

計算機程式設計

C語言 Unit Test

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單元測試 (Unit Test)

□ 測試

- 一個程式如何算完成，如何證明程式沒有問題。
- 應有測試程式(test driver)與測試案例(test case)驗證，程式通過這些test case。
- 單元測試用簡單明確方法，驗證某功能在測試案例如預期運作。

□ 計算BMI公式: $BMI = \text{體重(公斤)} / \text{身高}^2(\text{公尺平方})$

- 測試案例：52公斤的人，身高155公分，BMI為： $52(\text{公斤}) / (1.55 * 1.55)(\text{公尺平方}) = 21.64412$ 。兩位小數 21.64

```
double computeBMI(int kg, int height) {  
    double M = height/100.0;  
    double BMI = 0.0;  
    if (kg<=0 || height<=0)  
        return -1;  
    BMI = round(kg/(M*M),2); //四捨五入取兩位小數  
    return BMI;  
}
```

單元測試 (Unit Test)

❑ #include <assert.h> , **assert(int expression)** , 錯誤會中斷程式。

```
#include <stdio.h>           // main.c
#include <math.h>
#include <assert.h>
double computeBMI(int kg, int height) {
    double BMI = 0.0, M = height/100.0;
    if (kg<=0 || height<=0)
        return -1;
    BMI = round(100*kg/(M*M))/100; //四捨五入取兩位小數
    return BMI;
}
int main() {
    int kg = 52, height = 155;
    double expectedResult = 21.64f;
    double result = computeBMI(kg, height);
    assert(fabs(result-expectedResult)<0.0001);
    printf("Hi\n");
    return 0;
}
```

程式碼涵蓋度 (Code Coverage)

- 程式碼涵蓋度 (Code Coverage) – 指令涵蓋與分支涵蓋
 - 每條指令是否執行過? 每個分支判斷 True/False 是否執行過?
- 、 □ gcov (GCC Coverage)，測試程式碼覆蓋率的工具
 - 分析哪幾行程式被執行過，統計每一行程式的執行次數
- 、 □ gprof 程式分析工具 (profiling tool)，分析程式耗費時間
 - 藉以改善程式執行效率

程式碼涵蓋度 (Code Coverage)

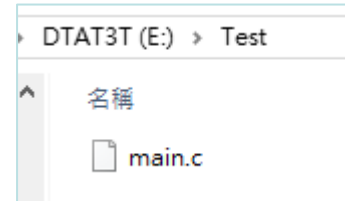
□ 指令行執行步驟

- 編輯main.c
- 在指令行執行gcc -fprofile-arcs -ftest-coverage -o main main.c
 - 在目標檔中加入gcov所需extra profiling information
 - 產生main.exe、main.gcno(gcov 所需檔案)
- 在指令行執行main.exe
 - 產生test.gcda檔案(gcov 所需data檔案)
- 在指令行執行gcov -b -c main.c
 - 顯示code coverage資訊
 - 產生main.c.gcda，紀錄每行程式碼執行的次數
- 使用記事本打開main.c.gcov，查看每行程式碼執行的次數

程式碼涵蓋度 (Code Coverage)

□ 指令行執行步驟

- 在e:\Test目錄，編輯main.c



```
main.c - 記事本
檔案(F) 編輯(E) 格式(O) 檢視(V) 說明(H)
#include <stdio.h>
#include <math.h>
#include <assert.h>
double computeBMI(int kg, int height) {
    double M = height/100.0;
    double BMI = 0.0;
    if (kg<=0 || height<=0)
        return -1;
    BMI = round(100*kg/(M*M))/100; //四捨五入取兩位小數
    return BMI;
}
int main() {
    int kg = 52, height = 155;
    double expectedResult = 21.64f;
    double result = computeBMI(kg, height);
    assert(fabs(result-expectedResult)<0.0001);
    printf("Hi\n");
    return 0;
}
```

程式碼涵蓋度 (Code Coverage)

- 在指令行執行 `gcc -fprofile-arcs -ftest-coverage -o main main.c`
 - 開啟命令提示字元
 - `e:`
 - `cd e:\Test`
 - `dir main.c`
 - `path=%path%;C:\Program Files (x86)\CodeBlocks\MinGW\bin`
 - `C:\Program Files (x86)\CodeBlocks\MinGW\bin` 安裝codeblock的地方，或gcc的地方
 - `gcc -fprofile-arcs -ftest-coverage -o main main.c`
 - `dir`
 - 確認產生 `main.exe`、`main.gcno`

程式碼涵蓋度 (Code Coverage)

- 在指令行執行 `gcc -fprofile-arcs -ftest-coverage -o main main.c`

```
命令提示字元

C:\Users\jykuo>e:

E:\>cd Test

E:\Test>dir main.c
磁碟區 E 中的磁碟是 DTAT3T
磁碟區序號: B613-6B32

E:\Test 的目錄
2020/02/16 上午 10:42          499 main.c
               1 個檔案          499 位元組
               0 個目錄 845,378,142,208 位元組可用

E:\Test>path=%path%;C:\Program Files (x86)\CodeBlocks\MinGW\bin

E:\Test>gcc -fprofile-arcs -ftest-coverage -o main main.c

E:\Test>dir
磁碟區 E 中的磁碟是 DTAT3T
磁碟區序號: B613-6B32

E:\Test 的目錄
2020/02/16 上午 11:22 <DIR>          .
2020/02/16 上午 11:22 <DIR>          ..
2020/02/16 上午 10:42          499 main.c
2020/02/16 上午 11:22      132,620 main.exe  -
2020/02/16 上午 11:22          796 main.gcno -
               3 個檔案      133,915 位元組
               2 個目錄 845,378,142,208 位元組可用
```


程式碼涵蓋度 (Code Coverage)

- 在指令行執行main.exe
 - 產生main.gcda檔案(gcov 所需data檔案)

```
E:\Test>main.exe
Hi

E:\Test>dir
磁碟區 E 中的磁碟是 DTAT3T
磁碟區序號: B613-6B32

E:\Test 的目錄
2020/02/16 上午 11:27 <DIR> .
2020/02/16 上午 11:27 <DIR> ..
2020/02/16 上午 10:42      499 main.c
2020/02/16 上午 11:22    132,620 main.exe
2020/02/16 上午 11:27      244 main.gcda
2020/02/16 上午 11:22      796 main.gcno
                4 個檔案      134,159 位元組
                2 個目錄    845,378,142,208 位元組可用
```

程式碼涵蓋度 (Code Coverage)

- 在指令行執行 `gcov -b -c main.c`
 - 顯示 code coverage 資訊
 - 產生 `main.c.gcov`，紀錄每行程式碼執行的次數

