4.1

```
└─$ python process-run.py -l 5:100,5:100
Produce a trace of what would happen when you run these processes:
Process 0
  cpu
  cpu
  cpu
  cpu
  cpu

Process 1
  cpu
  cpu
  cpu
  cpu
  cpu

Important behaviors:
  System will switch when the current process is FINISHED or ISSUES A
  After IOs, the process issuing the IO will run LATER (when it is it
```

猜测结果:

启动参数为 两个进程都100%使用CPU 都执行5条指令

所以应该分先后使用CPU 都为100%

实际结果如下:

```
└─$ ./process-run.py -l 5:100,5:100 -c
Time      PID: 0     PID: 1        CPU        IOs
  1     RUN:cpu      READY          1
  2     RUN:cpu      READY          1
  3     RUN:cpu      READY          1
  4     RUN:cpu      READY          1
  5     RUN:cpu      READY          1
  6        DONE    RUN:cpu          1
  7        DONE    RUN:cpu          1
  8        DONE    RUN:cpu          1
  9        DONE    RUN:cpu          1
 10        DONE    RUN:cpu          1
```

4.2

```
└─$ python process-run.py -l 4:100,1:0
Produce a trace of what would happen when you run these processes:
Process 0
  cpu
  cpu
  cpu
  cpu

Process 1
  io
```

进程1 执行4条指令 100%使用CPU

进程2 执行1条指令 0%使用CPU

由于进程1先执行 所以进程2需要等到进程1用完CPU才能开始IO

CPU利用率50%

实际结果如下:

```
└─$ python process-run.py -l 4:100,1:0 -c
Time      PID: 0     PID: 1        CPU        IOs
  1     RUN:cpu      READY          1
  2     RUN:cpu      READY          1
  3     RUN:cpu      READY          1
  4     RUN:cpu      READY          1
  5        DONE     RUN:io          1
  6        DONE    WAITING                    1
  7        DONE    WAITING                    1
  8        DONE    WAITING                    1
  9        DONE    WAITING                    1
 10*       DONE       DONE
```

4.3

```
└─$ python process-run.py -l 1:0,4:100
Produce a trace of what would happen when you run these processes:
Process 0
  io

Process 1
  cpu
  cpu
  cpu
  cpu

Important behaviors:
  System will switch when the current process is FINISHED or ISSUES AN IO
  After IOs, the process issuing the IO will run LATER (when it is its turn)
```

进程1 执行1条指令 0%使用CPU

进程2 执行4条指令 100%使用CPU

所以进程1和进程2可以并行

CPU使用率100%

实际结果如下:

```
└─$ python process-run.py -l 1:0,4:100 -c
Time     PID: 0     PID: 1        CPU        IOs
  1      RUN:io      READY          1
  2     WAITING    RUN:cpu          1          1
  3     WAITING    RUN:cpu          1          1
  4     WAITING    RUN:cpu          1          1
  5     WAITING    RUN:cpu          1          1
  6*       DONE       DONE
```

4.4

```
└─$ python process-run.py -l 1:0,4:100  -S SWITCH_ON_END
Produce a trace of what would happen when you run these processes:
Process 0
  io

Process 1
  cpu
  cpu
  cpu
  cpu

Important behaviors:
  System will switch when the current process is FINISHED
  After IOs, the process issuing the IO will run LATER (when it is its turn)
```

增加SWITCH_ON_END标识

进程1会等待进程0结束后再开始

CPU不会切换进程

CPU利用率50%

```
└─$ python process-run.py -l 1:0,4:100  -S SWITCH_ON_END -c
Time     PID: 0     PID: 1        CPU        IOs
  1      RUN:io      READY          1
  2     WAITING      READY                     1
  3     WAITING      READY                     1
  4     WAITING      READY                     1
  5     WAITING      READY                     1
  6*       DONE    RUN:cpu          1
  7        DONE    RUN:cpu          1
  8        DONE    RUN:cpu          1
  9        DONE    RUN:cpu          1
```

4.5

增加SWITCH_ON_IO标识

进程0等待IO时会切换进程1

CPU利用率100%

结果如下:

```
└─$ python process-run.py -l 1:0,4:100 -c  -S SWITCH_ON_IO
Time     PID: 0     PID: 1        CPU        IOs
  1      RUN:io      READY          1
  2     WAITING    RUN:cpu          1          1
  3     WAITING    RUN:cpu          1          1
  4     WAITING    RUN:cpu          1          1
  5     WAITING    RUN:cpu          1          1
  6*       DONE       DONE
```

5.1

```c
#include<stdio.h>
#include<unistd.h>
#include<stdlib.h>

int main()
{
    int x = 10;
    printf("x = %d, (pid:%d)\n", x, (int)getpid());
    int rc = fork();
    if (rc < 0) {
        fprintf(stderr, "fork failed");
        exit(1);
    } else if (rc == 0) {
        printf("child x = %d (pid:%d)\n", x, (int)getpid());
        x = 200;
        printf("child changed x = %d (pid:%d)\n", x, (int)getpid());
    } else {
        printf("parent x = %d (pid:%d)\n", x, (int)getpid());
        x = 300;
        printf("parent changed x = %d (pid:%d)\n", x, (int)getpid());
    }
    return 0;
}
```

运行结果如下:

```
└─$ gcc 5.1.c && ./a.out
x = 10, (pid:2016189)
parent x = 10 (pid:2016189)
parent changed x = 300 (pid:2016189)

child x = 10 (pid:2016190)
child changed x = 200 (pid:2016190)
```

5.2

```c
#include<stdio.h>
#include<unistd.h>
#include<stdlib.h>
#include<fcntl.h>
```

```c
#include<string.h>
#include<sys/wait.h>

int main()
{
    int fd = open("./5.2.txt", O_CREAT|O_WRONLY|O_TRUNC, S_IRWXU);
    int rc = fork();
    if (rc < 0) {
        close(fd);
        fprintf(stderr, "fork failed");
        exit(1);
    } else if (rc == 0) {
        char * s = "child write!\n";
        write(fd, s, strlen(s));
    } else {
        char * s = "parent write\n";
        write(fd, s, strlen(s));
        wait(NULL);
        close(fd);
    }
    return 0;
}
```

```
└─$ gcc 5.2.c && ./a.out && cat 5.2.txt
parent write
child write!
```

5.4

```c
#include<stdio.h>
#include<unistd.h>
#include<stdlib.h>

int flag = 0;
const int MAX = 6;
int main()
{
    char * s = "/bin/ls";
    char * ss = "ls";
    char * s2 = "/tmp";
    char * sv[] = { ss, s2, NULL };
    for(flag = 0;flag < MAX; ++flag) {
        int rc = fork();
        if (rc < 0) {
            fprintf(stderr, "fork failed");
            exit(1);
        } else if (rc == 0) {
            switch(flag) {
            case 0:
                execl(s, ss, s2, NULL);
                break;
            case 1:
                execle(s, ss, s2, NULL);
                break;
```

```
            case 2:
                execlp(s, s, s2, NULL);
                break;
            case 3:
                execv(s, sv);
                break;
            case 4:
                execvp(ss, sv);
                break;
            case 5:
                execvpe(ss, sv);
                break;
            default: break;
            }
        } else {
            ;
        }
    }
    return 0;
}
```

```
└─$ gcc 5.4.c && ./a.out
5.4.c: In function 'main':
5.4.c:36:5: warning: implicit declaration of function 'execvpe'; did you mean 'execvp'? [-Wimplicit-function-declaration]
   36 |     execvpe(ss, sv);
      |     ^~~~~~~
      |     execvp
5.4.c:41:4: warning: implicit declaration of function 'wait' [-Wimplicit-function-declaration]
   41 |    wait(NULL);
      |    ^~~~
20d759af90bbf6211c4b51c6ef216f08  pyright-2140368-F6JH7yWu1ET3  pyright-3960507-17MCNFgQ7kk7
b7f34bd9fb84da4f4269c3bd9deb11d5  pyright-2152385-3YaSAPUjCxoF  pyright-4155121-HDy6Z08MGqJh
cvm_init.log                      pyright-2211044-SUNDf7TjqBU1  pyright-578493-CNhTJQMQ4YeX
pip-ephem-wheel-cache-jis02ak_    pyright-2251321-FjyHy8DBaIhI  pyright-586492-LCG0wDOdJABB
pip-install-wj2d31lp              pyright-2368064-OBNbzL5FwrdH  pyright-673383-JR5uWD8Bhn4K
pip-req-tracker-pchiltz6          pyright-2374350-CYc7IRehbJwX  pyright-735550-Tu7Q65c4fZXV
pip-unpack-0s3m9ct6               pyright-2567923-uLzzzUi5dV8V  pyright-743487-wsar03iTXUkc
__pycache__                       pyright-2591709-t7RNQeThGmE3  pyright-791553-i1MfNmetAue6
pyright-1001773-UvmXK5m3o2Sz      pyright-2599935-obYhWUvyI115  pyright-814692-CnAORMa6VUX7
pyright-1022657-J6TEqELKtLyd      pyright-2600563-SO4xZMBo6fcm  pyright-881299-4dS0b8OFmhXC
pyright-102708-Isin6tIKjq1m       pyright-2609291-1XUqFjdIVuyX  pyright-959293-bG7vp2VOU4AA
pyright-11194-ydgY7LUwd5w9        pyright-2815288-k5ohQ62j4wzJ  pyright-977071-7YwGQgL9C3NI
pyright-1176369-I09a5o1LWxAG      pyright-2852850-Em5rzS1lPCoT  pyright-978726-fgBjz3LU6Y6E
pyright-1181692-51cOtWmitcLm      pyright-3058401-uF50nxZOSBvw  pyright-991610-7fXLLbmVCFKM
pyright-1191519-LxME7sPE6y4w      pyright-3059902-3eGLvC6fpx4s  pyright-995210-1IR5hfsQJQob
pyright-1217658-X9q9m4FGT3KE      pyright-3064977-pck4Tmj6tpwK  python-languageserver-cancellation
pyright-140934-nSCjTWdUglbC       pyright-3071791-15ap3zOT0ODn  ssh-HT72KHhjBL5K
pyright-1435693-Hl41o5i4RTIw      pyright-3096009-D76Iy4lQ0QFe  ssh-nrKzwqZFv6pD
pyright-148636-8OOZvYfDgHdM       pyright-3287080-vmB4hdAIZa7r  stargate.lock
pyright-1504343-4ZNtbqhjYahn      pyright-3302454-mjuP4nWdlZLU  systemd-private-8b9c417bdedb421f85655a25e75621d1-colord.service-iq0dyf
```

