學號：407210013　　　姓名：　曾峻麒

功能一：「pi -p 7」


```
s407210013@workstation1: ~/osdi/sharedFolder/hw05.pthread
 File  Edit  View  Search  Terminal  Help
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ ./pi -p 7

lowerbdd is 3.14159265856
upperbdd is 3.14159266856

pi is 3.14159266356
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

功能二：「pi -p 7 -P 5」


```
s407210013@workstation1: ~/osdi/sharedFolder/hw05.pthread
 File  Edit  View  Search  Terminal  Help
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ ./pi -p 7 -P 5

lowerbdd is 3.14159265859
upperbdd is 3.14159266859

pi is 3.14159266359
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

功能三：「./pi」

主題甲：

時間計算 (皆採用 48 核心去做計算)：

Real time：在 48 核心下需花費的總實際時間。

User time：user mode 處理時總共 CPU 花費的時間。

System time：printf 之類在 kernal mode 所花費的時間。

逼近到小數點第 5 位數

逼近到小數點第 6 位數

```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6

lowerbdd is 3.14159270259
upperbdd is 3.14159280259

pi is 3.14159275259

real    0m1.456s
user    0m18.766s
sys     0m1.837s
```

逼近到小數點第 7 位數

```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 7

lowerbdd is 3.14159265856
upperbdd is 3.14159266856

pi is 3.14159266356

real    0m6.971s
user    3m15.146s
sys     0m2.897s
```

逼近到小數點第 8 位數

```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 8

lowerbdd is 3.14159265407
upperbdd is 3.14159265505

pi is 3.14159265456

real    0m54.397s
user    33m55.730s
sys     0m3.619s
```

逼近到小數點第 9 位數

```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 9

lowerbdd is 3.14159265364
upperbdd is 3.14159265374

pi is 3.14159265369

real    8m9.803s
user    342m59.332s
sys     0m5.688s
```

