including the corresponding *header files* (suffix .h), which contain constant definitions and function prototypes. In a subsequent step we have to link our program with the libraries containing the actual implementations of the function prototypes.

The file 'drawObjects.cpp' contains four include files (the include commands in the file on the server are slightly different and are explained in the next paragraph):

```
#include <windows.h>
#include "gl.h"
#include "glu.h"    // not used in this example program
#include "glut.h"
```

The header file `windows.h` contains constants and function prototypes of the *Graphic Device Interface* (GDI), which is at the core of all Windows graphics. Since the include file `gl.h` makes use of some of the GDI types and functions we have to include `windows.h` **before** `gl.h`. The angle brackets (< and >) around the header's name indicate the header file is to be looked for on the system disk. When using MS Visual Studio .NET then all predefined header files are stored in the directory "…/Visual Studio .NET/Vc7/include" and "…/Visual Studio .NET/Vc7/Platform SDK/Include", or somewhere around there. If the header file is written in double quotes, e.g. "`gl.h`" then it is assumed it is stored in the current working directory. In our example this assumes that `gl.h`, `glu.h` and `glut.h` are stored in the same directory as the file `drawObjects.cpp`.

A better way to include libraries:

Since it is very annoying to copy for each project the header files into the current working directory it is preferable to put all header files of common libraries (such as OpenGL, GLU and GLUT) into a default system directory.

In order to do this create in the directory ".../Visual Studio .NET/Vc7/Include" a subdirectory 'GL' and copy into this directory the files `gl.h`, `glu.h` and `glut.h` as shown in the image below[2] (note that file names in Windows are not case-sensitive).

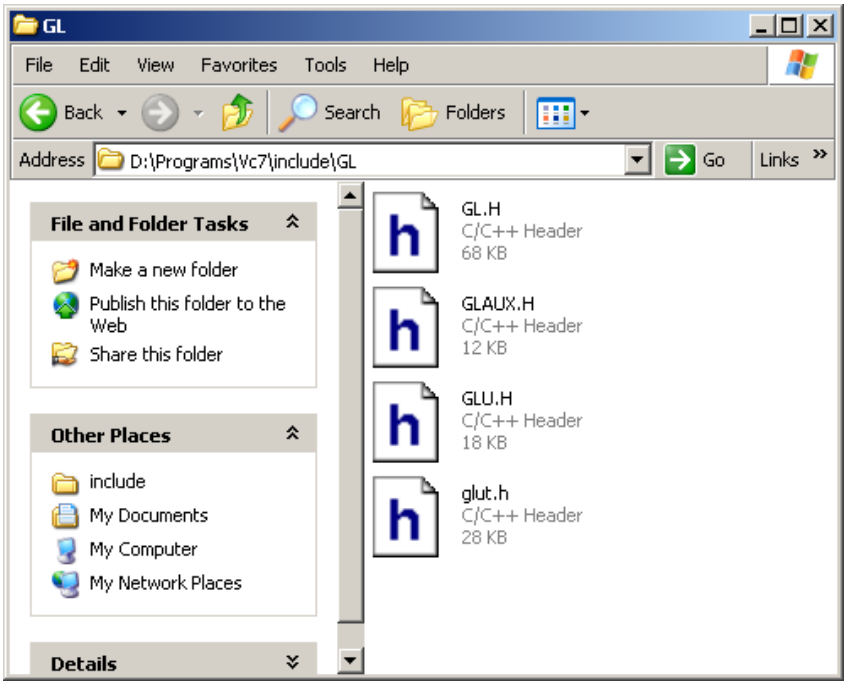


Figure 9 - MS Visual Studio include-headers folder

[2] If you are using Microsoft Visual Studio .NET in the lab then this has already been done. Visual Studio 6.0 already includes `gl.h` and `glu.h` and you only have to add `glut.h`.

You also have to change the include statements in the file 'drawObjects.cpp' accordingly:

```
#include <windows.h>
#include <gl/gl.h>
#include <gl/glu.h>
#include <gl/glut.h>
```

Figure 10 – Including the OpenGL header files.