7.1

使用FIFO进行调度

所以3个任务先后执行

计算结果如下:

```
└─$ python scheduler.py -p FIFO -l 200,200,200 -c
ARG policy FIFO
ARG jlist 200,200,200

Here is the job list, with the run time of each job:
  Job 0 ( length = 200.0 )
  Job 1 ( length = 200.0 )
  Job 2 ( length = 200.0 )


** Solutions **

Execution trace:
  [ time   0 ] Run job 0 for 200.00 secs ( DONE at 200.00 )
  [ time 200 ] Run job 1 for 200.00 secs ( DONE at 400.00 )
  [ time 400 ] Run job 2 for 200.00 secs ( DONE at 600.00 )

Final statistics:
  Job   0 -- Response: 0.00  Turnaround 200.00  Wait 0.00
  Job   1 -- Response: 200.00  Turnaround 400.00  Wait 200.00
  Job   2 -- Response: 400.00  Turnaround 600.00  Wait 400.00

  Average -- Response: 200.00  Turnaround 400.00  Wait 200.00
```

7.2

使用FIFO进行调度

所以3个任务先后执行

计算结果如下:

```
└─$ python scheduler.py -p FIFO -l 100,200,300 -c
ARG policy FIFO
ARG jlist 100,200,300

Here is the job list, with the run time of each job:
  Job 0 ( length = 100.0 )
  Job 1 ( length = 200.0 )
  Job 2 ( length = 300.0 )


** Solutions **

Execution trace:
  [ time   0 ] Run job 0 for 100.00 secs ( DONE at 100.00 )
  [ time 100 ] Run job 1 for 200.00 secs ( DONE at 300.00 )
  [ time 300 ] Run job 2 for 300.00 secs ( DONE at 600.00 )

Final statistics:
  Job   0 -- Response: 0.00  Turnaround 100.00  Wait 0.00
  Job   1 -- Response: 100.00  Turnaround 300.00  Wait 100.00
  Job   2 -- Response: 300.00  Turnaround 600.00  Wait 300.00

  Average -- Response: 133.33  Turnaround 333.33  Wait 133.33
```

