Q1:
Compute the solutions for simulations with 3 jobs and random seeds of 1, 2, and 3.

Seed 1----
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)

Here is the set of random numbers you will need (at most):
Random 651593
Random 788724
Random 93859
Random 28347
Random 835765
Random 432767
Random 762280
Random 2106
Random 445387
Random 721540
Random 228762
Random 945271

Answer:
Total tickets = 84 + 25 + 44 = 153

Random 651593 % 153 = 119
Count = 0 + 84(job0) = 84 < 119
Count = 84 + 25(job1) = 109 < 119
Count = 109 + 44(job2) = 153 > 119 (winner)
Run job 2
Job2(3/4)

Random 788724 % 153 = 9
Count = 0 + 84(job0) = 84 > 9 (winner)
Run job0

Job0(0/1) done

Random 93859 % (25+44) = 19
Count = 0 + 25(job1) = 25 > 19 (winner)
Run job1
Job1(6/7)

Random 28347 % 69 = 57
Count = 0 + 25(job1) = 25 < 57
Count = 25 + 44(job2) = 69 > 19(winner)
Run job2
Job2(2/3)

Random 835765 -> Winning ticket 37 (of 69) -> Run 2
Job2(1/4)

Random 432767 -> Winning ticket 68 (of 69) -> Run 2
Job2(0/4) done

Random 762280 -> Winning ticket 5 (of 25) -> Run 1
Job1(5/7)

Random 2106 -> Winning ticket 6 (of 25) -> Run 1
Job1(4/7)

Random 445387 -> Winning ticket 12 (of 25) -> Run 1
Job1(3/7)

721540 -> Winning ticket 15 (of 25) -> Run 1
Job1(2/7)

Random 228762 -> Winning ticket 12 (of 25) -> Run 1
Job1(1/7)

Random 945271 -> Winning ticket 21 (of 25) -> Run 1
Job1(0/7) done

All job done

Seed 2----
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)

Here is the set of random numbers you will need (at most):
Random 605944
Random 606802
Random 581204
Random 158383
Random 430670
Random 393532
Random 723012
Random 994820
Random 949396
Random 544177
Random 444854
Random 268241
Random 35924
Random 27444
Random 464894
Random 318465
Random 380015
Random 891790
Random 525753
Random 560510
Random 236123
Random 23858
Random 325143

Random 605944 -> Winning ticket 169 (of 197) -> Run 2
Job0(9/9) job1(8/8) Job2(5/6)

Random 606802 -> Winning ticket 42 (of 197) -> Run 0
Job0(8/9) job1(8/8) Job2(5/6)

Random 581204 -> Winning ticket 54 (of 197) -> Run 0
Job0(7/9) job1(8/8) Job2(5/6)

Random 158383 -> Winning ticket 192 (of 197) -> Run 2
Job0(7/9) job1(8/8) Job2(4/6)

Random 430670 -> Winning ticket 28 (of 197) -> Run 0
Job0(6/9) job1(8/8) Job2(4/6)

Random 393532 -> Winning ticket 123 (of 197) -> Run 1
Job0(6/9) job1(7/8) Job2(4/6)

Random 723012 -> Winning ticket 22 (of 197) -> Run 0
Job0(5/9) job1(7/8) Job2(4/6)

Random 994820 -> Winning ticket 167 (of 197) -> Run 2
Random 949396 -> Winning ticket 53 (of 197) -> Run 0
Random 544177 -> Winning ticket 63 (of 197) -> Run 0
Random 444854 -> Winning ticket 28 (of 197) -> Run 0
Random 268241 -> Winning ticket 124 (of 197) -> Run 1
Random 35924 -> Winning ticket 70 (of 197) -> Run 0
Random 27444 -> Winning ticket 61 (of 197) -> Run 0
--> JOB 0 DONE at time 14
Random 464894 -> Winning ticket 55 (of 103) -> Run 1
Random 318465 -> Winning ticket 92 (of 103) -> Run 2
Random 380015 -> Winning ticket 48 (of 103) -> Run 1
Random 891790 -> Winning ticket 16 (of 103) -> Run 1
Random 525753 -> Winning ticket 41 (of 103) -> Run 1
Random 560510 -> Winning ticket 87 (of 103) -> Run 2
Random 236123 -> Winning ticket 47 (of 103) -> Run 1
Random 23858 -> Winning ticket 65 (of 103) -> Run 1
--> JOB 1 DONE at time 22
Random 325143 -> Winning ticket 3 (of 30) -> Run 2
--> JOB 2 DONE at time 23

Seed 2----
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)

Here is the set of random numbers you will need (at most):
Random 13168
Random 837469
Random 259354
Random 234331
Random 995645
Random 470263
Random 836462
Random 476353
Random 639068
Random 150616
Random 634861