It remains to specify the libraries the project is using. To do this, right click on the project name in the 'Solution Explorer' tab, and select 'Properties'. In the resulting pop-up window, expand the 'Configuration Properties' folder, expand the 'Linker' folder, and click on 'Input'. Now add the names of the libraries to the cell titled 'Additional Dependencies'. Click OK when you are finished. The image below gives an example.

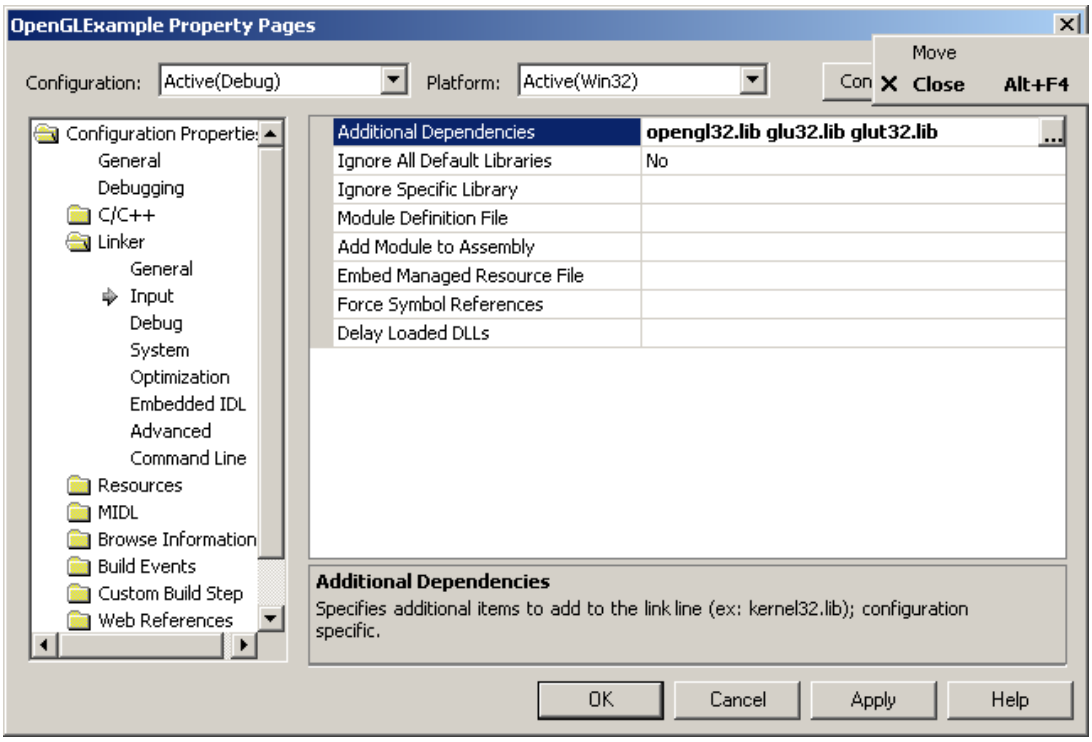


Figure 1 - Using the project properties to add library modules.

If you specify the libraries with their name only, as done above, the linker will search both in the working directory of your project and in certain system directories. Rather than putting all libraries into your working directory it is a good idea to copy them into the folder ".../Visual Studio .NET/Vc7/lib" or "…/Visual Studio .NET/Vc7/PlatformSDK/lib" as shown below.