7.3

使用RR调度

时间片长度为1

计算结果如下:

```
└─$ python scheduler.py -p RR -q 1 -l 100,200,300 -c
ARG policy RR
ARG jlist 100,200,300

Here is the job list, with the run time of each job:
  Job 0 ( length = 100.0 )
  Job 1 ( length = 200.0 )
  Job 2 ( length = 300.0 )


** Solutions **

Execution trace:
  [ time   0 ] Run job   0 for 1.00 secs
  [ time   1 ] Run job   1 for 1.00 secs
  [ time   2 ] Run job   2 for 1.00 secs
  [ time   3 ] Run job   0 for 1.00 secs
  [ time   4 ] Run job   1 for 1.00 secs
  [ time   5 ] Run job   2 for 1.00 secs
  [ time   6 ] Run job   0 for 1.00 secs
  [ time   7 ] Run job   1 for 1.00 secs
  [ time   8 ] Run job   2 for 1.00 secs
  [ time   9 ] Run job   0 for 1.00 secs
```

```
[ time  10 ] Run job   1 for 1.00 secs
[ time  11 ] Run job   2 for 1.00 secs
[ time  12 ] Run job   0 for 1.00 secs
[ time  13 ] Run job   1 for 1.00 secs
[ time  14 ] Run job   2 for 1.00 secs
[ time  15 ] Run job   0 for 1.00 secs
[ time  16 ] Run job   1 for 1.00 secs
[ time  17 ] Run job   2 for 1.00 secs
[ time  18 ] Run job   0 for 1.00 secs
[ time  19 ] Run job   1 for 1.00 secs
[ time  20 ] Run job   2 for 1.00 secs
[ time  21 ] Run job   0 for 1.00 secs
[ time  22 ] Run job   1 for 1.00 secs
[ time  23 ] Run job   2 for 1.00 secs
[ time  24 ] Run job   0 for 1.00 secs
[ time  25 ] Run job   1 for 1.00 secs
[ time  26 ] Run job   2 for 1.00 secs
[ time  27 ] Run job   0 for 1.00 secs
[ time  28 ] Run job   1 for 1.00 secs
[ time  29 ] Run job   2 for 1.00 secs
[ time  30 ] Run job   0 for 1.00 secs
[ time  31 ] Run job   1 for 1.00 secs
[ time  32 ] Run job   2 for 1.00 secs
[ time  33 ] Run job   0 for 1.00 secs
[ time  34 ] Run job   1 for 1.00 secs
[ time  35 ] Run job   2 for 1.00 secs
[ time  36 ] Run job   0 for 1.00 secs
[ time  37 ] Run job   1 for 1.00 secs
[ time  38 ] Run job   2 for 1.00 secs
[ time  39 ] Run job   0 for 1.00 secs
[ time  40 ] Run job   1 for 1.00 secs
[ time  41 ] Run job   2 for 1.00 secs
[ time  42 ] Run job   0 for 1.00 secs
[ time  43 ] Run job   1 for 1.00 secs
[ time  44 ] Run job   2 for 1.00 secs
[ time  45 ] Run job   0 for 1.00 secs
[ time  46 ] Run job   1 for 1.00 secs
[ time  47 ] Run job   2 for 1.00 secs
[ time  48 ] Run job   0 for 1.00 secs
[ time  49 ] Run job   1 for 1.00 secs
[ time  50 ] Run job   2 for 1.00 secs
[ time  51 ] Run job   0 for 1.00 secs
[ time  52 ] Run job   1 for 1.00 secs
[ time  53 ] Run job   2 for 1.00 secs
[ time  54 ] Run job   0 for 1.00 secs
[ time  55 ] Run job   1 for 1.00 secs
[ time  56 ] Run job   2 for 1.00 secs
[ time  57 ] Run job   0 for 1.00 secs
[ time  58 ] Run job   1 for 1.00 secs
[ time  59 ] Run job   2 for 1.00 secs
[ time  60 ] Run job   0 for 1.00 secs
[ time  61 ] Run job   1 for 1.00 secs
[ time  62 ] Run job   2 for 1.00 secs
[ time  63 ] Run job   0 for 1.00 secs
[ time  64 ] Run job   1 for 1.00 secs
[ time  65 ] Run job   2 for 1.00 secs
[ time  66 ] Run job   0 for 1.00 secs
[ time  67 ] Run job   1 for 1.00 secs
```

```
[ time  68 ] Run job   2 for 1.00 secs
[ time  69 ] Run job   0 for 1.00 secs
[ time  70 ] Run job   1 for 1.00 secs
[ time  71 ] Run job   2 for 1.00 secs
[ time  72 ] Run job   0 for 1.00 secs
[ time  73 ] Run job   1 for 1.00 secs
[ time  74 ] Run job   2 for 1.00 secs
[ time  75 ] Run job   0 for 1.00 secs
[ time  76 ] Run job   1 for 1.00 secs
[ time  77 ] Run job   2 for 1.00 secs
[ time  78 ] Run job   0 for 1.00 secs
[ time  79 ] Run job   1 for 1.00 secs
[ time  80 ] Run job   2 for 1.00 secs
[ time  81 ] Run job   0 for 1.00 secs
[ time  82 ] Run job   1 for 1.00 secs
[ time  83 ] Run job   2 for 1.00 secs
[ time  84 ] Run job   0 for 1.00 secs
[ time  85 ] Run job   1 for 1.00 secs
[ time  86 ] Run job   2 for 1.00 secs
[ time  87 ] Run job   0 for 1.00 secs
[ time  88 ] Run job   1 for 1.00 secs
[ time  89 ] Run job   2 for 1.00 secs
[ time  90 ] Run job   0 for 1.00 secs
[ time  91 ] Run job   1 for 1.00 secs
[ time  92 ] Run job   2 for 1.00 secs
[ time  93 ] Run job   0 for 1.00 secs
[ time  94 ] Run job   1 for 1.00 secs
[ time  95 ] Run job   2 for 1.00 secs
[ time  96 ] Run job   0 for 1.00 secs
[ time  97 ] Run job   1 for 1.00 secs
[ time  98 ] Run job   2 for 1.00 secs
[ time  99 ] Run job   0 for 1.00 secs
[ time 100 ] Run job   1 for 1.00 secs
[ time 101 ] Run job   2 for 1.00 secs
[ time 102 ] Run job   0 for 1.00 secs
[ time 103 ] Run job   1 for 1.00 secs
[ time 104 ] Run job   2 for 1.00 secs
[ time 105 ] Run job   0 for 1.00 secs
[ time 106 ] Run job   1 for 1.00 secs
[ time 107 ] Run job   2 for 1.00 secs
[ time 108 ] Run job   0 for 1.00 secs
[ time 109 ] Run job   1 for 1.00 secs
[ time 110 ] Run job   2 for 1.00 secs
[ time 111 ] Run job   0 for 1.00 secs
[ time 112 ] Run job   1 for 1.00 secs
[ time 113 ] Run job   2 for 1.00 secs
[ time 114 ] Run job   0 for 1.00 secs
[ time 115 ] Run job   1 for 1.00 secs
[ time 116 ] Run job   2 for 1.00 secs
[ time 117 ] Run job   0 for 1.00 secs
[ time 118 ] Run job   1 for 1.00 secs
[ time 119 ] Run job   2 for 1.00 secs
[ time 120 ] Run job   0 for 1.00 secs
[ time 121 ] Run job   1 for 1.00 secs
[ time 122 ] Run job   2 for 1.00 secs
[ time 123 ] Run job   0 for 1.00 secs
[ time 124 ] Run job   1 for 1.00 secs
[ time 125 ] Run job   2 for 1.00 secs
```

```
[ time 126 ] Run job   0 for 1.00 secs
[ time 127 ] Run job   1 for 1.00 secs
[ time 128 ] Run job   2 for 1.00 secs
[ time 129 ] Run job   0 for 1.00 secs
[ time 130 ] Run job   1 for 1.00 secs
[ time 131 ] Run job   2 for 1.00 secs
[ time 132 ] Run job   0 for 1.00 secs
[ time 133 ] Run job   1 for 1.00 secs
[ time 134 ] Run job   2 for 1.00 secs
[ time 135 ] Run job   0 for 1.00 secs
[ time 136 ] Run job   1 for 1.00 secs
[ time 137 ] Run job   2 for 1.00 secs
[ time 138 ] Run job   0 for 1.00 secs
[ time 139 ] Run job   1 for 1.00 secs
[ time 140 ] Run job   2 for 1.00 secs
[ time 141 ] Run job   0 for 1.00 secs
[ time 142 ] Run job   1 for 1.00 secs
[ time 143 ] Run job   2 for 1.00 secs
[ time 144 ] Run job   0 for 1.00 secs
[ time 145 ] Run job   1 for 1.00 secs
[ time 146 ] Run job   2 for 1.00 secs
[ time 147 ] Run job   0 for 1.00 secs
[ time 148 ] Run job   1 for 1.00 secs
[ time 149 ] Run job   2 for 1.00 secs
[ time 150 ] Run job   0 for 1.00 secs
[ time 151 ] Run job   1 for 1.00 secs
[ time 152 ] Run job   2 for 1.00 secs
[ time 153 ] Run job   0 for 1.00 secs
[ time 154 ] Run job   1 for 1.00 secs
[ time 155 ] Run job   2 for 1.00 secs
[ time 156 ] Run job   0 for 1.00 secs
[ time 157 ] Run job   1 for 1.00 secs
[ time 158 ] Run job   2 for 1.00 secs
[ time 159 ] Run job   0 for 1.00 secs
[ time 160 ] Run job   1 for 1.00 secs
[ time 161 ] Run job   2 for 1.00 secs
[ time 162 ] Run job   0 for 1.00 secs
[ time 163 ] Run job   1 for 1.00 secs
[ time 164 ] Run job   2 for 1.00 secs
[ time 165 ] Run job   0 for 1.00 secs
[ time 166 ] Run job   1 for 1.00 secs
[ time 167 ] Run job   2 for 1.00 secs
[ time 168 ] Run job   0 for 1.00 secs
[ time 169 ] Run job   1 for 1.00 secs
[ time 170 ] Run job   2 for 1.00 secs
[ time 171 ] Run job   0 for 1.00 secs
[ time 172 ] Run job   1 for 1.00 secs
[ time 173 ] Run job   2 for 1.00 secs
[ time 174 ] Run job   0 for 1.00 secs
[ time 175 ] Run job   1 for 1.00 secs
[ time 176 ] Run job   2 for 1.00 secs
[ time 177 ] Run job   0 for 1.00 secs
[ time 178 ] Run job   1 for 1.00 secs
[ time 179 ] Run job   2 for 1.00 secs
[ time 180 ] Run job   0 for 1.00 secs
[ time 181 ] Run job   1 for 1.00 secs
[ time 182 ] Run job   2 for 1.00 secs
[ time 183 ] Run job   0 for 1.00 secs
```

```
[ time 184 ] Run job   1 for 1.00 secs
[ time 185 ] Run job   2 for 1.00 secs
[ time 186 ] Run job   0 for 1.00 secs
[ time 187 ] Run job   1 for 1.00 secs
[ time 188 ] Run job   2 for 1.00 secs
[ time 189 ] Run job   0 for 1.00 secs
[ time 190 ] Run job   1 for 1.00 secs
[ time 191 ] Run job   2 for 1.00 secs
[ time 192 ] Run job   0 for 1.00 secs
[ time 193 ] Run job   1 for 1.00 secs
[ time 194 ] Run job   2 for 1.00 secs
[ time 195 ] Run job   0 for 1.00 secs
[ time 196 ] Run job   1 for 1.00 secs
[ time 197 ] Run job   2 for 1.00 secs
[ time 198 ] Run job   0 for 1.00 secs
[ time 199 ] Run job   1 for 1.00 secs
[ time 200 ] Run job   2 for 1.00 secs
[ time 201 ] Run job   0 for 1.00 secs
[ time 202 ] Run job   1 for 1.00 secs
[ time 203 ] Run job   2 for 1.00 secs
[ time 204 ] Run job   0 for 1.00 secs
[ time 205 ] Run job   1 for 1.00 secs
[ time 206 ] Run job   2 for 1.00 secs
[ time 207 ] Run job   0 for 1.00 secs
[ time 208 ] Run job   1 for 1.00 secs
[ time 209 ] Run job   2 for 1.00 secs
[ time 210 ] Run job   0 for 1.00 secs
[ time 211 ] Run job   1 for 1.00 secs
[ time 212 ] Run job   2 for 1.00 secs
[ time 213 ] Run job   0 for 1.00 secs
[ time 214 ] Run job   1 for 1.00 secs
[ time 215 ] Run job   2 for 1.00 secs
[ time 216 ] Run job   0 for 1.00 secs
[ time 217 ] Run job   1 for 1.00 secs
[ time 218 ] Run job   2 for 1.00 secs
[ time 219 ] Run job   0 for 1.00 secs
[ time 220 ] Run job   1 for 1.00 secs
[ time 221 ] Run job   2 for 1.00 secs
[ time 222 ] Run job   0 for 1.00 secs
[ time 223 ] Run job   1 for 1.00 secs
[ time 224 ] Run job   2 for 1.00 secs
[ time 225 ] Run job   0 for 1.00 secs
[ time 226 ] Run job   1 for 1.00 secs
[ time 227 ] Run job   2 for 1.00 secs
[ time 228 ] Run job   0 for 1.00 secs
[ time 229 ] Run job   1 for 1.00 secs
[ time 230 ] Run job   2 for 1.00 secs
[ time 231 ] Run job   0 for 1.00 secs
[ time 232 ] Run job   1 for 1.00 secs
[ time 233 ] Run job   2 for 1.00 secs
[ time 234 ] Run job   0 for 1.00 secs
[ time 235 ] Run job   1 for 1.00 secs
[ time 236 ] Run job   2 for 1.00 secs
[ time 237 ] Run job   0 for 1.00 secs
[ time 238 ] Run job   1 for 1.00 secs
[ time 239 ] Run job   2 for 1.00 secs
[ time 240 ] Run job   0 for 1.00 secs
[ time 241 ] Run job   1 for 1.00 secs
```