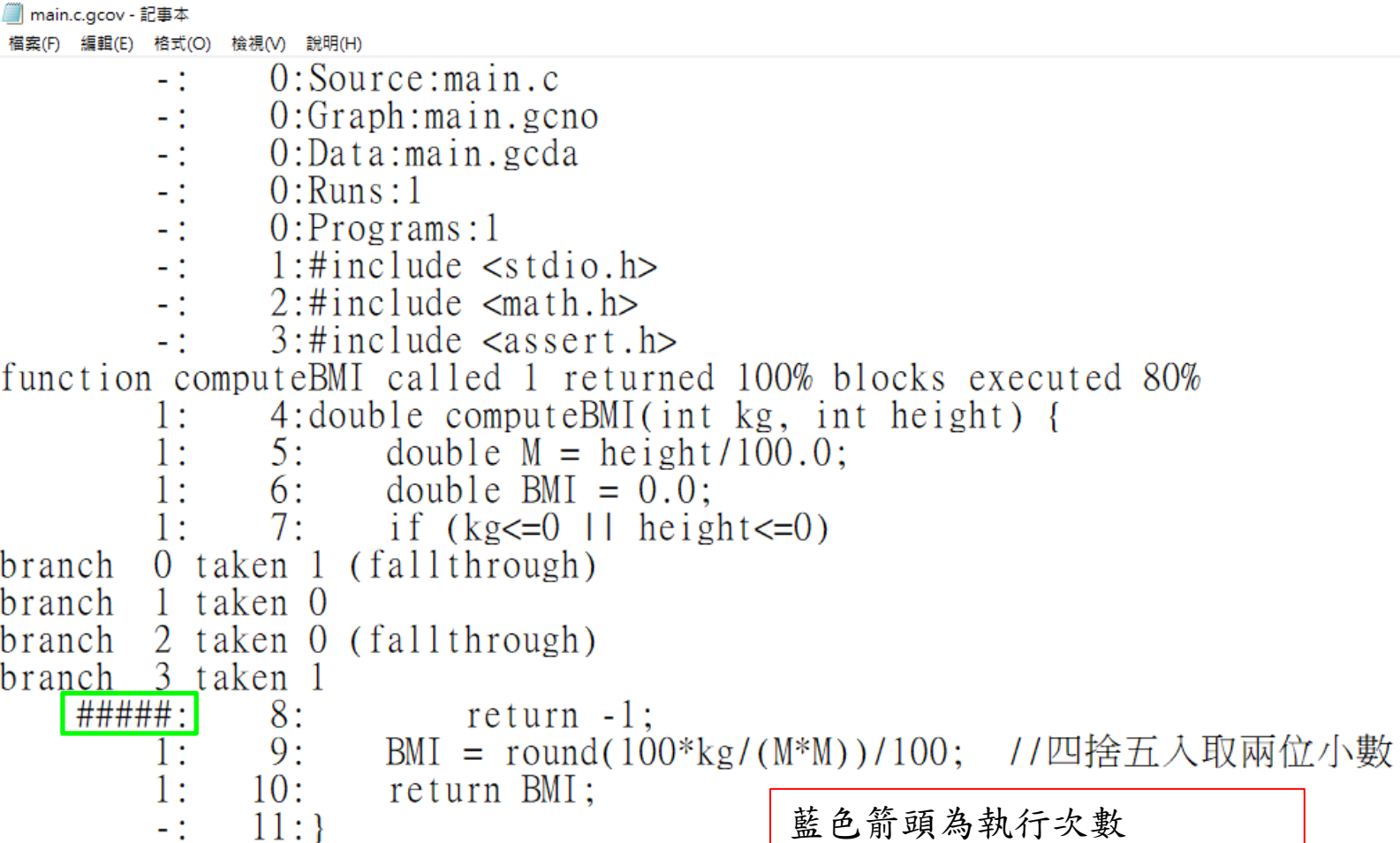
```
E:\Test>gcov -b -c main.c
File 'main.c'
Lines executed:92.86% of 14
Branches executed:100.00% of 6
Taken at least once:50.00% of 6
Calls executed:66.67% of 3
Creating 'main.c.gcov'

E:\Test>dir
磁碟區 E 中的磁碟是 DTAT3T
磁碟區序號: B613-6B32

E:\Test 的目錄
2020/02/16 上午 11:27 <DIR> .
2020/02/16 上午 11:27 <DIR> ..
2020/02/16 上午 10:42 499 main.c
2020/02/16 上午 11:27 1,315 main.c.gcov
2020/02/16 上午 11:22 132,620 main.exe
2020/02/16 上午 11:27 244 main.gcda
2020/02/16 上午 11:22 796 main.gcno
                    5 個檔案      135,474 位元組
                    2 個目錄      845,378,138,112 位元組可用
```

程式碼涵蓋度 (Code Coverage)

- 使用記事本打開main.c.gcov，查看每行程式碼執行的次數



```
main.c.gcov - 記事本
檔案(F) 編輯(E) 格式(O) 檢視(V) 說明(H)

-: 0:Source:main.c
-: 0:Graph:main.gcno
-: 0:Data:main.gcda
-: 0:Runs:1
-: 0:Programs:1
-: 1:#include <stdio.h>
-: 2:#include <math.h>
-: 3:#include <assert.h>
function computeBMI called 1 returned 100% blocks executed 80%
1: 4:double computeBMI(int kg, int height) {
1: 5:     double M = height/100.0;
1: 6:     double BMI = 0.0;
1: 7:     if (kg<=0 || height<=0)
branch 0 taken 1 (fallthrough)
branch 1 taken 0
branch 2 taken 0 (fallthrough)
branch 3 taken 1
#####: 8:         return -1;
1: 9:     BMI = round(100*kg/(M*M))/100; //四捨五入取兩位小數
1: 10:    return BMI;
-: 11:}
```



藍色箭頭為執行次數

紅色箭頭為行數

綠色框框的#####表示沒執行到

程式碼涵蓋度 (Code Coverage)

- 使用記事本打開main.c.gcov，查看每行程式碼執行的次數

```
function main called 1 returned 100% blocks executed 83%
    1: 12:int main() {
    1: 13:     int kg = 52, height = 155;
    1: 14:     double expectedResult = 21.64f;
    1: 15:     double result = computeBMI(kg, height);
call   0 returned 1
    1: 16:     assert(fabs(result-expectedResult)<0.0001);
branch 0 taken 0 (fallthrough)
branch 1 taken 1
call   2 never executed
    1: 17:     printf("Hi\n");
call   0 returned 1
    1: 18:     return 0;
    -: 19: }
    -: 20:
```

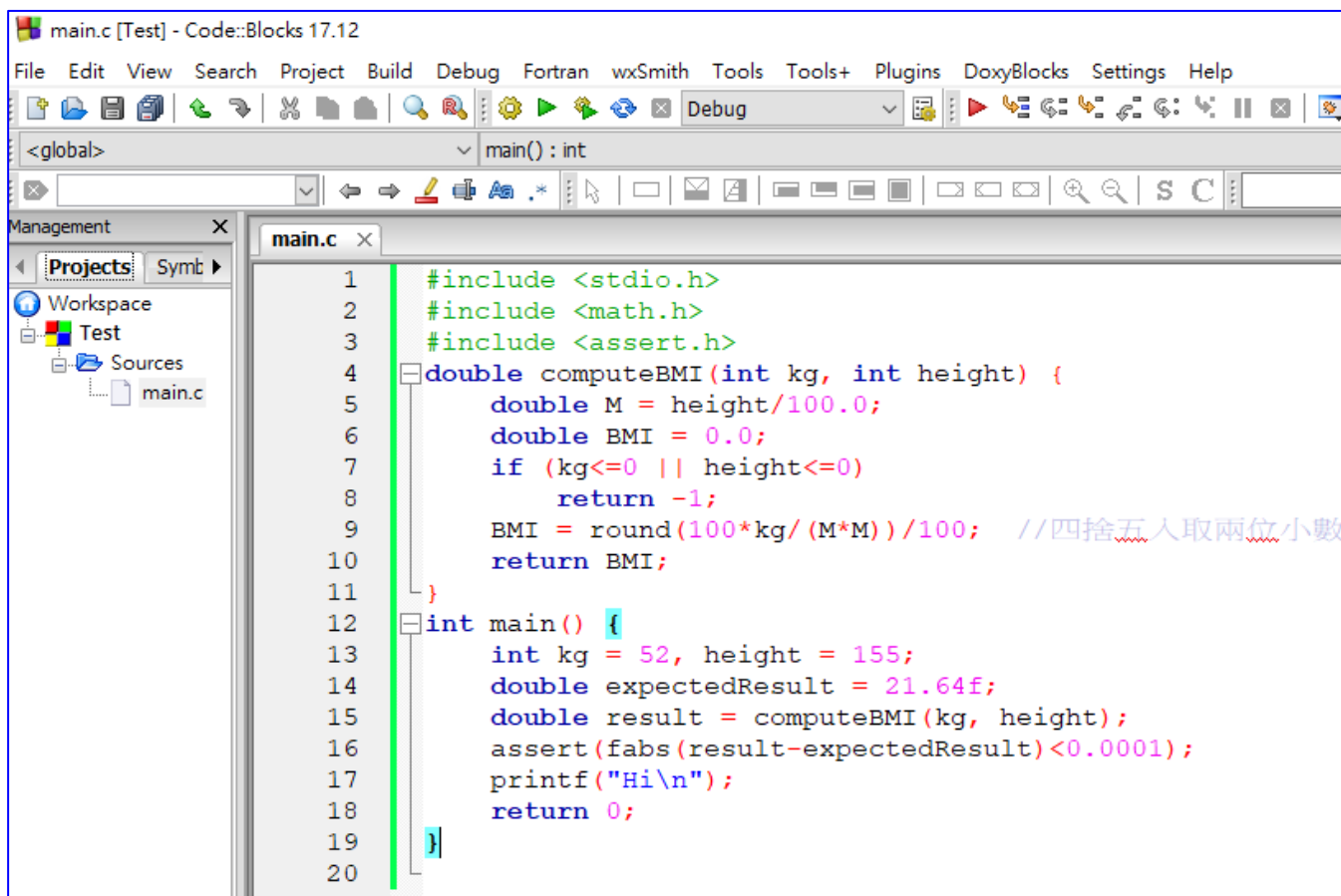
Exercise

- 如何使得涵蓋度 100%

程式碼涵蓋度 (Code Coverage)