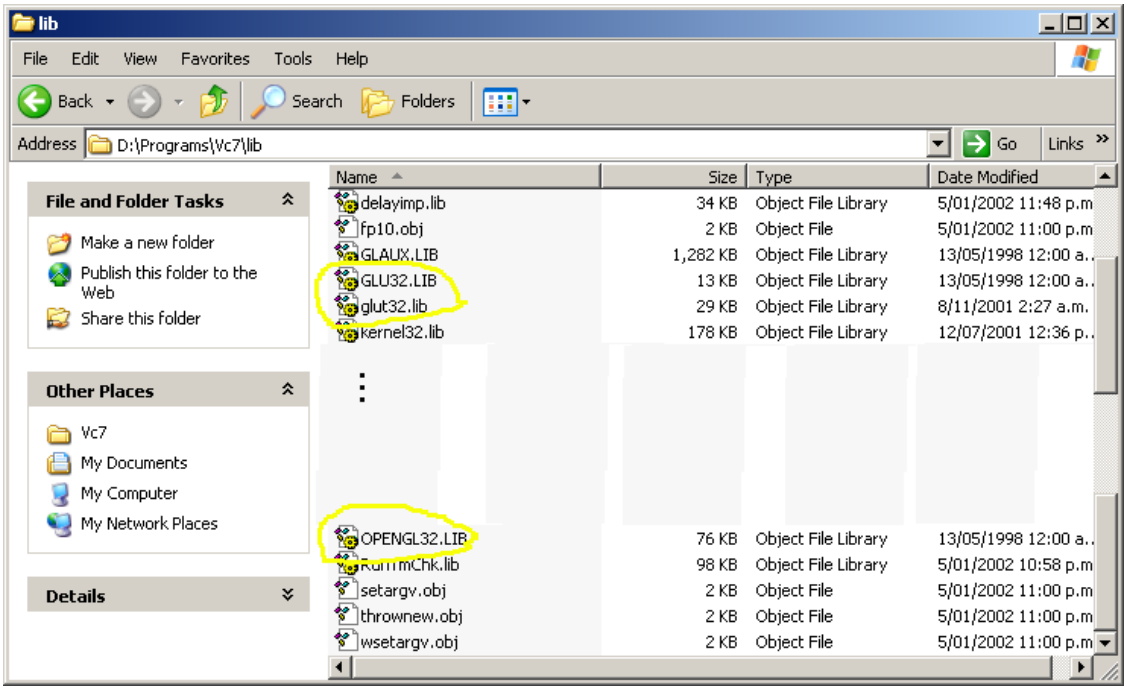


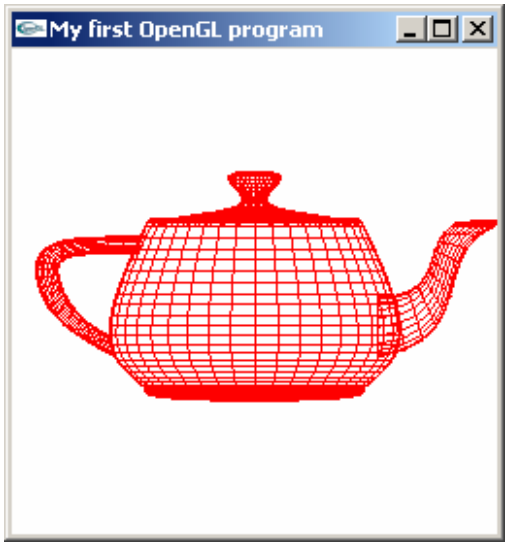
Figure 12 - MS Visual Studio folder for include-libraries.

Alternatively you can specify the path to the library. For example, if the library `glut32.lib` is in the root directory of the disk `G` than you must type in the project properties 'G:/glut32.lib'. Note, however that this is bad style and won't be accepted by the markers. The machines in the lab are set up as shown in figure 9 and figure 12 (note that the directory "Vc7" is usually in the directory "Visual Studio .NET"). This means that the OpenGL header files are always included as shown in figure 10.