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[ time 242 ] Run job   2 for 1.00 secs
[ time 243 ] Run job   0 for 1.00 secs
[ time 244 ] Run job   1 for 1.00 secs
[ time 245 ] Run job   2 for 1.00 secs
[ time 246 ] Run job   0 for 1.00 secs
[ time 247 ] Run job   1 for 1.00 secs
[ time 248 ] Run job   2 for 1.00 secs
[ time 249 ] Run job   0 for 1.00 secs
[ time 250 ] Run job   1 for 1.00 secs
[ time 251 ] Run job   2 for 1.00 secs
[ time 252 ] Run job   0 for 1.00 secs
[ time 253 ] Run job   1 for 1.00 secs
[ time 254 ] Run job   2 for 1.00 secs
[ time 255 ] Run job   0 for 1.00 secs
[ time 256 ] Run job   1 for 1.00 secs
[ time 257 ] Run job   2 for 1.00 secs
[ time 258 ] Run job   0 for 1.00 secs
[ time 259 ] Run job   1 for 1.00 secs
[ time 260 ] Run job   2 for 1.00 secs
[ time 261 ] Run job   0 for 1.00 secs
[ time 262 ] Run job   1 for 1.00 secs
[ time 263 ] Run job   2 for 1.00 secs
[ time 264 ] Run job   0 for 1.00 secs
[ time 265 ] Run job   1 for 1.00 secs
[ time 266 ] Run job   2 for 1.00 secs
[ time 267 ] Run job   0 for 1.00 secs
[ time 268 ] Run job   1 for 1.00 secs
[ time 269 ] Run job   2 for 1.00 secs
[ time 270 ] Run job   0 for 1.00 secs
[ time 271 ] Run job   1 for 1.00 secs
[ time 272 ] Run job   2 for 1.00 secs
[ time 273 ] Run job   0 for 1.00 secs
[ time 274 ] Run job   1 for 1.00 secs
[ time 275 ] Run job   2 for 1.00 secs
[ time 276 ] Run job   0 for 1.00 secs
[ time 277 ] Run job   1 for 1.00 secs
[ time 278 ] Run job   2 for 1.00 secs
[ time 279 ] Run job   0 for 1.00 secs
[ time 280 ] Run job   1 for 1.00 secs
[ time 281 ] Run job   2 for 1.00 secs
[ time 282 ] Run job   0 for 1.00 secs
[ time 283 ] Run job   1 for 1.00 secs
[ time 284 ] Run job   2 for 1.00 secs
[ time 285 ] Run job   0 for 1.00 secs
[ time 286 ] Run job   1 for 1.00 secs
[ time 287 ] Run job   2 for 1.00 secs
[ time 288 ] Run job   0 for 1.00 secs
[ time 289 ] Run job   1 for 1.00 secs
[ time 290 ] Run job   2 for 1.00 secs
[ time 291 ] Run job   0 for 1.00 secs
[ time 292 ] Run job   1 for 1.00 secs
[ time 293 ] Run job   2 for 1.00 secs
[ time 294 ] Run job   0 for 1.00 secs
[ time 295 ] Run job   1 for 1.00 secs
[ time 296 ] Run job   2 for 1.00 secs
[ time 297 ] Run job   0 for 1.00 secs ( DONE at 298.00 )
[ time 298 ] Run job   1 for 1.00 secs
[ time 299 ] Run job   2 for 1.00 secs
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[ time 300 ] Run job   1 for 1.00 secs
[ time 301 ] Run job   2 for 1.00 secs
[ time 302 ] Run job   1 for 1.00 secs
[ time 303 ] Run job   2 for 1.00 secs
[ time 304 ] Run job   1 for 1.00 secs
[ time 305 ] Run job   2 for 1.00 secs
[ time 306 ] Run job   1 for 1.00 secs
[ time 307 ] Run job   2 for 1.00 secs
[ time 308 ] Run job   1 for 1.00 secs
[ time 309 ] Run job   2 for 1.00 secs
[ time 310 ] Run job   1 for 1.00 secs
[ time 311 ] Run job   2 for 1.00 secs
[ time 312 ] Run job   1 for 1.00 secs
[ time 313 ] Run job   2 for 1.00 secs
[ time 314 ] Run job   1 for 1.00 secs
[ time 315 ] Run job   2 for 1.00 secs
[ time 316 ] Run job   1 for 1.00 secs
[ time 317 ] Run job   2 for 1.00 secs
[ time 318 ] Run job   1 for 1.00 secs
[ time 319 ] Run job   2 for 1.00 secs
[ time 320 ] Run job   1 for 1.00 secs
[ time 321 ] Run job   2 for 1.00 secs
[ time 322 ] Run job   1 for 1.00 secs
[ time 323 ] Run job   2 for 1.00 secs
[ time 324 ] Run job   1 for 1.00 secs
[ time 325 ] Run job   2 for 1.00 secs
[ time 326 ] Run job   1 for 1.00 secs
[ time 327 ] Run job   2 for 1.00 secs
[ time 328 ] Run job   1 for 1.00 secs
[ time 329 ] Run job   2 for 1.00 secs
[ time 330 ] Run job   1 for 1.00 secs
[ time 331 ] Run job   2 for 1.00 secs
[ time 332 ] Run job   1 for 1.00 secs
[ time 333 ] Run job   2 for 1.00 secs
[ time 334 ] Run job   1 for 1.00 secs
[ time 335 ] Run job   2 for 1.00 secs
[ time 336 ] Run job   1 for 1.00 secs
[ time 337 ] Run job   2 for 1.00 secs
[ time 338 ] Run job   1 for 1.00 secs
[ time 339 ] Run job   2 for 1.00 secs
[ time 340 ] Run job   1 for 1.00 secs
[ time 341 ] Run job   2 for 1.00 secs
[ time 342 ] Run job   1 for 1.00 secs
[ time 343 ] Run job   2 for 1.00 secs
[ time 344 ] Run job   1 for 1.00 secs
[ time 345 ] Run job   2 for 1.00 secs
[ time 346 ] Run job   1 for 1.00 secs
[ time 347 ] Run job   2 for 1.00 secs
[ time 348 ] Run job   1 for 1.00 secs
[ time 349 ] Run job   2 for 1.00 secs
[ time 350 ] Run job   1 for 1.00 secs
[ time 351 ] Run job   2 for 1.00 secs
[ time 352 ] Run job   1 for 1.00 secs
[ time 353 ] Run job   2 for 1.00 secs
[ time 354 ] Run job   1 for 1.00 secs
[ time 355 ] Run job   2 for 1.00 secs
[ time 356 ] Run job   1 for 1.00 secs
[ time 357 ] Run job   2 for 1.00 secs
```

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[ time 358 ] Run job   1 for 1.00 secs
[ time 359 ] Run job   2 for 1.00 secs
[ time 360 ] Run job   1 for 1.00 secs
[ time 361 ] Run job   2 for 1.00 secs
[ time 362 ] Run job   1 for 1.00 secs
[ time 363 ] Run job   2 for 1.00 secs
[ time 364 ] Run job   1 for 1.00 secs
[ time 365 ] Run job   2 for 1.00 secs
[ time 366 ] Run job   1 for 1.00 secs
[ time 367 ] Run job   2 for 1.00 secs
[ time 368 ] Run job   1 for 1.00 secs
[ time 369 ] Run job   2 for 1.00 secs
[ time 370 ] Run job   1 for 1.00 secs
[ time 371 ] Run job   2 for 1.00 secs
[ time 372 ] Run job   1 for 1.00 secs
[ time 373 ] Run job   2 for 1.00 secs
[ time 374 ] Run job   1 for 1.00 secs
[ time 375 ] Run job   2 for 1.00 secs
[ time 376 ] Run job   1 for 1.00 secs
[ time 377 ] Run job   2 for 1.00 secs
[ time 378 ] Run job   1 for 1.00 secs
[ time 379 ] Run job   2 for 1.00 secs
[ time 380 ] Run job   1 for 1.00 secs
[ time 381 ] Run job   2 for 1.00 secs
[ time 382 ] Run job   1 for 1.00 secs
[ time 383 ] Run job   2 for 1.00 secs
[ time 384 ] Run job   1 for 1.00 secs
[ time 385 ] Run job   2 for 1.00 secs
[ time 386 ] Run job   1 for 1.00 secs
[ time 387 ] Run job   2 for 1.00 secs
[ time 388 ] Run job   1 for 1.00 secs
[ time 389 ] Run job   2 for 1.00 secs
[ time 390 ] Run job   1 for 1.00 secs
[ time 391 ] Run job   2 for 1.00 secs
[ time 392 ] Run job   1 for 1.00 secs
[ time 393 ] Run job   2 for 1.00 secs
[ time 394 ] Run job   1 for 1.00 secs
[ time 395 ] Run job   2 for 1.00 secs
[ time 396 ] Run job   1 for 1.00 secs
[ time 397 ] Run job   2 for 1.00 secs
[ time 398 ] Run job   1 for 1.00 secs
[ time 399 ] Run job   2 for 1.00 secs
[ time 400 ] Run job   1 for 1.00 secs
[ time 401 ] Run job   2 for 1.00 secs
[ time 402 ] Run job   1 for 1.00 secs
[ time 403 ] Run job   2 for 1.00 secs
[ time 404 ] Run job   1 for 1.00 secs
[ time 405 ] Run job   2 for 1.00 secs
[ time 406 ] Run job   1 for 1.00 secs
[ time 407 ] Run job   2 for 1.00 secs
[ time 408 ] Run job   1 for 1.00 secs
[ time 409 ] Run job   2 for 1.00 secs
[ time 410 ] Run job   1 for 1.00 secs
[ time 411 ] Run job   2 for 1.00 secs
[ time 412 ] Run job   1 for 1.00 secs
[ time 413 ] Run job   2 for 1.00 secs
[ time 414 ] Run job   1 for 1.00 secs
[ time 415 ] Run job   2 for 1.00 secs
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[ time 416 ] Run job   1 for 1.00 secs
[ time 417 ] Run job   2 for 1.00 secs
[ time 418 ] Run job   1 for 1.00 secs
[ time 419 ] Run job   2 for 1.00 secs
[ time 420 ] Run job   1 for 1.00 secs
[ time 421 ] Run job   2 for 1.00 secs
[ time 422 ] Run job   1 for 1.00 secs
[ time 423 ] Run job   2 for 1.00 secs
[ time 424 ] Run job   1 for 1.00 secs
[ time 425 ] Run job   2 for 1.00 secs
[ time 426 ] Run job   1 for 1.00 secs
[ time 427 ] Run job   2 for 1.00 secs
[ time 428 ] Run job   1 for 1.00 secs
[ time 429 ] Run job   2 for 1.00 secs
[ time 430 ] Run job   1 for 1.00 secs
[ time 431 ] Run job   2 for 1.00 secs
[ time 432 ] Run job   1 for 1.00 secs
[ time 433 ] Run job   2 for 1.00 secs
[ time 434 ] Run job   1 for 1.00 secs
[ time 435 ] Run job   2 for 1.00 secs
[ time 436 ] Run job   1 for 1.00 secs
[ time 437 ] Run job   2 for 1.00 secs
[ time 438 ] Run job   1 for 1.00 secs
[ time 439 ] Run job   2 for 1.00 secs
[ time 440 ] Run job   1 for 1.00 secs
[ time 441 ] Run job   2 for 1.00 secs
[ time 442 ] Run job   1 for 1.00 secs
[ time 443 ] Run job   2 for 1.00 secs
[ time 444 ] Run job   1 for 1.00 secs
[ time 445 ] Run job   2 for 1.00 secs
[ time 446 ] Run job   1 for 1.00 secs
[ time 447 ] Run job   2 for 1.00 secs
[ time 448 ] Run job   1 for 1.00 secs
[ time 449 ] Run job   2 for 1.00 secs
[ time 450 ] Run job   1 for 1.00 secs
[ time 451 ] Run job   2 for 1.00 secs
[ time 452 ] Run job   1 for 1.00 secs
[ time 453 ] Run job   2 for 1.00 secs
[ time 454 ] Run job   1 for 1.00 secs
[ time 455 ] Run job   2 for 1.00 secs
[ time 456 ] Run job   1 for 1.00 secs
[ time 457 ] Run job   2 for 1.00 secs
[ time 458 ] Run job   1 for 1.00 secs
[ time 459 ] Run job   2 for 1.00 secs
[ time 460 ] Run job   1 for 1.00 secs
[ time 461 ] Run job   2 for 1.00 secs
[ time 462 ] Run job   1 for 1.00 secs
[ time 463 ] Run job   2 for 1.00 secs
[ time 464 ] Run job   1 for 1.00 secs
[ time 465 ] Run job   2 for 1.00 secs
[ time 466 ] Run job   1 for 1.00 secs
[ time 467 ] Run job   2 for 1.00 secs
[ time 468 ] Run job   1 for 1.00 secs
[ time 469 ] Run job   2 for 1.00 secs
[ time 470 ] Run job   1 for 1.00 secs
[ time 471 ] Run job   2 for 1.00 secs
[ time 472 ] Run job   1 for 1.00 secs
[ time 473 ] Run job   2 for 1.00 secs
```