□ 使用Code:Blocks

- 新增一個 Console Application 專案，編輯main.c

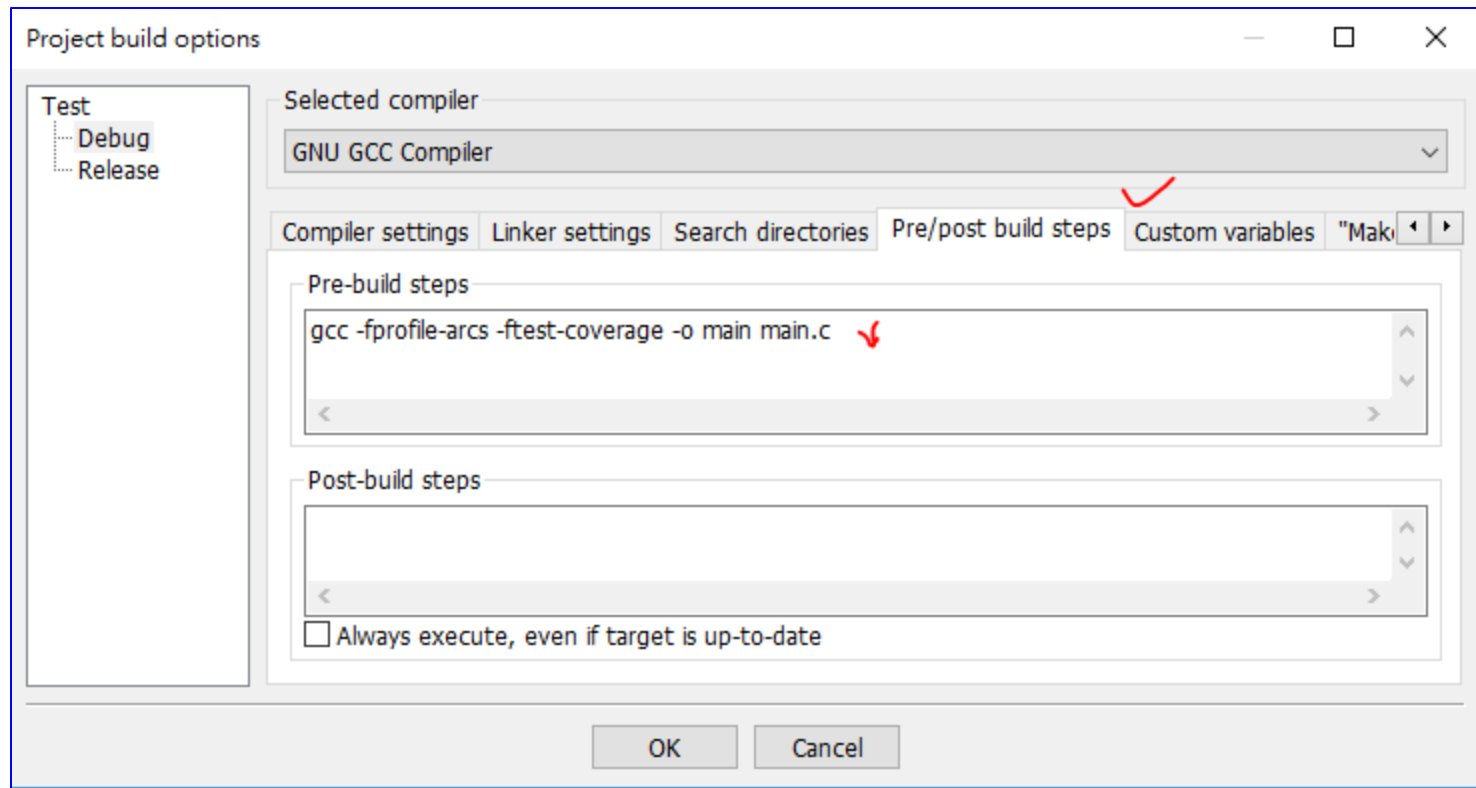


The screenshot shows the Code::Blocks IDE interface. The title bar reads "main.c [Test] - Code::Blocks 17.12". The menu bar includes File, Edit, View, Search, Project, Build, Debug, Fortran, wxSmith, Tools, Tools+, Plugins, DoxyBlocks, Settings, and Help. The toolbar contains various icons for file operations, editing, and execution. The "Project" dropdown menu is set to "main() : int". The "Management" panel on the left shows a tree view with "Workspace", "Test", "Sources", and "main.c". The main editor window displays the following C code:

```
1  #include <stdio.h>
2  #include <math.h>
3  #include <assert.h>
4  double computeBMI(int kg, int height) {
5      double M = height/100.0;
6      double BMI = 0.0;
7      if (kg<=0 || height<=0)
8          return -1;
9      BMI = round(100*kg/(M*M))/100; //四捨五入取兩位小數
10     return BMI;
11 }
12 int main() {
13     int kg = 52, height = 155;
14     double expectedResult = 21.64f;
15     double result = computeBMI(kg, height);
16     assert(fabs(result-expectedResult)<0.0001);
17     printf("Hi\n");
18     return 0;
19 }
20
```

程式碼涵蓋度 (Code Coverage)

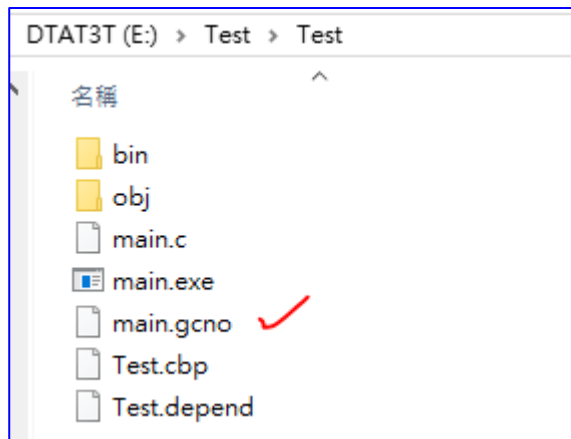
- 選單 project – build options – pre/post build steps，輸入
 - `gcc -fprofile-arcs -ftest-coverage -o main main.c`



- 按 OK
- 選單 File – save project

程式碼涵蓋度 (Code Coverage)

- 選單 Build – Build and run
- 查看檔案總管，產生main.gcno



Exercise

□ 測試計算BMI值的function

- BMI值計算公式: $BMI = \text{體重(公斤)} / \text{身高}^2(\text{公尺平方})$
- 例如：一個52公斤的人，身高是155公分，則BMI為：
- $52(\text{公斤}) / (1.55 * 1.55)(\text{公尺平方}) = 21.64412$
- 正常範圍為 $BMI = 18.5 \sim 24$
- 請設計一個 function，傳入身高(公分)、體重(公斤)，回傳BMI，取兩位小數四捨五入。
- 當 $BMI < 18.5$ ，輸出-1。
- 當 $BMI > 24$ ，輸出-2。
- 當身高或體重 < 0 ，輸出0。

Exercise

□ 測試計算BMI值的function

```
#include <stdio.h>           // main.c
#include <math.h>
#include <assert.h>

double computeBMI(int kg, int height) {
    double BMI = 0.0, M = height/100.0;
    if (kg<=0 || height<=0)
        return 0;
    BMI = round(100*kg/(M*M))/100; //四捨五入取兩位小數
    if (BMI <18.5)
        return -1;
    if (BMI >24)
        return -2;
    return BMI;
}

int main() {
    int kg = 52, height = 155;
    double expectedResult = 21.64f;
    double result = computeBMI(kg, height);
    assert(fabs(result-expectedResult)<0.0001);
    printf("Hi\n");
    return 0;
}
```