NOTE: If you include `<glut.h>` and put the library files into the "Vc7/Lib" directory as shown above then you **don't** have to specify the library modules in the project settings as shown in figure 1.4. The reason for this is that the file `glut.h` from the 372 Resources page contains the preprocessor directives shown below, which include the libraries during compilation:

```
/* To enable automatic SGI OpenGL for Windows library usage for GLUT,
   define GLUT_USE_SGI_OPENGL in your compile preprocessor options.  */
#  ifdef GLUT_USE_SGI_OPENGL
#   pragma comment (lib, "opengl.lib")     /* link with SGI OpenGL for Windows lib */
#   pragma comment (lib, "glu.lib")        /* link with SGI OpenGL Utility lib */
#   pragma comment (lib, "glut.lib")       /* link with Win32 GLUT for SGI OpenGL lib */
#  else
#   pragma comment (lib, "opengl32.lib")   /* link with Microsoft OpenGL lib */
#   pragma comment (lib, "glu32.lib")      /* link with Microsoft OpenGL Utility lib */
#   pragma comment (lib, "glut32.lib")     /* link with Win32 GLUT lib */
#  endif
# endif
```

You can now build your project (i.e. compile and link it) by selecting the corresponding menu item (see section 1). Execute your application (CTRL+F5) and you will get as output a window displaying a red wireframe teapot as shown below.



Adding additional include and library directories to the search path

Since copying libraries and headers to the "…/Visual Studio .NET/Vc7/…" directory can be tedious if you have to do it for a number of different libraries, it can be beneficial to instead add additional directories to the list of directories Visual C++ will search for include files and libraries. You can do this by selecting 'Options' from the 'Tools' menu (up top).

Then expand the 'Projects' folder and select 'VC++ Directories'. Here you can add paths to additional directories to be searched for headers/libraries during compilation/linking. Refer to the VS.NET help for further info.

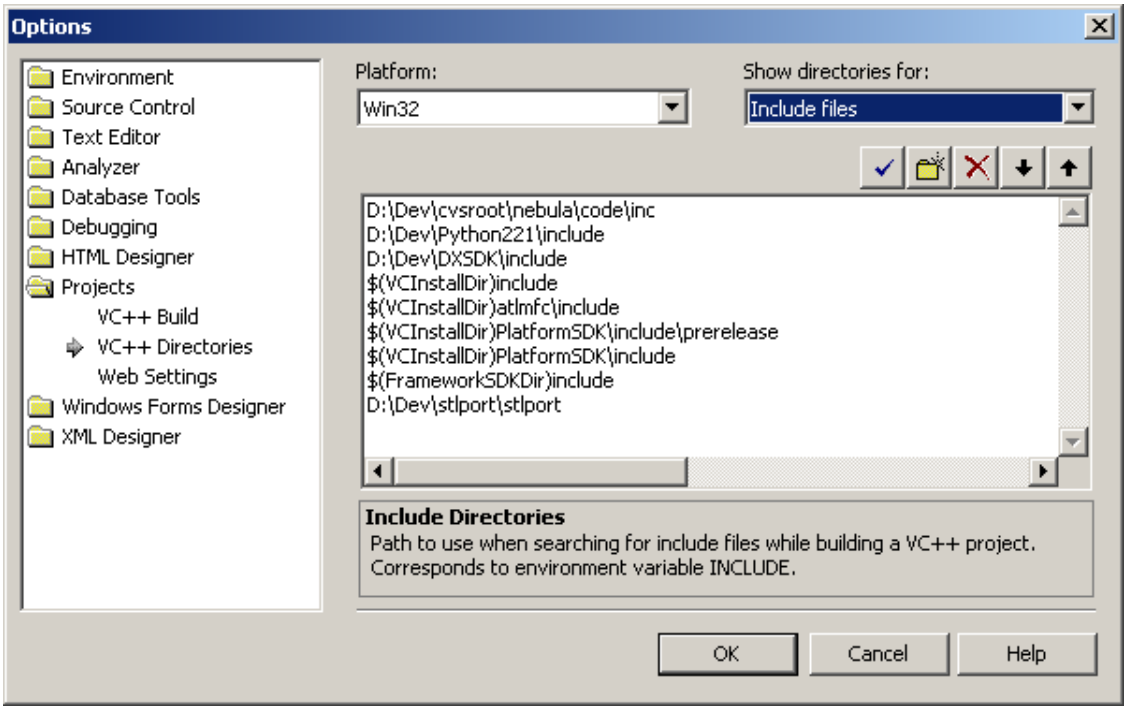


Figure 13 - Specifying additional include directories.