Question 3 (14 marks)

In the `q3` directory (in the file `main.c`) is a program which

- takes three command line arguments: *EdgeFile, StartVertex, Dist*
- reads edge data from the *EdgeFile* and builds a graph data structure
- calls a function determine all vertices within distance *Dist* of the *StartVertex*
- prints all of these vertices, one per line, to standard output

Distance to a vertex *V* is measured in terms of the number of edges on the shortest path between *StartVertex* and vertex *V*. The list of vertices should *not* include *StartVertex* and should include all vertices whose distance to *StartVertex* is less than or equal to *Dist*. Each relevant vertex should occur in the list exactly once (no duplicates).

Also in the `q3` directory are source code for a number of potentially useful ADTs. In particular, the files `Graph.h` and `Graph.c` define a `Graph` ADT which uses an adjacency matrix representation.

The `main` function prints the list of vertices, but the list is actually computed by the function

```
int within(Graph g, Vertex s, int d, Vertex *vs) { ... }
```

defined in the `Graph` ADT. (It is called `within` because all of the vertices in the list must be *within* a distance `d` of the start vertex).

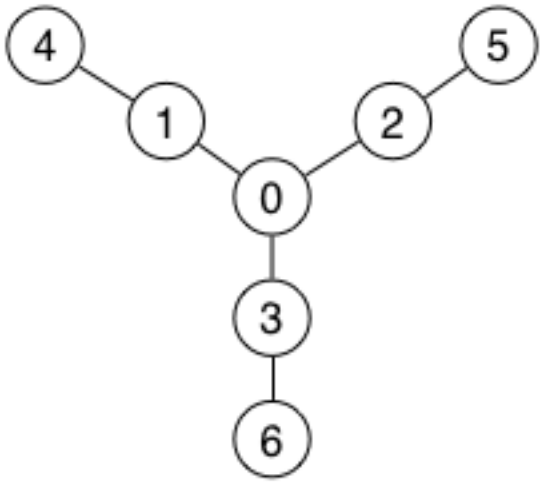
Your task for this question is to implement the `within()` function in the `Graph.c` file.

The `within()` function takes four parameters:

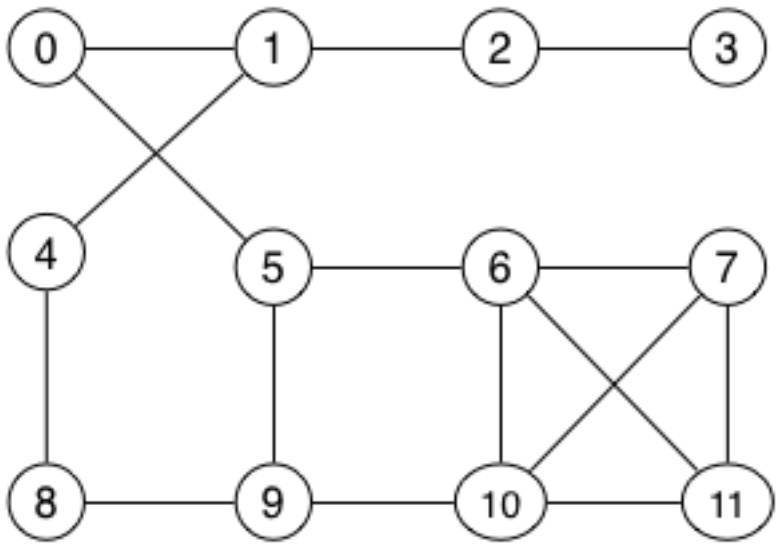
- `g` ... an instance of the `Graph` ADT
- `s` ... the start/origin vertex
- `d` ... the maximum distance from the start vertex
- `vs` ... the address of an array of `Vertex` values

The function stores all reachable vertices in the `vs[]` array and returns a count of the number of `Vertex` values stored in the array. You can assume that the `vs[]` array is large enough to store all of vertices in the graph, if needed. The order that you store the vertices in the `vs[]` array is not important; the test scripts sort the output before comparing it against the expected results. You can find a skeleton `within()` function at around line 272 in the `Graph.c` file.

To give some concrete examples, consider the following undirected graphs:



Graph1



Graph2

The following table shows the sets of vertices that would be produced for various calls to the `within()` function:

Call to `within()` function	`x`	Vertices in vs[]
`x = within(`*`Graph1`*`,0,1,vs)`	3	{1,2,3}
`x = within(`*`Graph1`*`,0,2,vs)`	6	{1,2,3,4,5,6}
`x = within(`*`Graph1`*`,6,1,vs)`	1	{3}
`x = within(`*`Graph1`*`,6,2,vs)`	2	{0,3}
`x = within(`*`Graph1`*`,6,3,vs)`	4	{0,1,2,3}
`x = within(`*`Graph2`*`,0,2,vs)`	6	{1,2,4,5,6,9}
`x = within(`*`Graph2`*`,0,99,vs)`	11	{1,2,3,4,5,6,7,8,9,10,11}

You can find out more about the behaviour of the `q3` program by looking at the files in `q3/tests` directory. Each file named `t`*`X`*`.sh` contains the commands to run one test. Each test will use one of the files named `graph`*`X`* as input. Each test has a corresponding file `t`*`X`*`.exp` which contains the expected output from a correct implementation of `q3`, run using `t`*`X`*`.sh`.

The `q3` directory also contains a `Makefile` which you use as:

```
make q3     # build the q3 program
```

You can test your `q3` program using the command:

```
check q3    # run tests on the q3 program
```

Once you are satisfied with your program, submit it using the command:

```
submit q3
```

This will make a copy of the `Graph.c` file from the `q3` directory as your answer for this question. You can run the `submit` command as many times as you like, but make sure that your final submission compiles without any errors or warnings. Test your program thoroughly, possibly using test cases additional to those supplied. Your program will be tested with extra tests that are different to the examples in the `q3/tests` directory.

You can add any additional functions (apart from `within()`) to the `Graph.c` file, but you may not change any of the other files.

If, at some stage, you need to "re-install" the files (although you should not need to), you can copy all of the original files into the `q3` directory by running the command:

```
re-start q3
```

Beware: this will overwrite all of your existing files for this question, so only do it if you seriously mess things up.