Random 13168 -> Winning ticket 88 (of 120) -> Run 1
Random 837469 -> Winning ticket 109 (of 120) -> Run 1
Random 259354 -> Winning ticket 34 (of 120) -> Run 0
Random 234331 -> Winning ticket 91 (of 120) -> Run 1
--> JOB 1 DONE at time 4
Random 995645 -> Winning ticket 5 (of 60) -> Run 0
--> JOB 0 DONE at time 5
Random 470263 -> Winning ticket 1 (of 6) -> Run 2
Random 836462 -> Winning ticket 2 (of 6) -> Run 2
Random 476353 -> Winning ticket 1 (of 6) -> Run 2
Random 639068 -> Winning ticket 2 (of 6) -> Run 2
Random 150616 -> Winning ticket 4 (of 6) -> Run 2
Random 634861 -> Winning ticket 1 (of 6) -> Run 2
--> JOB 2 DONE at time 11

Q2:

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?

Command: **./lottery.py -l 10:1,10:100 -c**

The scheduler will always pick job 1 to execute the, after job 1 finish the job 0 will start. Highly unlikely the job 0 would every run, the chance 1/101 around 0.99% which is less than 1%. This ticket imbalance will starve the less tickets job especially in short amount of time. For example, if the length of two job is around 1000, then the job 0 may 10 times to run in 1000 length.

Q3:

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

Command: **./lottery.py -s 1 -l 100:100,100:100 -c**

Job 1 done at time 196, job 0 done at 200. Thus, job 1 is 4ms earlier

Command: **./lottery.py -s 2 -l 100:100,100:100 -c**

Job 1 done at time 190, job 0 done at 200. Thus, job 1 is 10ms earlier

Command: **./lottery.py -s 10 -l 100:100,100:100 -c**

Job 1 done at time 196, job 0 done at 200. Thus, job 1 is 10ms earlier

Command: **./lottery.py -s 100 -l 100:100,100:100 -c**

Job 1 done at time 185, job 0 done at 200. Thus, job 1 is 15ms earlier

Command: **./lottery.py -s 1000 -l 100:100,100:100 -c**

Job 1 done at time 200, job 0 done at 195. Thus, job 0 is 5ms earlier

Now lets sum up number of the all the errors then divide the number of he runes we got:

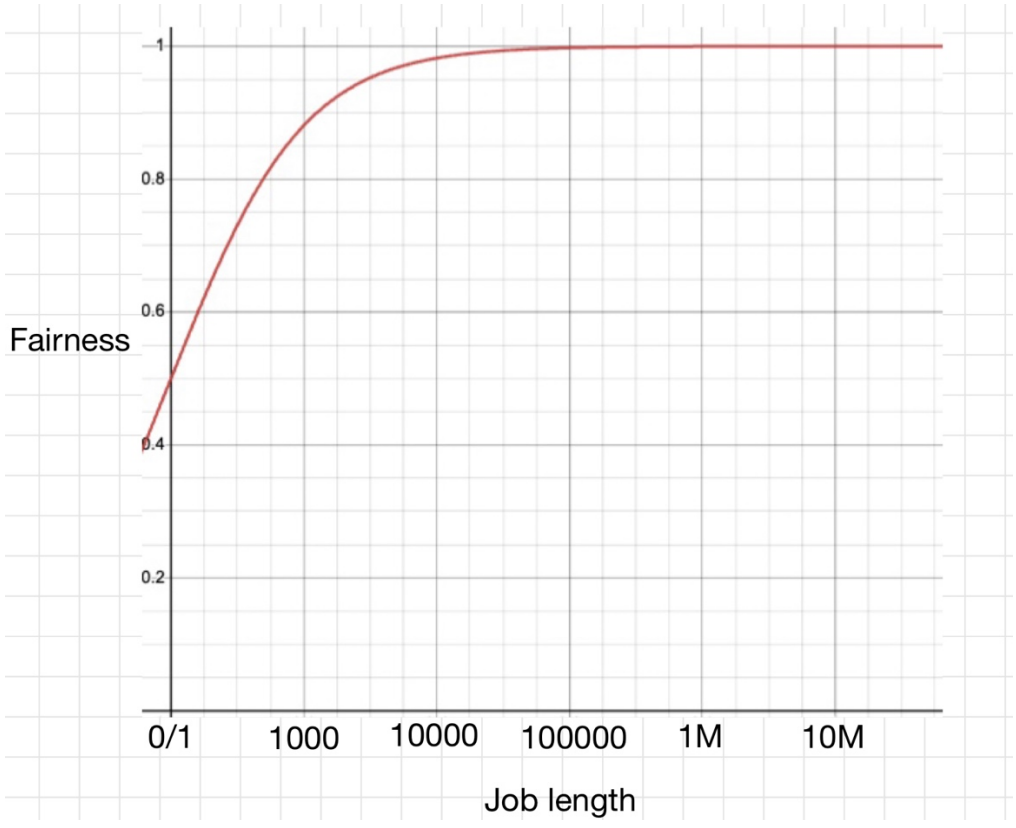
$$\frac{4 + 10 + 10 + 15 + 5}{5} = 8.8\ ms$$

Base on above 5 simulations the average unfairness is 8.8 ms. But if we run 10000 times or we increase the job length by 10000 fold, the by Probability theory the average unfairness score will converge to 1.