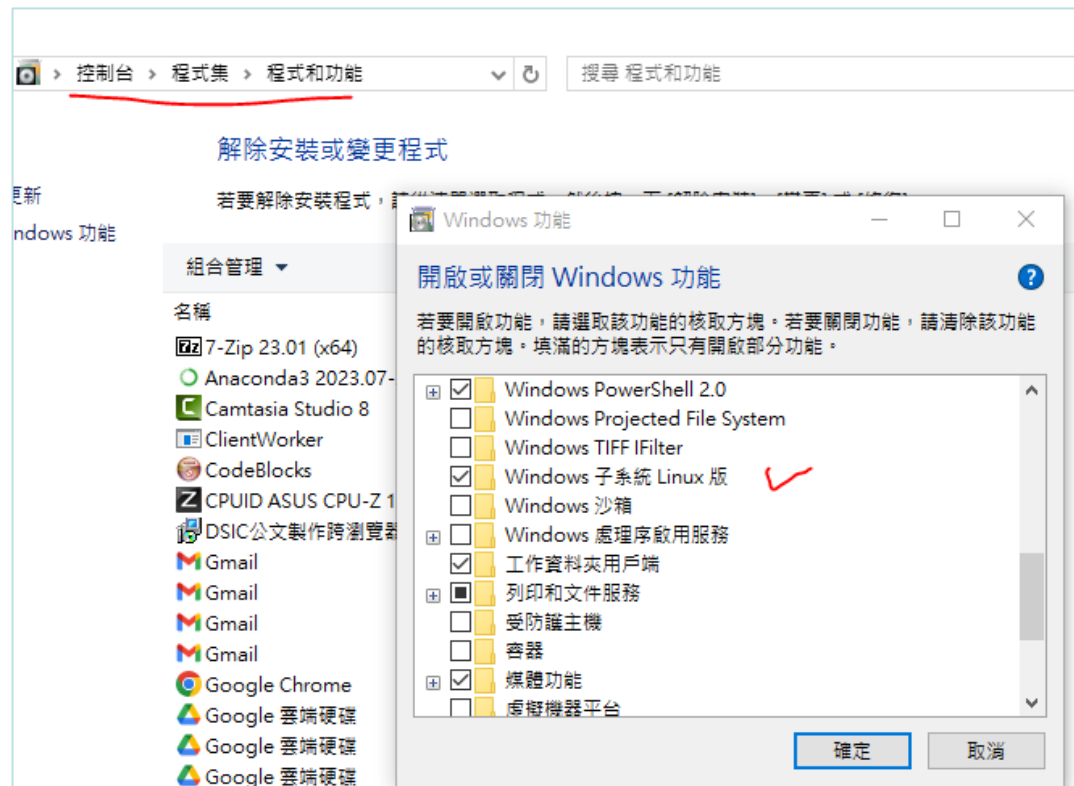
Exercise

- 給予一組學生名單，包括名字、學號以及其三科成績，計算每位學生的平均分數，並將最高分與最低分的學生姓名分數印出。

Google Test

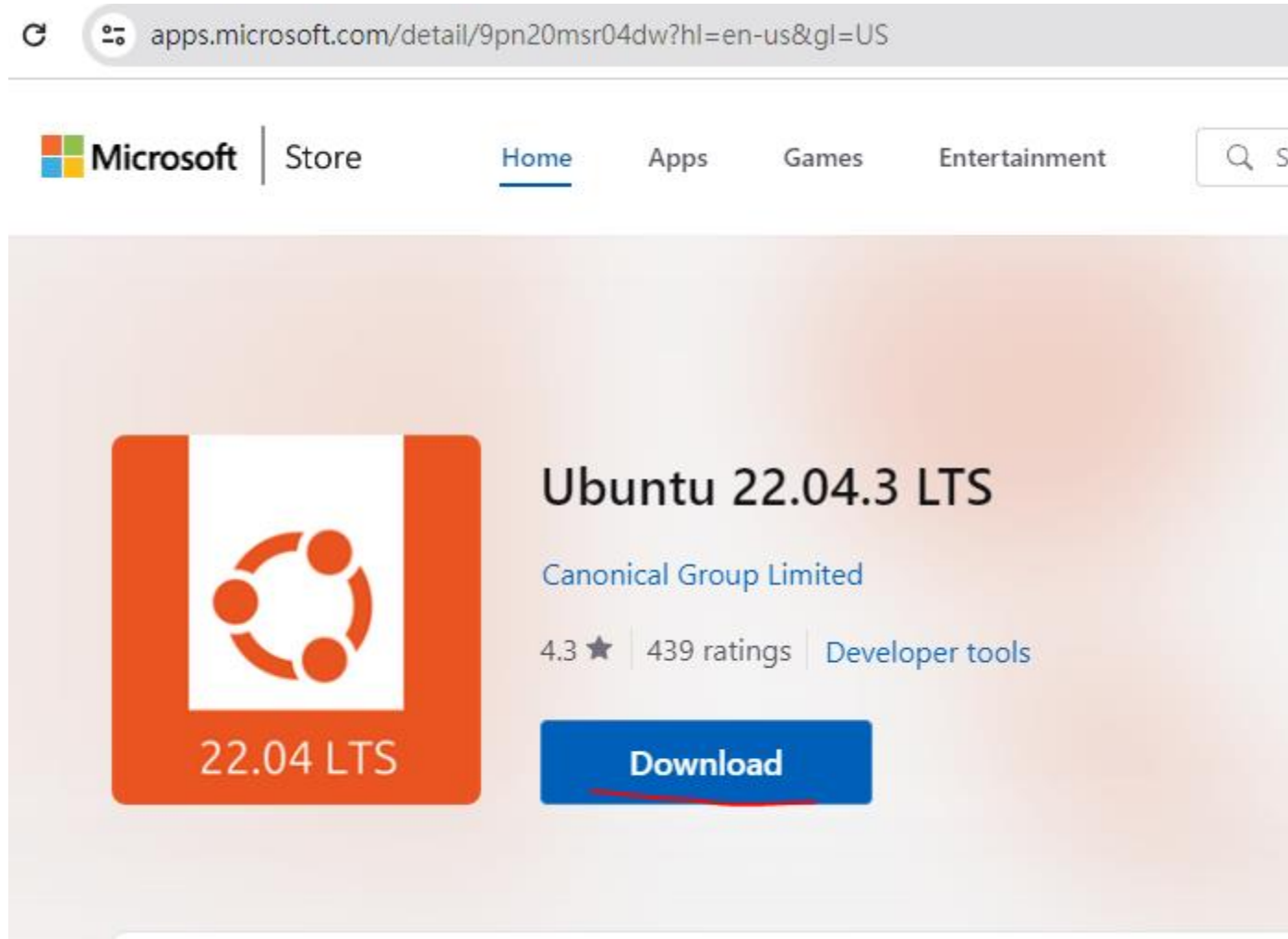
❑ Windows 10 安裝 Ubuntu bash

- 控制台 -> 應用程式與功能 -> 程式和功能 -> 開啟或關閉 Windows 功能
- 勾選『適用於 Linux 的 Windows 子系統 (立刻重新啟動)』



Google Test

- ❑ 搜尋 Microsoft Store 安裝 ubuntu ，安裝完 成後按「啟動」



Google Test

- ❑ 若 Windows 10 是 LTSC 版，無法在 Microsoft Store 安裝
 - 手動下載 Windows 子系統 Linux 版散發版本套件
 - <https://docs.microsoft.com/zh-tw/windows/wsl/install-manual>

下載發行版本

如果無法使用 Microsoft Store 應用程式，您可以按一下下列連結，下載並手動安裝 Linux 散發版本：

- [Ubuntu 20.04](#)
- [Ubuntu 20.04 ARM](#)
- [Ubuntu 18.04](#)