主題乙：

統一選擇逼近到小數點第6位數，探討在同樣的精準度下，觀察核心數與時間的關係。

```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 1

lowerbdd is 3.14159270358
upperbdd is 3.14159280358

pi is 3.14159275358

real    0m15.078s
user    0m15.015s
sys     0m0.040s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 2

lowerbdd is 3.14159270359
upperbdd is 3.14159280359

pi is 3.14159275359

real    0m7.681s
user    0m15.104s
sys     0m0.068s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 3

lowerbdd is 3.14159270356
upperbdd is 3.14159280356

pi is 3.14159275356

real    0m5.276s
user    0m15.371s
sys     0m0.060s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 4

lowerbdd is 3.14159270359
upperbdd is 3.14159280359

pi is 3.14159275359

real    0m4.001s
user    0m15.339s
sys     0m0.113s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 5

lowerbdd is 3.14159270359
upperbdd is 3.14159280359

pi is 3.14159275359

real    0m3.408s
user    0m15.645s
sys     0m0.100s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 6

lowerbdd is 3.14159270345
upperbdd is 3.14159280345

pi is 3.14159275345

real    0m2.914s
user    0m15.690s
sys     0m0.161s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

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s407210013@workstation1: ~/osdi/sharedFolder/hw05.pthread

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```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 7

lowerbdd is 3.14159270340
upperbdd is 3.14159280340

pi is 3.14159275340

real    0m2.602s
user    0m15.912s
sys     0m0.136s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 8

lowerbdd is 3.14159270359
upperbdd is 3.14159280359

pi is 3.14159275359

real    0m2.366s
user    0m15.865s
sys     0m0.212s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 9

lowerbdd is 3.14159270345
upperbdd is 3.14159280345

pi is 3.14159275345

real    0m2.107s
user    0m15.888s
sys     0m0.233s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

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s407210013@workstation1: ~/osdi/sharedFolder/hw05.pthread

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```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 10

lowerbdd is 3.14159270359
upperbdd is 3.14159280359

pi is 3.14159275359

real    0m2.132s
user    0m16.368s
sys     0m0.263s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 11

lowerbdd is 3.14159270328
upperbdd is 3.14159280328

pi is 3.14159275328

real    0m2.091s
user    0m16.819s
sys     0m0.300s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 12

lowerbdd is 3.14159270345
upperbdd is 3.14159280345

pi is 3.14159275345

real    0m2.018s
user    0m16.998s
sys     0m0.283s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

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```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 13

lowerbdd is 3.14159270356
upperbdd is 3.14159280356

pi is 3.14159275356

real    0m1.867s
user    0m16.569s
sys     0m0.417s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 14

lowerbdd is 3.14159270293
upperbdd is 3.14159280293

pi is 3.14159275293

real    0m1.781s
user    0m16.696s
sys     0m0.392s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 15

lowerbdd is 3.14159270308
upperbdd is 3.14159280308

pi is 3.14159275308

real    0m1.788s
user    0m16.971s
sys     0m0.458s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 16

lowerbdd is 3.14159270359
upperbdd is 3.14159280359

pi is 3.14159275359

real    0m1.712s
user    0m17.064s
sys     0m0.468s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 17

lowerbdd is 3.14159270349
upperbdd is 3.14159280349

pi is 3.14159275349

real    0m1.737s
user    0m17.453s
sys     0m0.466s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 18

lowerbdd is 3.14159270345
upperbdd is 3.14159280345

pi is 3.14159275345

real    0m1.690s
user    0m17.274s
sys     0m0.594s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

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```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 19

lowerbdd is 3.14159270349
upperbdd is 3.14159280349

pi is 3.14159275349

real    0m1.629s
user    0m17.349s
sys     0m0.623s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 20

lowerbdd is 3.14159270359
upperbdd is 3.14159280359

pi is 3.14159275359

real    0m1.625s
user    0m17.574s
sys     0m0.614s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 21

lowerbdd is 3.14159270231
upperbdd is 3.14159280231

pi is 3.14159275231

real    0m1.600s
user    0m17.844s
sys     0m0.622s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

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```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 22

lowerbdd is 3.14159270240
upperbdd is 3.14159280240

pi is 3.14159275240

real    0m1.570s
user    0m17.714s
sys     0m0.808s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 23

lowerbdd is 3.14159270308
upperbdd is 3.14159280308

pi is 3.14159275308

real    0m1.510s
user    0m17.580s
sys     0m0.764s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 24

lowerbdd is 3.14159270259
upperbdd is 3.14159280259

pi is 3.14159275259

real    0m1.503s
user    0m17.850s
sys     0m0.846s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 25
```

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s407210013@workstation1: ~/osdi/sharedFolder/hw05.pthread

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```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 25

lowerbdd is 3.14159270359
upperbdd is 3.14159280359

pi is 3.14159275359

real    0m1.515s
user    0m17.997s
sys     0m0.831s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 26

lowerbdd is 3.14159270277
upperbdd is 3.14159280277

pi is 3.14159275277

real    0m1.495s
user    0m17.906s
sys     0m0.961s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 27

lowerbdd is 3.14159270285
upperbdd is 3.14159280285

pi is 3.14159275285

real    0m1.465s
user    0m17.900s
sys     0m0.974s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

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s407210013@workstation1: ~/osdi/sharedFolder/hw05.pthread

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```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 28

lowerbdd is 3.14159270293
upperbdd is 3.14159280293

pi is 3.14159275293

real    0m1.493s
user    0m18.330s
sys     0m0.968s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 29

lowerbdd is 3.14159270308
upperbdd is 3.14159280308

pi is 3.14159275308

real    0m1.482s
user    0m18.164s
sys     0m1.065s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 30

lowerbdd is 3.14159270308
upperbdd is 3.14159280308

pi is 3.14159275308

real    0m1.458s
user    0m18.073s
sys     0m1.088s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

