Homework Questions

(about the lottery scheduler)

1. **Compute the solutions for simulations with 3 jobs and random seeds of 1, 2, and 3.**

   seed 1

```
python lottery.py -j 3 -s 1 -c
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
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
--> 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:
Random 28347 -> Winning ticket 57 (of 69) -> Run 2
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (  job:1 timeleft:6 tix:25 )  (* job:2 timeleft:
Random 835765 -> Winning ticket 37 (of 69) -> Run 2
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (  job:1 timeleft:6 tix:25 )  (* job:2 timeleft:
Random 432767 -> Winning ticket 68 (of 69) -> Run 2
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (  job:1 timeleft:6 tix:25 )  (* job:2 timeleft:
--> 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:
Random 2106 -> Winning ticket 6 (of 25) -> Run 1
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (* job:1 timeleft:5 tix:25 )  (  job:2 timeleft:
Random 445387 -> Winning ticket 12 (of 25) -> Run 1
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (* job:1 timeleft:4 tix:25 )  (  job:2 timeleft:
Random 721540 -> Winning ticket 15 (of 25) -> Run 1
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (* job:1 timeleft:3 tix:25 )  (  job:2 timeleft:
Random 228762 -> Winning ticket 12 (of 25) -> Run 1
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (* job:1 timeleft:2 tix:25 )  (  job:2 timeleft:
Random 945271 -> Winning ticket 21 (of 25) -> Run 1
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (* job:1 timeleft:1 tix:25 )  (  job:2 timeleft:
--> JOB 1 DONE at time 12
```

seed 2

```
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
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
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
```

```
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
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
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
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
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
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
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
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
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
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
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
--> 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:
Random 318465 -> Winning ticket 92 (of 103) -> Run 2
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (  job:1 timeleft:5 tix:73 )  (* job:2 timeleft:
Random 380015 -> Winning ticket 48 (of 103) -> Run 1
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (* job:1 timeleft:5 tix:73 )  (  job:2 timeleft:
Random 891790 -> Winning ticket 16 (of 103) -> Run 1
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (* job:1 timeleft:4 tix:73 )  (  job:2 timeleft:
```

```
Random 525753 -> Winning ticket 41 (of 103) -> Run 1
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (* job:1 timeleft:3 tix:73 )  (  job:2 timeleft:
Random 560510 -> Winning ticket 87 (of 103) -> Run 2
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (  job:1 timeleft:2 tix:73 )  (* job:2 timeleft:
Random 236123 -> Winning ticket 47 (of 103) -> Run 1
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (* job:1 timeleft:2 tix:73 )  (  job:2 timeleft:
Random 23858 -> Winning ticket 65 (of 103) -> Run 1
    Jobs:
    (  job:0 timeleft:0 tix:--- )  (* job:1 timeleft:1 tix:73 )  (  job:2 timeleft:
--> 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
--> JOB 2 DONE at time 23
```

seed 3

```
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
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
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
```

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

2. **Now run with two specific jobs: each of length 10, but one (job 0) with just 1 ticket and the other (job 1) with 100 (e.g., -l 10:1,10:100). What happens when the number of tickets is so imbalanced? Will job 0 ever run before job 1 completes? How often? In general, what does such a ticket imbalance do to the behavior of lottery scheduling?**

   It is extremely unlikely that job 0 will ever run before job 1 because of the imbalance of tickets. The behaviour changes into more of FIFO scheduling and becomes unfair.

3. **When running with two jobs of length 100 and equal ticket alocations of 100 (-l 100:100,100:100), how unfair is the scheduler? Run with some different random seeds to determine the (probalistic) answer; let unfairness be determined by how much earlier one job finishes than the other.**

Unfairness metric = U
U = the time the first job completes divided by the time the second job completes
(A perfectly fair scheduler achieves U = 1)

(rounded to 2 decimal places)

Run 0
$s = 0$
$U = \frac{192}{200} = 0.96$

Run 1
$s = 1$
$U = \frac{196}{200} = 0.98$

Run 2
$s = 2$
$U = \frac{190}{200} = 0.95$

Run 3
$s = 3$
$U = \frac{196}{200} = 0.98$

Run 4
$s = 4$
$U = \frac{199}{200} = 1.00$

So, overall the scheduler is pretty fair.

4. **How does your answer to the previous question change as the quantum size (-q) gets larger?**

- length of time slice in prev question was 1

q = 10 Run 0
$s = 0$
$U = \frac{150}{200} = 0.75$

Run 1
$s = 1$
$U = \frac{160}{200} = 0.80$

Run 2
$s = 2$
$U = \frac{190}{200} = 0.95$

Run 3
$s = 3$
$U = \frac{190}{200} = 0.95$

Run 4
$s = 4$
$U = \frac{190}{200} = 0.95$

q = 50 Run 0
$s = 0$
$U = \frac{150}{200} = 0.75$

Run 1
$s = 1$
$U = \frac{150}{200} = 0.75$

Run 2
$s = 2$
$U = \frac{100}{200} = 0.50$

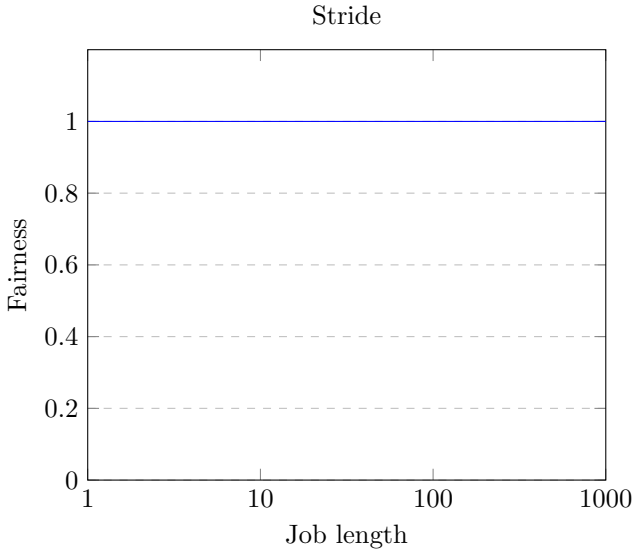
Run 3
$s = 3$
$U = \frac{150}{200} = 0.75$

Run 4
$s = 4$
$U = \frac{150}{200} = 0.75$

As the quantum size gets larger, the scheduler becomes more unfair.

5. **Can you make a version of the graph that is found in the chapter? What else would be worth exploring? How would the graph look with a stride scheduler?**


Lottery
Fairness
1
0.8
0.6
0.4
0.2
0
1
10
100
1000
Job length


Stride
Fairness
1
0.8
0.6
0.4
0.2
0
1
10
100
1000
Job length