- 使用 PowerShell 安裝散發版本
- `Add-AppxPackage .\Ubuntu_1804.2019.522.0_x64.appx`

```
PS D:\desk> Add-AppxPackage .\Ubuntu_1804.2019.522.0_x64.appx
PS D:\desk>
```

Google Test

❑ 在 Ubuntu (win10-Ubuntu) 設定 Google test

○ 左下角程式集，開啟 Ubuntu bash



○ 一開始設定帳號、密碼

```
jykuo@DESKTOP-CE8JI9C: /usr/src/gtest
Installing, this may take a few minutes...
Please create a default UNIX user account. The username does not need to match your Windows username.
For more information visit: https://aka.ms/wslusers
Enter new UNIX username: jykuo
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
Installation successful!
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

jykuo@DESKTOP-CE8JI9C:~$ sudo apt-get update
[sudo] password for jykuo:
```

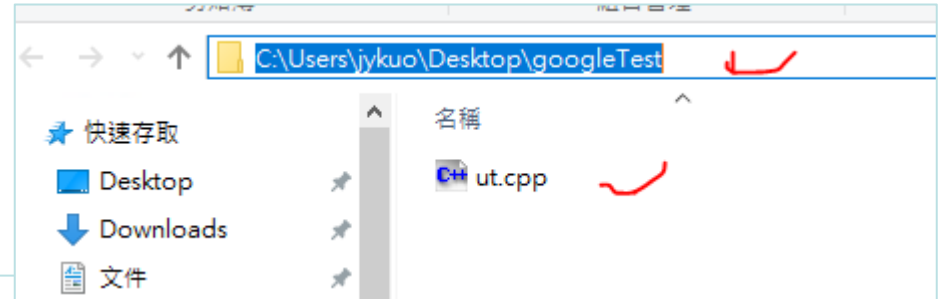
Google Test

❑ 在 Ubuntu bash 一行一行 輸入以下指令(需要十幾分鐘)

- `sudo apt-get update`
- `sudo apt-get install g++`
- `sudo apt-get install make`
- `sudo apt-get install libgtest-dev`
- `sudo apt-get install cmake`
- `cd /usr/src/gtest`
- `sudo cmake CMakeLists.txt`
- `sudo make`
- `cd lib`
- `sudo cp *.a /usr/lib`

Google Test

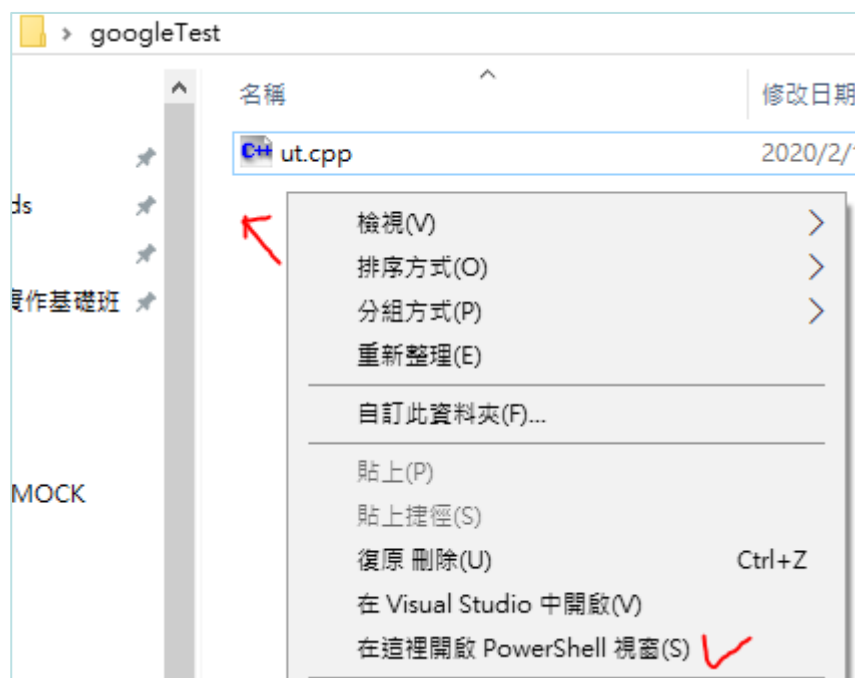
- ❑ 在 Windows 10 桌面新增googleTest目錄
- ❑ 在目錄內編輯 ut.cpp



```
#include <cstdlib>
#include <gtest/gtest.h>
int mul( int a , int b ) {
    return a * b ;
}
TEST( multest , HandleNoneZeroInput ) {
    ASSERT_EQ( 21 , mul( 3 , 7 ) ) ;
    ASSERT_EQ( -24 , mul( -6 , 4 ) ) ;
}
int main( int argc , char **argv ){
    testing :: InitGoogleTest( &argc , argv ) ;
    return RUN_ALL_TESTS( ) ;
}
```

Google Test

- ❑ 在桌面googleTest目錄，按shift + 滑鼠右鍵
 - 選開啟powerShell，在指令行輸入bash，進入Linux Ubuntu。



```
jykuo@DESKTOP-CE8JI9C: /mnt/c/Users/jykuo/Desktop/googleTest
PS C:\Users\jykuo\Desktop\googleTest> bash
jykuo@DESKTOP-CE8JI9C: /mnt/c/Users/jykuo/Desktop/googleTest$
```

Google Test

❑ 輸入指令，編譯、執行、看code coverage報表

- `g++ -pg -fprofile-arcs -ftest-coverage ut.cpp -o ut -lgtest -lpthread`
- `./ut`

```
jykuo@DESKTOP-CE8JI9C: /mnt/c/Users/jykuo/Desktop/googleTest
jykuo@DESKTOP-CE8JI9C:/mnt/c/Users/jykuo/Desktop/googleTest$ g++ -pg -fprofile-arcs -ftest-coverage ut.cpp -o ut -lgtest -lpthread
jykuo@DESKTOP-CE8JI9C:/mnt/c/Users/jykuo/Desktop/googleTest$ ./ut
Running 1 test from 1 test case.
Global test environment set-up.
1 test from multtest
multtest.HandleNoneZeroInput
multtest.HandleNoneZeroInput (0 ms)
1 test from multtest (1 ms total)

Global test environment tear-down
1 test from 1 test case ran. (2 ms total)
PASSED 1 test.
jykuo@DESKTOP-CE8JI9C:/mnt/c/Users/jykuo/Desktop/googleTest$
```

- `gcov -c -b ut.cpp`

```
jykuo@DESKTOP-CE8JI9C: /mnt/c/Users/jykuo/Desktop/googleTest
jykuo@DESKTOP-CE8JI9C:/mnt/c/Users/jykuo/Desktop/googleTest$ gcov -c -b ut.cpp
File 'ut.cpp'
Lines executed:100.00% of 9
Branches executed:57.89% of 38
Taken at least once:28.95% of 38
Calls executed:53.19% of 47
Creating 'ut.cpp.gcov'
```

Google Test - 安裝html報表

- ❑ 安裝 lcov , `sudo apt-get install -y lcov`

```
jykuo@DESKTOP-CE8JI9C:/mnt/c/Users/jykuo/Desktop/googleTest$ sudo apt-get install -y lcov
[sudo] password for jykuo:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
```

- ❑ 產生html報表 ,

- `lcov -c -o ut.info -d . --rc lcov_branch_coverage=1`

```
jykuo@DESKTOP-CE8JI9C:/mnt/c/Users/jykuo/Desktop/googleTest$ lcov -c -o ut.info -d . --rc lcov_branch_coverage=1
Capturing coverage data from .
Found gcov version: 7.4.0
Scanning . for .gcda files ...
Found 1 data files in .
Processing ut.gcda
Finished .info-file creation
```

- `genhtml ut.info -o report --branch-coverage`

```
jykuo@DESKTOP-CE8JI9C:/mnt/c/Users/jykuo/Desktop/googleTest$ genhtml ut.info -o report --branch-coverage
Reading data file ut.info
Found 8 entries.
Found common filename prefix "/usr/include"
Writing .css and .png files.
Generating output.
Processing file /mnt/c/Users/jykuo/Desktop/googleTest/ut.cpp
Processing file c++/7/iostream
```