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```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 31

lowerbdd is 3.14159270240
upperbdd is 3.14159280240

pi is 3.14159275240

real    0m1.470s
user    0m18.217s
sys     0m1.221s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 32

lowerbdd is 3.14159270359
upperbdd is 3.14159280359

pi is 3.14159275359

real    0m1.467s
user    0m18.180s
sys     0m1.194s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 33

lowerbdd is 3.14159270328
upperbdd is 3.14159280328

pi is 3.14159275328

real    0m1.466s
user    0m17.969s
sys     0m1.462s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 34

lowerbdd is 3.14159270221
upperbdd is 3.14159280221

pi is 3.14159275221

real    0m1.465s
user    0m18.175s
sys     0m1.552s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 35

lowerbdd is 3.14159270340
upperbdd is 3.14159280340

pi is 3.14159275340

real    0m1.470s
user    0m18.282s
sys     0m1.448s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 36

lowerbdd is 3.14159270345
upperbdd is 3.14159280345

pi is 3.14159275345

real    0m1.431s
user    0m18.472s
sys     0m1.186s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

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s407210013@workstation1: ~/osdi/sharedFolder/hw05.pthread

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```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 37

lowerbdd is 3.14159270349
upperbdd is 3.14159280349

pi is 3.14159275349

real    0m1.460s
user    0m18.315s
sys     0m1.301s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 38

lowerbdd is 3.14159270200
upperbdd is 3.14159280200

pi is 3.14159275200

real    0m1.409s
user    0m18.426s
sys     0m1.353s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 39

lowerbdd is 3.14159270356
upperbdd is 3.14159280356

pi is 3.14159275356

real    0m1.470s
user    0m18.633s
sys     0m1.523s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```

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s407210013@workstation1: ~/osdi/sharedFolder/hw05.pthread

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```
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 40

lowerbdd is 3.14159270359
upperbdd is 3.14159280359

pi is 3.14159275359

real    0m1.454s
user    0m18.279s
sys     0m1.601s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 41

lowerbdd is 3.14159270095
upperbdd is 3.14159280095

pi is 3.14159275095

real    0m1.470s
user    0m18.759s
sys     0m1.523s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$ time ./pi -p 6 -P 42