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[ time 474 ] Run job   1 for 1.00 secs
[ time 475 ] Run job   2 for 1.00 secs
[ time 476 ] Run job   1 for 1.00 secs
[ time 477 ] Run job   2 for 1.00 secs
[ time 478 ] Run job   1 for 1.00 secs
[ time 479 ] Run job   2 for 1.00 secs
[ time 480 ] Run job   1 for 1.00 secs
[ time 481 ] Run job   2 for 1.00 secs
[ time 482 ] Run job   1 for 1.00 secs
[ time 483 ] Run job   2 for 1.00 secs
[ time 484 ] Run job   1 for 1.00 secs
[ time 485 ] Run job   2 for 1.00 secs
[ time 486 ] Run job   1 for 1.00 secs
[ time 487 ] Run job   2 for 1.00 secs
[ time 488 ] Run job   1 for 1.00 secs
[ time 489 ] Run job   2 for 1.00 secs
[ time 490 ] Run job   1 for 1.00 secs
[ time 491 ] Run job   2 for 1.00 secs
[ time 492 ] Run job   1 for 1.00 secs
[ time 493 ] Run job   2 for 1.00 secs
[ time 494 ] Run job   1 for 1.00 secs
[ time 495 ] Run job   2 for 1.00 secs
[ time 496 ] Run job   1 for 1.00 secs
[ time 497 ] Run job   2 for 1.00 secs
[ time 498 ] Run job   1 for 1.00 secs ( DONE at 499.00 )
[ time 499 ] Run job   2 for 1.00 secs
[ time 500 ] Run job   2 for 1.00 secs
[ time 501 ] Run job   2 for 1.00 secs
[ time 502 ] Run job   2 for 1.00 secs
[ time 503 ] Run job   2 for 1.00 secs
[ time 504 ] Run job   2 for 1.00 secs
[ time 505 ] Run job   2 for 1.00 secs
[ time 506 ] Run job   2 for 1.00 secs
[ time 507 ] Run job   2 for 1.00 secs
[ time 508 ] Run job   2 for 1.00 secs
[ time 509 ] Run job   2 for 1.00 secs
[ time 510 ] Run job   2 for 1.00 secs
[ time 511 ] Run job   2 for 1.00 secs
[ time 512 ] Run job   2 for 1.00 secs
[ time 513 ] Run job   2 for 1.00 secs
[ time 514 ] Run job   2 for 1.00 secs
[ time 515 ] Run job   2 for 1.00 secs
[ time 516 ] Run job   2 for 1.00 secs
[ time 517 ] Run job   2 for 1.00 secs
[ time 518 ] Run job   2 for 1.00 secs
[ time 519 ] Run job   2 for 1.00 secs
[ time 520 ] Run job   2 for 1.00 secs
[ time 521 ] Run job   2 for 1.00 secs
[ time 522 ] Run job   2 for 1.00 secs
[ time 523 ] Run job   2 for 1.00 secs
[ time 524 ] Run job   2 for 1.00 secs
[ time 525 ] Run job   2 for 1.00 secs
[ time 526 ] Run job   2 for 1.00 secs
[ time 527 ] Run job   2 for 1.00 secs
[ time 528 ] Run job   2 for 1.00 secs
[ time 529 ] Run job   2 for 1.00 secs
[ time 530 ] Run job   2 for 1.00 secs
[ time 531 ] Run job   2 for 1.00 secs
```

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[ time 532 ] Run job   2 for 1.00 secs
[ time 533 ] Run job   2 for 1.00 secs
[ time 534 ] Run job   2 for 1.00 secs
[ time 535 ] Run job   2 for 1.00 secs
[ time 536 ] Run job   2 for 1.00 secs
[ time 537 ] Run job   2 for 1.00 secs
[ time 538 ] Run job   2 for 1.00 secs
[ time 539 ] Run job   2 for 1.00 secs
[ time 540 ] Run job   2 for 1.00 secs
[ time 541 ] Run job   2 for 1.00 secs
[ time 542 ] Run job   2 for 1.00 secs
[ time 543 ] Run job   2 for 1.00 secs
[ time 544 ] Run job   2 for 1.00 secs
[ time 545 ] Run job   2 for 1.00 secs
[ time 546 ] Run job   2 for 1.00 secs
[ time 547 ] Run job   2 for 1.00 secs
[ time 548 ] Run job   2 for 1.00 secs
[ time 549 ] Run job   2 for 1.00 secs
[ time 550 ] Run job   2 for 1.00 secs
[ time 551 ] Run job   2 for 1.00 secs
[ time 552 ] Run job   2 for 1.00 secs
[ time 553 ] Run job   2 for 1.00 secs
[ time 554 ] Run job   2 for 1.00 secs
[ time 555 ] Run job   2 for 1.00 secs
[ time 556 ] Run job   2 for 1.00 secs
[ time 557 ] Run job   2 for 1.00 secs
[ time 558 ] Run job   2 for 1.00 secs
[ time 559 ] Run job   2 for 1.00 secs
[ time 560 ] Run job   2 for 1.00 secs
[ time 561 ] Run job   2 for 1.00 secs
[ time 562 ] Run job   2 for 1.00 secs
[ time 563 ] Run job   2 for 1.00 secs
[ time 564 ] Run job   2 for 1.00 secs
[ time 565 ] Run job   2 for 1.00 secs
[ time 566 ] Run job   2 for 1.00 secs
[ time 567 ] Run job   2 for 1.00 secs
[ time 568 ] Run job   2 for 1.00 secs
[ time 569 ] Run job   2 for 1.00 secs
[ time 570 ] Run job   2 for 1.00 secs
[ time 571 ] Run job   2 for 1.00 secs
[ time 572 ] Run job   2 for 1.00 secs
[ time 573 ] Run job   2 for 1.00 secs
[ time 574 ] Run job   2 for 1.00 secs
[ time 575 ] Run job   2 for 1.00 secs
[ time 576 ] Run job   2 for 1.00 secs
[ time 577 ] Run job   2 for 1.00 secs
[ time 578 ] Run job   2 for 1.00 secs
[ time 579 ] Run job   2 for 1.00 secs
[ time 580 ] Run job   2 for 1.00 secs
[ time 581 ] Run job   2 for 1.00 secs
[ time 582 ] Run job   2 for 1.00 secs
[ time 583 ] Run job   2 for 1.00 secs
[ time 584 ] Run job   2 for 1.00 secs
[ time 585 ] Run job   2 for 1.00 secs
[ time 586 ] Run job   2 for 1.00 secs
[ time 587 ] Run job   2 for 1.00 secs
[ time 588 ] Run job   2 for 1.00 secs
[ time 589 ] Run job   2 for 1.00 secs
```

```
  [ time 590 ] Run job   2 for 1.00 secs
  [ time 591 ] Run job   2 for 1.00 secs
  [ time 592 ] Run job   2 for 1.00 secs
  [ time 593 ] Run job   2 for 1.00 secs
  [ time 594 ] Run job   2 for 1.00 secs
  [ time 595 ] Run job   2 for 1.00 secs
  [ time 596 ] Run job   2 for 1.00 secs
  [ time 597 ] Run job   2 for 1.00 secs
  [ time 598 ] Run job   2 for 1.00 secs
  [ time 599 ] Run job   2 for 1.00 secs ( DONE at 600.00 )

Final statistics:
  Job   0 -- Response: 0.00  Turnaround 298.00  Wait 198.00
  Job   1 -- Response: 1.00  Turnaround 499.00  Wait 299.00
  Job   2 -- Response: 2.00  Turnaround 600.00  Wait 300.00

  Average -- Response: 1.00  Turnaround 465.67  Wait 265.67
```

7.4

按照执行时间从小到大安排任务的情况下 SJF和FIFO有相同的周转时间

7.5

量子长度大于最长的工作负载的长度时，RR可以看作是SJF, 有相同的响应时间

7.6

任务的执行时间越长 响应时间越大

```
└─$ python scheduler.py -p SJF -l 100,100,100 -c
ARG policy SJF
ARG jlist 100,100,100

Here is the job list, with the run time of each job:
  Job 0 ( length = 100.0 )
  Job 1 ( length = 100.0 )
  Job 2 ( length = 100.0 )


** Solutions **

Execution trace:
  [ time   0 ] Run job 0 for 100.00 secs ( DONE at 100.00 )
  [ time 100 ] Run job 1 for 100.00 secs ( DONE at 200.00 )
  [ time 200 ] Run job 2 for 100.00 secs ( DONE at 300.00 )

Final statistics:
  Job   0 -- Response: 0.00  Turnaround 100.00  Wait 0.00
  Job   1 -- Response: 100.00  Turnaround 200.00  Wait 100.00
  Job   2 -- Response: 200.00  Turnaround 300.00  Wait 200.00

  Average -- Response: 100.00  Turnaround 200.00  Wait 100.00
```

7.7

随着量子长度的增加，响应时间会越来越大。
设量子长度为m，且每个任务的长度比量子长度更长。
则响应时间的计算过程为：

$$\frac{\sum_{i=1}^{N} im}{N} = \frac{m\sum_{i=1}^{N} i}{N} = \frac{m\frac{N(N+1)}{2}}{N} = \frac{m(N+1)}{2}$$