Google Test - 安裝html報表

- 在googleTest\report目錄點選index.html

名稱	修改日期	類型	大小
c++	2020/3/31 下午 0...	檔案資料夾	
gtest	2020/3/31 下午 0...	檔案資料夾	
mnt	2020/3/31 下午 0...	檔案資料夾	
amber.png	2020/3/31 下午 0...	PNG 檔案	1 KB
emerald.png	2020/3/31 下午 0...	PNG 檔案	1 KB
gcov.css	2020/3/31 下午 0...	階層式樣式表文件	10 KB
glass.png	2020/3/31 下午 0...	PNG 檔案	1 KB
index.html	2020/3/31 下午 0...	Chrome HTML D...	7 KB

- ## □ 產生html報表

Current view: [top level](#) - [mnt/c/Users/jykuo/Desktop/googleTest](#) - [ut.cpp](#) (source / functions)

Test: ut.info

Date: 2020-03-31 15:32:43

Hit	Total	Coverage
-----	-------	----------

Lines: 20 20 100.0 %

Functions:	8	8	100.0 %
------------	---	---	---------

Branches:	28	88	31.8 %
-----------	----	----	--------

	Branch data	Line data	Source code
1	:	:	#include <stdlib>
2	:	:	#include <gtest/gtest.h>
3	:	:	#include <math.h>
4	:	5 :	double computeBMI(int kg, int height) {
5	:	5 :	double BMI = 0.0, M = height/100.0;
6	[+ +] [+ +] :	5 :	if (kg<=0 height<=0)
7	:	2 :	return 0;
8	:	3 :	BMI = round(100*kg/(M*M))/100; // 0.0000000000000000
9	[+ +] :	3 :	if (BMI <18.5)
10	:	1 :	return -1;
11	[+ +] :	2 :	if (BMI >24)
12	:	1 :	return -2;
13	:	1 :	return BMI;
14	:	:	}
15	[+ -] [+ -] :	8 :	TEST(multitest , HandleNoneZeroInput) {

Google Test - 分開測試檔案

□ 編輯三個檔案

```
// bmi.h  
double computeBMI(int kg, int height);
```

```
//bmi.cpp  
#include <math.h>  
double computeBMI(int kg, int height) {  
    double BMI = 0.0, M = height/100.0;  
    if (kg<=0 || height<=0)  
        return 0;  
    BMI = round(100*kg/(M*M))/100; //四捨五入取兩位小數  
    if (BMI <18.5)  
        return -1;  
    if (BMI >24)  
        return -2;  
    return BMI;  
}
```

Google Test - 分開測試檔案

□ 編輯三個檔案

```
//ut.cpp
#include <cstdlib>
#include <gtest/gtest.h>
#include "bmi.h"
TEST( multest , HandleNoneZeroInput ) {
    ASSERT_EQ( 0 , computeBMI( 0 , 0 ) );
    ASSERT_EQ( 0 , computeBMI( 100 , 0 ) );
    ASSERT_EQ( -2 , computeBMI( 52 , 100 ) );
    ASSERT_EQ( -1 , computeBMI( 42 , 155 ) );
    ASSERT_EQ( 21.64 , computeBMI( 52 , 155 ) );
}
int main( int argc , char **argv ){
    testing::InitGoogleTest( &argc , argv );
    return RUN_ALL_TESTS();
}
```

Google Test - 分開測試檔案

- `g++ -pg -fprofile-arcs -ftest-coverage bmi.cpp ut.cpp -o ut -lgtest -lpthread`

- `./ut`

```
jykuo@DESKTOP-CE8JI9C:/mnt/c/Users/jykuo/Desktop/googleTest$ g++ -pg -fprofile-arcs
-ftest-coverage bmi.cpp ut.cpp -o ut -lgtest -lpthread
jykuo@DESKTOP-CE8JI9C:/mnt/c/Users/jykuo/Desktop/googleTest$ ./ut
[-----] Running 1 test from 1 test case.
[-----] Global test environment set-up.
[-----] 1 test from multest
[ RUN      ] multest.HandleNoneZeroInput
[ OK       ] multest.HandleNoneZeroInput (0 ms)
[-----] 1 test from multest (5 ms total)

[-----] Global test environment tear-down
[-----] 1 test from 1 test case ran. (9 ms total)
[ PASSED  ] 1 test.
```

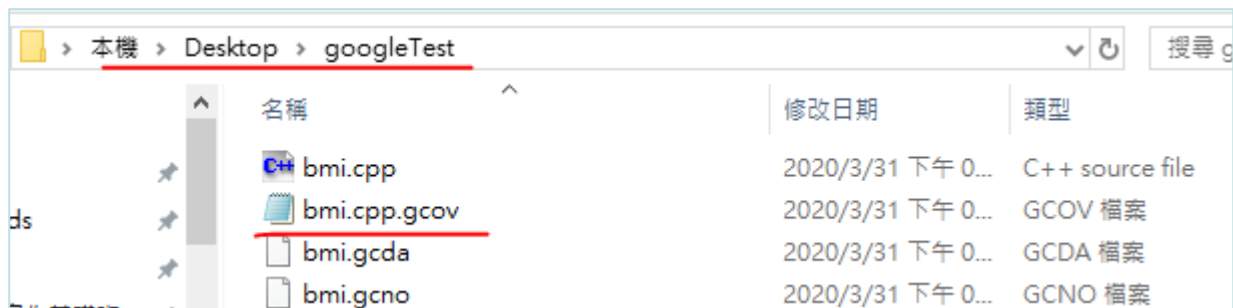
- `gcov -c -b ut.cpp`

- `gcov -c -b bmi.cpp`

```
jykuo@DESKTOP-CE8JI9C:/mnt/c/Users/jykuo/Desktop/googleTest$ gcov -c -b bmi.cpp
File 'bmi.cpp'
Lines executed:100.00% of 10
Branches executed:100.00% of 8
Taken at least once:100.00% of 8
No calls
Creating 'bmi.cpp.gcov'
```


Google Test - 分開測試檔案

- 在googleTest目錄，檢視bmi.cpp.gcov

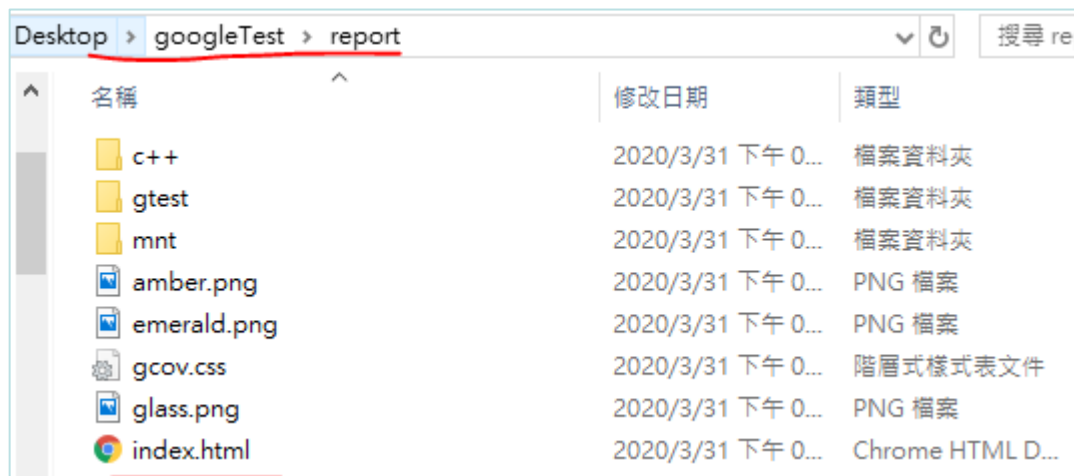


```
bmi.cpp.gcov
1  -: 0:Source:bmi.cpp
2  -: 0:Graph:bmi.gcno
3  -: 0:Data:bmi.gcda
4  -: 0:Runs:1
5  -: 0:Programs:1
6  -: 1:#include <math.h>
7  function _Z10computeBMIII called 5 returned 100% blocks executed 100%
8      5: 2:double computeBMI(int kg, int height) {
9      5: 3:     double BMI = 0.0, M = height/100.0;
10     5: 4:     if (kg<=0 || height<=0)
11 branch 0 taken 4 (fallthrough)
12 branch 1 taken 1
13 branch 2 taken 1 (fallthrough)
14 branch 3 taken 3
15     2: 5:         return 0;
16     3: 6:         BMI = round(100*kg/(M*M))/100; //四捨五入取兩位小數
17     3: 7:         if (BMI <18.5)
18 branch 0 taken 1 (fallthrough)
19 branch 1 taken 2
20     1: 8:             return -1;
21     2: 9:             if (BMI >24)
22 branch 0 taken 1 (fallthrough)
23 branch 1 taken 1
24     1: 10:                return -2;
25     1: 11:                return BMI;
26 -: 12:}
```