lowerbdd is 3.14159269975
upperbdd is 3.14159279975

pi is 3.14159274975

real    0m1.450s
user    0m18.572s
sys     0m1.609s
s407210013@workstation1:~/osdi/sharedFolder/hw05.pthread$
```
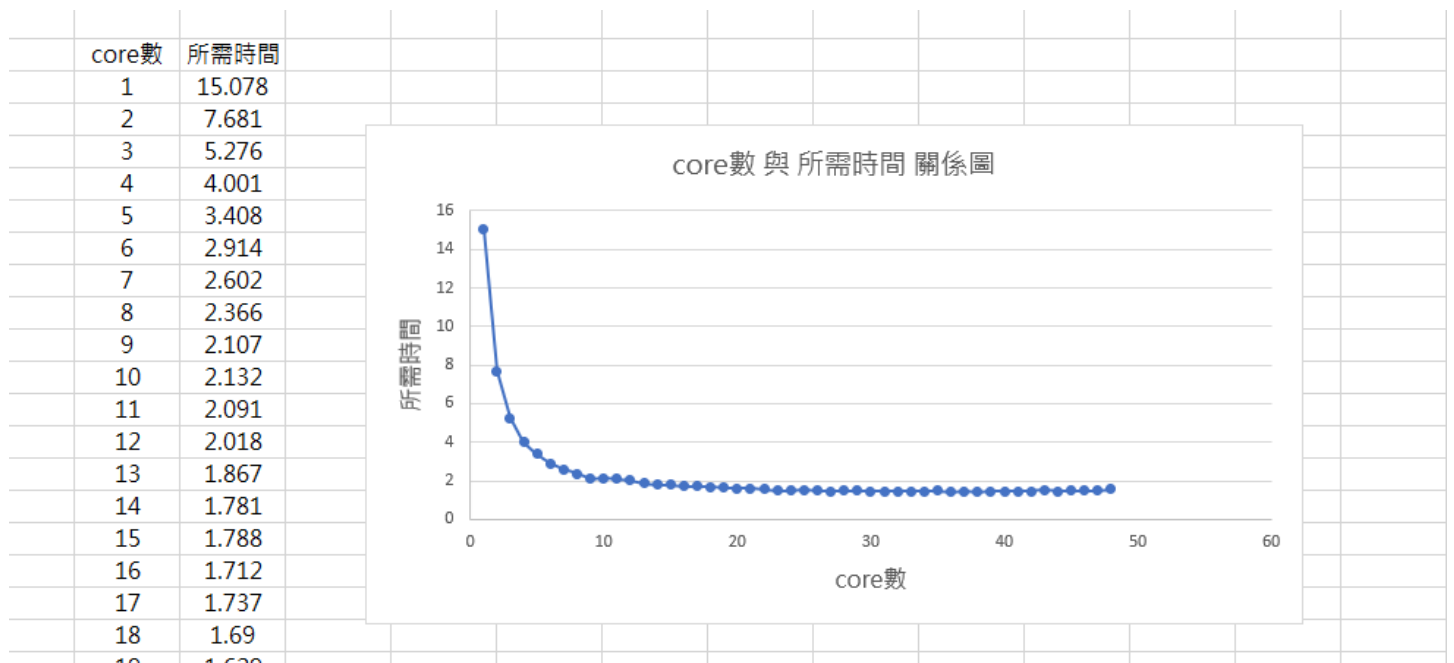
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以上為各核心數下統計出來的所需時間。

以下為Core數與所需時間之關係圖，發現可得到非比尋常的線性加速，執行上減少許多

花費的時間。

core數	所需時間
1	15.078
2	7.681
3	5.276
4	4.001
5	3.408
6	2.914
7	2.602
8	2.366
9	2.107
10	2.132
11	2.091
12	2.018
13	1.867
14	1.781
15	1.788
16	1.712
17	1.737
18	1.69
19	1.629

core數 與 所需時間 關係圖

主題丙：

對於上界與下界的取法，我們只對下界進行累加，由於上界值與下界值只少了一塊最左邊以圓半徑為長，等分切格的值為寬，所構成之矩形。因此讓下界加上此矩形，便為上界的值，讓時間減少不少。

```
27  //注意，我使用了「volatile」
28  volatile double score[100];
29
30  void thread(void *givenName) {
31      int id = (intptr_t)givenName;
32      double pi = 0.0;
33      double width = (double)1 / loopCount;
34      for(size_t i = loopCount / numCPU * id ; i < loopCount / numCPU * (id + 1) ; i++){
35          double x = (double)i / loopCount;
36          pi = pi + width * sqrt(1 - x * x);
37      }
38      score[id] = pi;
39  }
40
```

```
60      double lowerbdd = 0;
61      double upperbdd = 1;
62      double tol = pow(10 , -(x + 1));
63      int y = 3;
64      while((upperbdd - lowerbdd) >= (tol / 4) && keepRunning){
65          lowerbdd = 0;
66          pthread_t* tid = (pthread_t*)malloc(sizeof(pthread_t) * numCPU);
67          for (long i=0 ; i< numCPU ; i++)
68              pthread_create(&tid[i], NULL, (void *) thread, (void*)i);
69
70          for (int i=0 ; i< numCPU ; i++)
71              pthread_join(tid[i], NULL);
72
73          for (int i = 0; i < numCPU ; i++)
74              lowerbdd += score[i];
75
76          upperbdd = lowerbdd + (double)1 / loopCount;
77          if(loopCount / 10 < pow(10 , y)){
78              loopCount = loopCount + pow(10 , y - 1);
79          }
80          else{
81              loopCount = loopCount + pow(10 , y);
82              y = y + 1;
83          }
84
```