8.1

两个任务

单任务最长执行时间10

IO频率0

队列数量2

时间片长度3

计算结果如下:

```
└─$ python mlfq.py -j 2 -m 10 -M 0 -n 2 -q 3 -c
Here is the list of inputs:
OPTIONS jobs 2
OPTIONS queues 2
OPTIONS allotments for queue  1 is   1
OPTIONS quantum length for queue  1 is   3
OPTIONS allotments for queue  0 is   1
OPTIONS quantum length for queue  0 is   3
OPTIONS boost 0
OPTIONS ioTime 5
OPTIONS stayAfterIO False
OPTIONS iobump False


For each job, three defining characteristics are given:
  startTime : at what time does the job enter the system
  runTime   : the total CPU time needed by the job to finish
  ioFreq    : every ioFreq time units, the job issues an I/O
              (the I/O takes ioTime units to complete)

Job List:
  Job  0: startTime   0 - runTime   8 - ioFreq   0
  Job  1: startTime   0 - runTime   4 - ioFreq   0


Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] JOB BEGINS by JOB 1
[ time 0 ] Run JOB 0 at PRIORITY 1 [ TICKS 2 ALLOT 1 TIME 7 (of 8) ]
[ time 1 ] Run JOB 0 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 6 (of 8) ]
[ time 2 ] Run JOB 0 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 5 (of 8) ]
[ time 3 ] Run JOB 1 at PRIORITY 1 [ TICKS 2 ALLOT 1 TIME 3 (of 4) ]
[ time 4 ] Run JOB 1 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 2 (of 4) ]
[ time 5 ] Run JOB 1 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 1 (of 4) ]
[ time 6 ] Run JOB 0 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 4 (of 8) ]
```

```
[ time 7 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 3 (of 8) ]
[ time 8 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 2 (of 8) ]
[ time 9 ] Run JOB 1 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 0 (of 4) ]
[ time 10 ] FINISHED JOB 1
[ time 10 ] Run JOB 0 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 1 (of 8) ]
[ time 11 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 0 (of 8) ]
[ time 12 ] FINISHED JOB 0

Final statistics:
  Job  0: startTime   0 - response   0 - turnaround  12
  Job  1: startTime   0 - response   3 - turnaround  10

  Avg  1: startTime n/a - response 1.50 - turnaround 11.00
```

8.3

队列数量设置为1

```
python mlfq.py -l 0,50,0:0,50,0:0,50,0 -q 10 -n 1 -c
```

```
└─$ python mlfq.py -l 0,50,0:0,50,0:0,50,0 -q 10 -n 1 -c
Here is the list of inputs:
OPTIONS jobs 3
OPTIONS queues 1
OPTIONS allotments for queue  0 is   1
OPTIONS quantum length for queue  0 is  10
OPTIONS boost 0
OPTIONS ioTime 5
OPTIONS stayAfterIO False
OPTIONS iobump False


For each job, three defining characteristics are given:
  startTime : at what time does the job enter the system
  runTime   : the total CPU time needed by the job to finish
  ioFreq    : every ioFreq time units, the job issues an I/O
              (the I/O takes ioTime units to complete)

Job List:
  Job  0: startTime   0 - runTime  50 - ioFreq   0
  Job  1: startTime   0 - runTime  50 - ioFreq   0
  Job  2: startTime   0 - runTime  50 - ioFreq   0


Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] JOB BEGINS by JOB 1
[ time 0 ] JOB BEGINS by JOB 2
[ time 0 ] Run JOB 0 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 49 (of 50) ]
[ time 1 ] Run JOB 0 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 48 (of 50) ]
[ time 2 ] Run JOB 0 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 47 (of 50) ]
[ time 3 ] Run JOB 0 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 46 (of 50) ]
[ time 4 ] Run JOB 0 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 45 (of 50) ]
[ time 5 ] Run JOB 0 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 44 (of 50) ]
[ time 6 ] Run JOB 0 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 43 (of 50) ]
```

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[ time 7 ] Run JOB 0 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 42 (of 50) ]
[ time 8 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 41 (of 50) ]
[ time 9 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 40 (of 50) ]
[ time 10 ] Run JOB 1 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 49 (of 50) ]
[ time 11 ] Run JOB 1 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 48 (of 50) ]
[ time 12 ] Run JOB 1 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 47 (of 50) ]
[ time 13 ] Run JOB 1 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 46 (of 50) ]
[ time 14 ] Run JOB 1 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 45 (of 50) ]
[ time 15 ] Run JOB 1 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 44 (of 50) ]
[ time 16 ] Run JOB 1 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 43 (of 50) ]
[ time 17 ] Run JOB 1 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 42 (of 50) ]
[ time 18 ] Run JOB 1 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 41 (of 50) ]
[ time 19 ] Run JOB 1 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 40 (of 50) ]
[ time 20 ] Run JOB 2 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 49 (of 50) ]
[ time 21 ] Run JOB 2 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 48 (of 50) ]
[ time 22 ] Run JOB 2 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 47 (of 50) ]
[ time 23 ] Run JOB 2 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 46 (of 50) ]
[ time 24 ] Run JOB 2 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 45 (of 50) ]
[ time 25 ] Run JOB 2 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 44 (of 50) ]
[ time 26 ] Run JOB 2 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 43 (of 50) ]
[ time 27 ] Run JOB 2 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 42 (of 50) ]
[ time 28 ] Run JOB 2 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 41 (of 50) ]
[ time 29 ] Run JOB 2 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 40 (of 50) ]
[ time 30 ] Run JOB 0 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 39 (of 50) ]
[ time 31 ] Run JOB 0 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 38 (of 50) ]
[ time 32 ] Run JOB 0 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 37 (of 50) ]
[ time 33 ] Run JOB 0 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 36 (of 50) ]
[ time 34 ] Run JOB 0 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 35 (of 50) ]
[ time 35 ] Run JOB 0 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 34 (of 50) ]
[ time 36 ] Run JOB 0 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 33 (of 50) ]
[ time 37 ] Run JOB 0 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 32 (of 50) ]
[ time 38 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 31 (of 50) ]
[ time 39 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 30 (of 50) ]
[ time 40 ] Run JOB 1 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 39 (of 50) ]
[ time 41 ] Run JOB 1 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 38 (of 50) ]
[ time 42 ] Run JOB 1 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 37 (of 50) ]
[ time 43 ] Run JOB 1 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 36 (of 50) ]
[ time 44 ] Run JOB 1 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 35 (of 50) ]
[ time 45 ] Run JOB 1 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 34 (of 50) ]
[ time 46 ] Run JOB 1 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 33 (of 50) ]
[ time 47 ] Run JOB 1 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 32 (of 50) ]
[ time 48 ] Run JOB 1 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 31 (of 50) ]
[ time 49 ] Run JOB 1 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 30 (of 50) ]
[ time 50 ] Run JOB 2 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 39 (of 50) ]
[ time 51 ] Run JOB 2 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 38 (of 50) ]
[ time 52 ] Run JOB 2 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 37 (of 50) ]
[ time 53 ] Run JOB 2 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 36 (of 50) ]
[ time 54 ] Run JOB 2 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 35 (of 50) ]
[ time 55 ] Run JOB 2 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 34 (of 50) ]
[ time 56 ] Run JOB 2 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 33 (of 50) ]
[ time 57 ] Run JOB 2 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 32 (of 50) ]
[ time 58 ] Run JOB 2 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 31 (of 50) ]
[ time 59 ] Run JOB 2 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 30 (of 50) ]
[ time 60 ] Run JOB 0 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 29 (of 50) ]
[ time 61 ] Run JOB 0 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 28 (of 50) ]
[ time 62 ] Run JOB 0 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 27 (of 50) ]
[ time 63 ] Run JOB 0 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 26 (of 50) ]
[ time 64 ] Run JOB 0 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 25 (of 50) ]
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[ time 65 ] Run JOB 0 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 24 (of 50) ]
[ time 66 ] Run JOB 0 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 23 (of 50) ]
[ time 67 ] Run JOB 0 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 22 (of 50) ]
[ time 68 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 21 (of 50) ]
[ time 69 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 20 (of 50) ]
[ time 70 ] Run JOB 1 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 29 (of 50) ]
[ time 71 ] Run JOB 1 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 28 (of 50) ]
[ time 72 ] Run JOB 1 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 27 (of 50) ]
[ time 73 ] Run JOB 1 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 26 (of 50) ]
[ time 74 ] Run JOB 1 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 25 (of 50) ]
[ time 75 ] Run JOB 1 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 24 (of 50) ]
[ time 76 ] Run JOB 1 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 23 (of 50) ]
[ time 77 ] Run JOB 1 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 22 (of 50) ]
[ time 78 ] Run JOB 1 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 21 (of 50) ]
[ time 79 ] Run JOB 1 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 20 (of 50) ]
[ time 80 ] Run JOB 2 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 29 (of 50) ]
[ time 81 ] Run JOB 2 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 28 (of 50) ]
[ time 82 ] Run JOB 2 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 27 (of 50) ]
[ time 83 ] Run JOB 2 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 26 (of 50) ]
[ time 84 ] Run JOB 2 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 25 (of 50) ]
[ time 85 ] Run JOB 2 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 24 (of 50) ]
[ time 86 ] Run JOB 2 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 23 (of 50) ]
[ time 87 ] Run JOB 2 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 22 (of 50) ]
[ time 88 ] Run JOB 2 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 21 (of 50) ]
[ time 89 ] Run JOB 2 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 20 (of 50) ]
[ time 90 ] Run JOB 0 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 19 (of 50) ]
[ time 91 ] Run JOB 0 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 18 (of 50) ]
[ time 92 ] Run JOB 0 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 17 (of 50) ]
[ time 93 ] Run JOB 0 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 16 (of 50) ]
[ time 94 ] Run JOB 0 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 15 (of 50) ]
[ time 95 ] Run JOB 0 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 14 (of 50) ]
[ time 96 ] Run JOB 0 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 13 (of 50) ]
[ time 97 ] Run JOB 0 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 12 (of 50) ]
[ time 98 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 11 (of 50) ]
[ time 99 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 10 (of 50) ]
[ time 100 ] Run JOB 1 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 19 (of 50) ]
[ time 101 ] Run JOB 1 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 18 (of 50) ]
[ time 102 ] Run JOB 1 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 17 (of 50) ]
[ time 103 ] Run JOB 1 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 16 (of 50) ]
[ time 104 ] Run JOB 1 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 15 (of 50) ]
[ time 105 ] Run JOB 1 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 14 (of 50) ]
[ time 106 ] Run JOB 1 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 13 (of 50) ]
[ time 107 ] Run JOB 1 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 12 (of 50) ]
[ time 108 ] Run JOB 1 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 11 (of 50) ]
[ time 109 ] Run JOB 1 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 10 (of 50) ]
[ time 110 ] Run JOB 2 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 19 (of 50) ]
[ time 111 ] Run JOB 2 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 18 (of 50) ]
[ time 112 ] Run JOB 2 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 17 (of 50) ]
[ time 113 ] Run JOB 2 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 16 (of 50) ]
[ time 114 ] Run JOB 2 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 15 (of 50) ]
[ time 115 ] Run JOB 2 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 14 (of 50) ]
[ time 116 ] Run JOB 2 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 13 (of 50) ]
[ time 117 ] Run JOB 2 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 12 (of 50) ]
[ time 118 ] Run JOB 2 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 11 (of 50) ]
[ time 119 ] Run JOB 2 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 10 (of 50) ]
[ time 120 ] Run JOB 0 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 9 (of 50) ]
[ time 121 ] Run JOB 0 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 8 (of 50) ]
[ time 122 ] Run JOB 0 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 7 (of 50) ]
```

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[ time 123 ] Run JOB 0 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 6 (of 50) ]
[ time 124 ] Run JOB 0 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 5 (of 50) ]
[ time 125 ] Run JOB 0 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 4 (of 50) ]
[ time 126 ] Run JOB 0 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 3 (of 50) ]
[ time 127 ] Run JOB 0 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 2 (of 50) ]
[ time 128 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 1 (of 50) ]
[ time 129 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 0 (of 50) ]
[ time 130 ] FINISHED JOB 0
[ time 130 ] Run JOB 1 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 9 (of 50) ]
[ time 131 ] Run JOB 1 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 8 (of 50) ]
[ time 132 ] Run JOB 1 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 7 (of 50) ]
[ time 133 ] Run JOB 1 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 6 (of 50) ]
[ time 134 ] Run JOB 1 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 5 (of 50) ]
[ time 135 ] Run JOB 1 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 4 (of 50) ]
[ time 136 ] Run JOB 1 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 3 (of 50) ]
[ time 137 ] Run JOB 1 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 2 (of 50) ]
[ time 138 ] Run JOB 1 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 1 (of 50) ]
[ time 139 ] Run JOB 1 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 0 (of 50) ]
[ time 140 ] FINISHED JOB 1
[ time 140 ] Run JOB 2 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 9 (of 50) ]
[ time 141 ] Run JOB 2 at PRIORITY 0 [ TICKS 8 ALLOT 1 TIME 8 (of 50) ]
[ time 142 ] Run JOB 2 at PRIORITY 0 [ TICKS 7 ALLOT 1 TIME 7 (of 50) ]
[ time 143 ] Run JOB 2 at PRIORITY 0 [ TICKS 6 ALLOT 1 TIME 6 (of 50) ]
[ time 144 ] Run JOB 2 at PRIORITY 0 [ TICKS 5 ALLOT 1 TIME 5 (of 50) ]
[ time 145 ] Run JOB 2 at PRIORITY 0 [ TICKS 4 ALLOT 1 TIME 4 (of 50) ]
[ time 146 ] Run JOB 2 at PRIORITY 0 [ TICKS 3 ALLOT 1 TIME 3 (of 50) ]
[ time 147 ] Run JOB 2 at PRIORITY 0 [ TICKS 2 ALLOT 1 TIME 2 (of 50) ]
[ time 148 ] Run JOB 2 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 1 (of 50) ]
[ time 149 ] Run JOB 2 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 0 (of 50) ]
[ time 150 ] FINISHED JOB 2

Final statistics:
  Job  0: startTime   0 - response   0 - turnaround 130
  Job  1: startTime   0 - response  10 - turnaround 140
  Job  2: startTime   0 - response  20 - turnaround 150

  Avg  2: startTime n/a - response 10.00 - turnaround 140.00
```