Google Test - 分開測試檔案

□ 產生html報表

- `lcov -c -o ut.info -d . --rc lcov_branch_coverage=1`
- `genhtml ut.info -o report --branch-coverage`
- 在googleTest\report目錄點選index.html



Google Test - 分開測試檔案

□ 產生html報表





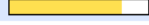
LCOV - code coverage report

Current view: [top level](#)

Test: [ut.info](#)

Date: 2020-03-31 16:15:28

	Hit	Total	Coverage
Lines:	50	86	58.1 %
Functions:	32	62	51.6 %
Branches:	40	142	28.2 %

Directory	Line Coverage	Functions	Branches
/mnt/c/Users/jykuo/Desktop/googleTest	 100.0 % 20 / 20	100.0 % 8 / 8	33.7 % 33 / 98
c++/7	 100.0 % 1 / 1	- 0 / 0	- 0 / 0
c++/7/bits	 100.0 % 2 / 2	100.0 % 1 / 1	- 0 / 0
gtest	 29.8 % 14 / 47	30.6 % 11 / 36	6.7 % 2 / 30
gtest/internal	 81.2 % 13 / 16	70.6 % 12 / 17	35.7 % 5 / 14

LCOV - code coverage report

Current view: [top level](#) - [mnt/c/Users/jykuo/Desktop/googleTest - bmi.cpp](#) (source / [functions](#))

Test: [ut.info](#)

Date: 2020-03-31 16:15:28

	Hit	Total	Coverage
Lines:	10	10	100.0 %
Functions:	1	1	100.0 %
Branches:	8	8	100.0 %

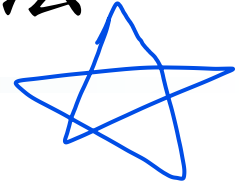
Branch data

Line data

Source code

1	:	:	#include <math.h>
2	:	10	double computeBMI(int kg, int height) {
3	:	10	double BMI = 0.0, M = height/100.0;
4	[+ +] [+ +]	10	if (kg<=0 height<=0)
5	:	4	return 0;
6	:	6	BMI = round(100*kg/(M*M))/100; //
7	[+ +]	6	if (BMI <18.5)
8	:	2	return -1;
9	[+ +]	4	if (BMI >24)
10	:	2	return -2;
11	:	2	return BMI;
12	:	:	}

設計測試案例(Test case)方法



□ 白箱測試(white box testing)

- 檢視程式碼，設計測試案例，執行所有程式碼可能路徑
- 評估測試案例的涵蓋度準則(coverage criteria)
 - Line coverage (statement coverage)，測試案例能執行所有程式碼行
 - branch coverage，測試案例能執行所有條件判斷狀況，一個條件判斷有二種狀況(True, False)，兩個條件組合有四種狀況(True/True, True/False, False/True, False False)

□ 黑箱測試(black box testing)

- 檢視題目需求，設計測試案例，執行題目需求可能狀況、功能
- 設計測試案例方法
 - 分類功能、規則、輸入條件，例如BMI太高或太低情況
 - 邊界值分析，考慮邊界情況，例如BMI太高或太低剛好邊界情況
 - 負向，不合規範的情況，例如負數體重、身高

黑箱測試方法 Homework

□ 題目需求

- 辨識輸入符號，Identifier是C語言的變數
- Input: rate R2D2 -2 time 555666 0.23 -1.2 #
- Output:
 - rate - Identifier
 - R2D2 - Identifier
 - -22 - Negative Integer
 - 555666 – Positive Integer
 - 0.23 - Positive Floating
 - -1.2 - Negative Floating
- Exercise: 考慮負向情況的測試案例

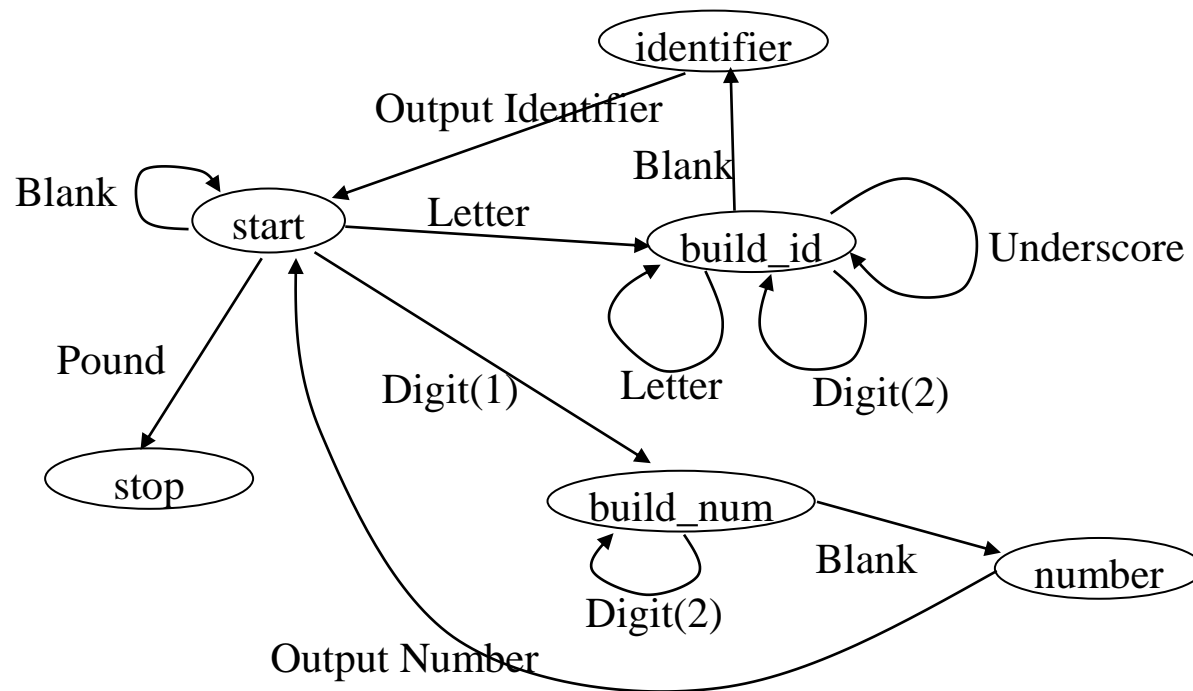
黑箱測試方法 Homework

□ 使用有限狀態機解題

○ 簡化題目

➤ 只處理 identifier, Number

Digit(1)	1, .., 9
Pound	#
Blank	empty
Letter	A,.., Z, a, .., z
Digit(2)	0, 1, .., 9
Underscore	_



黑箱測試方法 Homework

▣ typedef 自訂資料型別 data type

- 自訂資料型別，命名以_t結束，可以一此宣告變數

```
typedef int myInt_t;  
myInt x1=0, x2=3;  
x1 = x2 + 4;
```

▣ 列舉型別 (enumeration)，使程式易於閱讀、了解、修改

- 列舉所宣告的變數，有哪些值，第一個符號其值預設為0，後面依序加1
- state_t，是自訂資料型別，值有 start, build_id, build_num，其值分別為 0, 1, 2。

```
typedef enum {start, build_id, build_num} state_t;  
state_t x1, x2;  
x1 = start;  
x2 = build_num;  
printf("%d, %d\\", x1, x2); //印出 0, 1
```