8.5

设置-B参数为100

```
python mlfq.py -l 0,200,0:0,100,5:0,100,5 -q 10 -n 3 -i 5 -B 100 -c
```

9.1

计算过程如下

```
└─$ python lottery.py -j 3 -s 1 -c
                                                                    130 ×

ARG jlist
ARG jobs 3
```

```
ARG maxlen 10
ARG maxticket 100
ARG quantum 1
ARG seed 1

Here is the job list, with the run time of each job:
  Job 0 ( length = 1, tickets = 84 )
  Job 1 ( length = 7, tickets = 25 )
  Job 2 ( length = 4, tickets = 44 )


** Solutions **

Random 651593 -> Winning ticket 119 (of 153) -> Run 2
  Jobs:  (  job:0 timeleft:1 tix:84 )   (  job:1 timeleft:7 tix:25 )   (* job:2
timeleft:4 tix:44 )
Random 788724 -> Winning ticket 9 (of 153) -> Run 0
  Jobs:  (* job:0 timeleft:1 tix:84 )   (  job:1 timeleft:7 tix:25 )   (  job:2
timeleft:3 tix:44 )
--> JOB 0 DONE at time 2
Random 93859 -> Winning ticket 19 (of 69) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:7 tix:25 )   (  job:2
timeleft:3 tix:44 )
Random 28347 -> Winning ticket 57 (of 69) -> Run 2
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:6 tix:25 )   (* job:2
timeleft:3 tix:44 )
Random 835765 -> Winning ticket 37 (of 69) -> Run 2
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:6 tix:25 )   (* job:2
timeleft:2 tix:44 )
Random 432767 -> Winning ticket 68 (of 69) -> Run 2
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:6 tix:25 )   (* job:2
timeleft:1 tix:44 )
--> JOB 2 DONE at time 6
Random 762280 -> Winning ticket 5 (of 25) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:6 tix:25 )   (  job:2
timeleft:0 tix:--- )
Random 2106 -> Winning ticket 6 (of 25) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:5 tix:25 )   (  job:2
timeleft:0 tix:--- )
Random 445387 -> Winning ticket 12 (of 25) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:4 tix:25 )   (  job:2
timeleft:0 tix:--- )
Random 721540 -> Winning ticket 15 (of 25) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:3 tix:25 )   (  job:2
timeleft:0 tix:--- )
Random 228762 -> Winning ticket 12 (of 25) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:2 tix:25 )   (  job:2
timeleft:0 tix:--- )
Random 945271 -> Winning ticket 21 (of 25) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:1 tix:25 )   (  job:2
timeleft:0 tix:--- )
--> JOB 1 DONE at time 12

└─$ python lottery.py -j 3 -s 2 -c
ARG jlist
ARG jobs 3
ARG maxlen 10
ARG maxticket 100
```

```
ARG quantum 1
ARG seed 2

Here is the job list, with the run time of each job:
  Job 0 ( length = 9, tickets = 94 )
  Job 1 ( length = 8, tickets = 73 )
  Job 2 ( length = 6, tickets = 30 )


** Solutions **

Random 605944 -> Winning ticket 169 (of 197) -> Run 2
  Jobs:  (  job:0 timeleft:9 tix:94 )   (  job:1 timeleft:8 tix:73 )   (* job:2
timeleft:6 tix:30 )
Random 606802 -> Winning ticket 42 (of 197) -> Run 0
  Jobs:  (* job:0 timeleft:9 tix:94 )   (  job:1 timeleft:8 tix:73 )   (  job:2
timeleft:5 tix:30 )
Random 581204 -> Winning ticket 54 (of 197) -> Run 0
  Jobs:  (* job:0 timeleft:8 tix:94 )   (  job:1 timeleft:8 tix:73 )   (  job:2
timeleft:5 tix:30 )
Random 158383 -> Winning ticket 192 (of 197) -> Run 2
  Jobs:  (  job:0 timeleft:7 tix:94 )   (  job:1 timeleft:8 tix:73 )   (* job:2
timeleft:5 tix:30 )
Random 430670 -> Winning ticket 28 (of 197) -> Run 0
  Jobs:  (* job:0 timeleft:7 tix:94 )   (  job:1 timeleft:8 tix:73 )   (  job:2
timeleft:4 tix:30 )
Random 393532 -> Winning ticket 123 (of 197) -> Run 1
  Jobs:  (  job:0 timeleft:6 tix:94 )   (* job:1 timeleft:8 tix:73 )   (  job:2
timeleft:4 tix:30 )
Random 723012 -> Winning ticket 22 (of 197) -> Run 0
  Jobs:  (* job:0 timeleft:6 tix:94 )   (  job:1 timeleft:7 tix:73 )   (  job:2
timeleft:4 tix:30 )
Random 994820 -> Winning ticket 167 (of 197) -> Run 2
  Jobs:  (  job:0 timeleft:5 tix:94 )   (  job:1 timeleft:7 tix:73 )   (* job:2
timeleft:4 tix:30 )
Random 949396 -> Winning ticket 53 (of 197) -> Run 0
  Jobs:  (* job:0 timeleft:5 tix:94 )   (  job:1 timeleft:7 tix:73 )   (  job:2
timeleft:3 tix:30 )
Random 544177 -> Winning ticket 63 (of 197) -> Run 0
  Jobs:  (* job:0 timeleft:4 tix:94 )   (  job:1 timeleft:7 tix:73 )   (  job:2
timeleft:3 tix:30 )
Random 444854 -> Winning ticket 28 (of 197) -> Run 0
  Jobs:  (* job:0 timeleft:3 tix:94 )   (  job:1 timeleft:7 tix:73 )   (  job:2
timeleft:3 tix:30 )
Random 268241 -> Winning ticket 124 (of 197) -> Run 1
  Jobs:  (  job:0 timeleft:2 tix:94 )   (* job:1 timeleft:7 tix:73 )   (  job:2
timeleft:3 tix:30 )
Random 35924 -> Winning ticket 70 (of 197) -> Run 0
  Jobs:  (* job:0 timeleft:2 tix:94 )   (  job:1 timeleft:6 tix:73 )   (  job:2
timeleft:3 tix:30 )
Random 27444 -> Winning ticket 61 (of 197) -> Run 0
  Jobs:  (* job:0 timeleft:1 tix:94 )   (  job:1 timeleft:6 tix:73 )   (  job:2
timeleft:3 tix:30 )
--> JOB 0 DONE at time 14
Random 464894 -> Winning ticket 55 (of 103) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:6 tix:73 )   (  job:2
timeleft:3 tix:30 )
Random 318465 -> Winning ticket 92 (of 103) -> Run 2
```

```
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:5 tix:73 )   (* job:2
timeleft:3 tix:30 )
Random 380015 -> Winning ticket 48 (of 103) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:5 tix:73 )   (  job:2
timeleft:2 tix:30 )
Random 891790 -> Winning ticket 16 (of 103) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:4 tix:73 )   (  job:2
timeleft:2 tix:30 )
Random 525753 -> Winning ticket 41 (of 103) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:3 tix:73 )   (  job:2
timeleft:2 tix:30 )
Random 560510 -> Winning ticket 87 (of 103) -> Run 2
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:2 tix:73 )   (* job:2
timeleft:2 tix:30 )
Random 236123 -> Winning ticket 47 (of 103) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:2 tix:73 )   (  job:2
timeleft:1 tix:30 )
Random 23858 -> Winning ticket 65 (of 103) -> Run 1
  Jobs:  (  job:0 timeleft:0 tix:--- )   (* job:1 timeleft:1 tix:73 )   (  job:2
timeleft:1 tix:30 )
--> JOB 1 DONE at time 22
Random 325143 -> Winning ticket 3 (of 30) -> Run 2
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:0 tix:--- )   (* job:2
timeleft:1 tix:30 )
--> JOB 2 DONE at time 23

└─$ python lottery.py -j 3 -s 3 -c
ARG jlist
ARG jobs 3
ARG maxlen 10
ARG maxticket 100
ARG quantum 1
ARG seed 3

Here is the job list, with the run time of each job:
  Job 0 ( length = 2, tickets = 54 )
  Job 1 ( length = 3, tickets = 60 )
  Job 2 ( length = 6, tickets = 6 )


** Solutions **

Random 13168 -> Winning ticket 88 (of 120) -> Run 1
  Jobs:  (  job:0 timeleft:2 tix:54 )   (* job:1 timeleft:3 tix:60 )   (  job:2
timeleft:6 tix:6 )
Random 837469 -> Winning ticket 109 (of 120) -> Run 1
  Jobs:  (  job:0 timeleft:2 tix:54 )   (* job:1 timeleft:2 tix:60 )   (  job:2
timeleft:6 tix:6 )
Random 259354 -> Winning ticket 34 (of 120) -> Run 0
  Jobs:  (* job:0 timeleft:2 tix:54 )   (  job:1 timeleft:1 tix:60 )   (  job:2
timeleft:6 tix:6 )
Random 234331 -> Winning ticket 91 (of 120) -> Run 1
  Jobs:  (  job:0 timeleft:1 tix:54 )   (* job:1 timeleft:1 tix:60 )   (  job:2
timeleft:6 tix:6 )
--> JOB 1 DONE at time 4
Random 995645 -> Winning ticket 5 (of 60) -> Run 0
  Jobs:  (* job:0 timeleft:1 tix:54 )   (  job:1 timeleft:0 tix:--- )   (  job:2
timeleft:6 tix:6 )
```

```
--> JOB 0 DONE at time 5
Random 470263 -> Winning ticket 1 (of 6) -> Run 2
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:0 tix:--- )   (* job:2
timeleft:6 tix:6 )
Random 836462 -> Winning ticket 2 (of 6) -> Run 2
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:0 tix:--- )   (* job:2
timeleft:5 tix:6 )
Random 476353 -> Winning ticket 1 (of 6) -> Run 2
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:0 tix:--- )   (* job:2
timeleft:4 tix:6 )
Random 639068 -> Winning ticket 2 (of 6) -> Run 2
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:0 tix:--- )   (* job:2
timeleft:3 tix:6 )
Random 150616 -> Winning ticket 4 (of 6) -> Run 2
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:0 tix:--- )   (* job:2
timeleft:2 tix:6 )
Random 634861 -> Winning ticket 1 (of 6) -> Run 2
  Jobs:  (  job:0 timeleft:0 tix:--- )   (  job:1 timeleft:0 tix:--- )   (* job:2
timeleft:1 tix:6 )
--> JOB 2 DONE at time 11
```

可知模拟结果为:

JOB 0 DONE at time 2

JOB 1 DONE at time 12

JOB 2 DONE at time 6

JOB 0 DONE at time 14

JOB 1 DONE at time 22

JOB 2 DONE at time 23

JOB 0 DONE at time 5

JOB 1 DONE at time 4

JOB 2 DONE at time 11

9.2

模拟结果如下:

```
└─$ python lottery.py -l 10:1,10:100 -c
ARG jlist 10:1,10:100
ARG jobs 3
ARG maxlen 10
ARG maxticket 100
ARG quantum 1
ARG seed 0
```

```
Here is the job list, with the run time of each job:
  Job 0 ( length = 10, tickets = 1 )
  Job 1 ( length = 10, tickets = 100 )


** Solutions **

Random 844422 -> Winning ticket 62 (of 101) -> Run 1
  Jobs:  (  job:0 timeleft:10 tix:1 )   (* job:1 timeleft:10 tix:100 )
Random 757955 -> Winning ticket 51 (of 101) -> Run 1
  Jobs:  (  job:0 timeleft:10 tix:1 )   (* job:1 timeleft:9 tix:100 )
Random 420572 -> Winning ticket 8 (of 101) -> Run 1
  Jobs:  (  job:0 timeleft:10 tix:1 )   (* job:1 timeleft:8 tix:100 )
Random 258917 -> Winning ticket 54 (of 101) -> Run 1
  Jobs:  (  job:0 timeleft:10 tix:1 )   (* job:1 timeleft:7 tix:100 )
Random 511275 -> Winning ticket 13 (of 101) -> Run 1
  Jobs:  (  job:0 timeleft:10 tix:1 )   (* job:1 timeleft:6 tix:100 )
Random 404934 -> Winning ticket 25 (of 101) -> Run 1
  Jobs:  (  job:0 timeleft:10 tix:1 )   (* job:1 timeleft:5 tix:100 )
Random 783799 -> Winning ticket 39 (of 101) -> Run 1
  Jobs:  (  job:0 timeleft:10 tix:1 )   (* job:1 timeleft:4 tix:100 )
Random 303313 -> Winning ticket 10 (of 101) -> Run 1
  Jobs:  (  job:0 timeleft:10 tix:1 )   (* job:1 timeleft:3 tix:100 )
Random 476597 -> Winning ticket 79 (of 101) -> Run 1
  Jobs:  (  job:0 timeleft:10 tix:1 )   (* job:1 timeleft:2 tix:100 )
Random 583382 -> Winning ticket 6 (of 101) -> Run 1
  Jobs:  (  job:0 timeleft:10 tix:1 )   (* job:1 timeleft:1 tix:100 )
--> JOB 1 DONE at time 10
Random 908113 -> Winning ticket 0 (of 1) -> Run 0
  Jobs:  (* job:0 timeleft:10 tix:1 )   (  job:1 timeleft:0 tix:--- )
Random 504687 -> Winning ticket 0 (of 1) -> Run 0
  Jobs:  (* job:0 timeleft:9 tix:1 )   (  job:1 timeleft:0 tix:--- )
Random 281838 -> Winning ticket 0 (of 1) -> Run 0
  Jobs:  (* job:0 timeleft:8 tix:1 )   (  job:1 timeleft:0 tix:--- )
Random 755804 -> Winning ticket 0 (of 1) -> Run 0
  Jobs:  (* job:0 timeleft:7 tix:1 )   (  job:1 timeleft:0 tix:--- )
Random 618369 -> Winning ticket 0 (of 1) -> Run 0
  Jobs:  (* job:0 timeleft:6 tix:1 )   (  job:1 timeleft:0 tix:--- )
Random 250506 -> Winning ticket 0 (of 1) -> Run 0
  Jobs:  (* job:0 timeleft:5 tix:1 )   (  job:1 timeleft:0 tix:--- )
Random 909747 -> Winning ticket 0 (of 1) -> Run 0
  Jobs:  (* job:0 timeleft:4 tix:1 )   (  job:1 timeleft:0 tix:--- )
Random 982786 -> Winning ticket 0 (of 1) -> Run 0
  Jobs:  (* job:0 timeleft:3 tix:1 )   (  job:1 timeleft:0 tix:--- )
Random 810218 -> Winning ticket 0 (of 1) -> Run 0
  Jobs:  (* job:0 timeleft:2 tix:1 )   (  job:1 timeleft:0 tix:--- )
Random 902166 -> Winning ticket 0 (of 1) -> Run 0
  Jobs:  (* job:0 timeleft:1 tix:1 )   (  job:1 timeleft:0 tix:--- )
--> JOB 0 DONE at time 20
```

9.3

模拟结果为:

JOB 1 DONE at time 196

JOB 0 DONE at time 200

JOB 1 DONE at time 190

JOB 0 DONE at time 200

JOB 1 DONE at time 196

JOB 0 DONE at time 200

JOB 1 DONE at time 199

JOB 0 DONE at time 200