黑箱測試方法 Homework

```
#include <stdio.h>          // FMS.c
#include <ctype.h>
typedef enum {start, build_id, build_num, build_invalid, identifier, number, invalid, stop} state_t;
state_t getNextState(state_t current_state, char ch) {
    if (current_state == start) {
        if (ch == ' ') return start;
        else if (isalpha(ch)) return build_id;
        else if (isdigit(ch)) return build_num;
        else if (ch=='#') return stop;
    }
    if (current_state == build_id) {
        if (isalpha(ch)||isdigit(ch)||(ch=='_')) return build_id;
        else if (ch==' ') return identifier;
    }
    if (current_state == build_num) {
        if (isdigit(ch)) return build_num;
        else if (ch==' ') return number;
    }
    return stop;
}
```


黑箱測試方法 Homework

- 使用有限狀態機解題，只處理identifier, Number

```
void FMS() {
    char input_char;
    state_t current_state;
    current_state = start;
    do {
        if (current_state==identifier) {
            printf(" - identifier\n");
            current_state = start;
        }
        else if (current_state==number) {
            printf(" - number\n");
            current_state = start;
        }
        scanf("%c", &input_char);
        if (input_char != ' ') printf("%c", input_char);
        current_state = getNextState(current_state, input_char);
    } while (current_state!=stop);
}

int main() {    FMS();    return 0; }
```

黑箱測試方法 Homework

❑ 設計 test.txt

```
rate R2D2 2 time 55566 23 12 #
```

❑ 編譯 fms.c

❑ 在 cmd 模式，執行 fms.c 測試



```
命令提示字元
D:\Test>fms.exe<test.txt
rate - identifier
R2D2 - identifier
2 - number
time - identifier
55566 - number
23 - number
12 - number
#
D:\Test>
```

APPENDIX Google Test 白箱測試

```
#include <stdio.h>                // fms.cpp
#include <stdlib.h>
#include <ctype.h>
#include <string.h>
typedef enum {start, build_id, build_num, build_invalid, identifier, number, invalid, stop} state_t;
state_t getNextState(state_t current_state, char ch) {
    if (current_state == start) {
        if (ch == ' ')
            return start;
        else if (isalpha(ch))
            return build_id;
        else if (isdigit(ch)) return build_num;
        else if (ch=='#') return stop;
    }
    if (current_state == build_id) {
        if (isalpha(ch)||isdigit(ch)||(ch=='_'))
            return build_id;
        else if (ch==' ')
            return identifier;
    }
    if (current_state == build_num) {
        if (isdigit(ch))
            return build_num;
        else if (ch==' ')
            return number;
    }
    return stop;
}
```

APPENDIX Google Test 白箱測試

```
char * FMS(char *s) { // fms.cpp
    char out[80];
    char *output = (char*) malloc(sizeof(char)*500);
    char input_char;
    int index=0;
    state_t current_state;
    current_state = start;
    strcpy(output, "");
    do {
        if (current_state==identifier) {
            current_state = start;
            sprintf(out, " - identifier\n");
            strcat(output, out);
        }
        else if (current_state==number) {
            current_state = start;
            sprintf(out, " - number\n");
            strcat(output, out);
        }
        //scanf("%c", &input_char);
        input_char = s[index++];
        if ((input_char != ' ')&&(input_char != '#')) {
            sprintf(out, "%c", input_char);
            strcat(output, out);
        }
        current_state = getNextState(current_state, input_char);
    } while (current_state!=stop);
    return output;
}
```

黑箱測試方法 Homework

❑ 編輯 run.sh

```
#!/bin/bash
g++ -pg -fprofile-arcs -ftest-coverage fms.cpp ut.cpp -o ut -lgtest -lpthread
./ut
gcov -c -b fms.cpp
lcov -c -o ut.info -d . --rc lcov_branch_coverage=1
genhtml ut.info -o report --branch-coverage
```

```
//fms.h
char * FMS(char *s);
```

```
// ut.cpp
#include <cstdlib>
#include <gtest/gtest.h>
#include "fms.h"
TEST( fmsTest , HandleInput ) {
    char s[]="rate R2D2 2 time 55566 23 12 #";
    char expOutput[] = "rate - identifier\nR2D2 - identifier\n2 - number\ntime - identifier\n55566 - number\n23 - number\n12 - number\n";
    ASSERT_STREQ(expOutput, FMS(s));
}
int main( int argc , char **argv ){
    testing :: InitGoogleTest( &argc , argv );
    return RUN_ALL_TESTS( ) ;
}
```

黑箱測試方法 Homework

- ❑ 編輯 run.sh
 - vi run.sh 或 vim run.sh 或 gedit run.sh
- ❑ chmod +x run.sh
- ❑ ./run.sh

```
jykuo@DESKTOP-CE8JI9C:/mnt/d/Test/googleTest$ ./run.sh
[=====] Running 1 test from 1 test case.
[-----] Global test environment set-up.
[-----] 1 test from fmsTest
[ RUN      ] fmsTest.HandleInput
[          ] fmsTest.HandleInput (0 ms)
[-----] 1 test from fmsTest (14 ms total)

[-----] Global test environment tear-down
[=====] 1 test from 1 test case ran. (381 ms total)
[ PASSED  ] 1 test.
File 'fms.cpp'
Lines executed:95.12% of 41
Branches executed:100.00% of 40
Taken at least once:87.50% of 40
Calls executed:100.00% of 1
```

APPENDIX Google Test 白箱測試

LCOV - code coverage report

Current view: [top level](#) - [mnt/d/Test/googleTest - fms.cpp](#) (source / functions)

Test: ut.info

Date: 2020-04-02 17:09:09

	Hit	Total	Coverage
Lines:	39	41	95.1 %
Functions:	2	2	100.0 %
Branches:	35	40	87.5 %

	Branch data	Line data	Source code
1		:	: #include <stdio.h>
2		:	: #include <stdlib.h>
3		:	: #include <ctype.h>
4		:	: #include <string.h>
5		:	: typedef enum
6		:	: {start, build_id, build_num, build_invalid,
7		:	: identifier, number, invalid, stop}
8		:	: state_t;
9		31 :	state_t getNextState(state_t current_state, char ch) {
10	[+ +]	31 :	if (current_state == start) {
11	[+ +]	9 :	if (ch == ' ')
12		1 :	return start;
13	[+ +]	8 :	else if (isalpha(ch))
14		3 :	return build_id;
15	[+ +]	5 :	else if (isdigit(ch)) return build_num;
16	[+ -]	1 :	else if (ch=='#') return stop;
17		:	}
18	[+ +]	22 :	if (current_state == build_id) {
19	[+ +]	12 :	if (isalpha(ch) isdigit(ch) (ch=='_'))
20	[- +]	:	
21	[+ -]	9 :	return build_id;
22		3 :	else if (ch==' ')
23		3 :	return identifier;
24	[+ -]	:	}
25	[+ +]	10 :	if (current_state == build_num) {
26		10 :	if (isdigit(ch))
27	[+ -]	6 :	return build_num;
28		4 :	else if (ch==' ')
29		4 :	return number;
30		:	}
31		0 :	else return stop;
32		0 :	}
33		1 :	char * FMS(char *s) {
34		:	char out[80];
35		1 :	char *output = (char*) malloc(sizeof(char)*500);
36		:	char input_char;
37		1 :	int index=0;
38		:	state_t current_state;
39		1 :	current_state = start;
40		1 :	strcpy(output,"");
41	[+ +]	30 :	do {
42		31 :	if (current_state==identifier) {
43		3 :	current_state = start;
44		3 :	sprintf(out, " - identifier\n");
45		3 :	strcat(output, out);
46	[+ +]	:	}
47		28 :	else if (current_state==number) {
48		4 :	current_state = start;
49		4 :	sprintf(out, " - number\n");
50		4 :	strcat(output, out);

Exercise

```
int main() {  
    int kg = 52, height = 155;  
    double expectedResult = 21.64f;  
    double result = computeBMI(kg, height);  
    assert(fabs(result-expectedResult)<0.0001);  
    assert(computeBMI(0,0)==0);  
    assert(computeBMI(100,0)==0);  
    assert(computeBMI(52,100)==-2);  
    assert(computeBMI(42,155)==-1);  
    printf("Hi\n");  
    return 0;  
}
```

6rte - Invalid
r_yg - Identifier
t#ee - Invalid