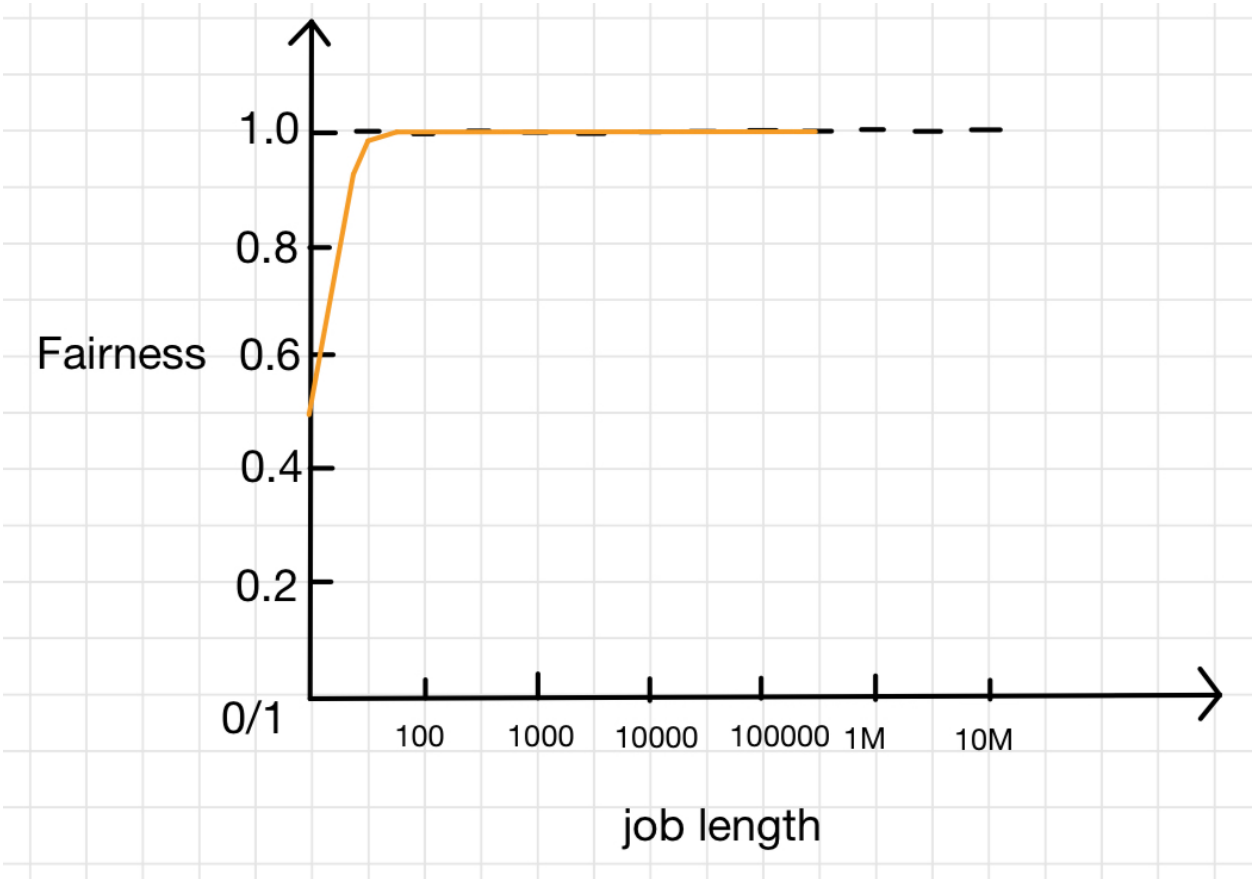
Q4:
How does your answer to the previous question change as the quantum size (-q) gets larger?

Command: ./lottery.py -s 1 -l 100:100,100:100 -q 10 -c
Job 0 done at time 200, job1 done at 160. Notice the when we increase the length of time slice by 10 fold, the unfairness is also increase 10 fold. This make sense, previous our time slice only 1 thus, and if there are 4 instants of unfairness happen, the unfairness point only be 4. But when the time lice become 10, and four time unfair happen, the unfairness point will be 40.

Q5
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?



Notice when the job length get larger and larger the fairness will extremely close to 1.
Stride graph below



Notice, the stride at begin will ascent shapely, then will become 1. Unlike lottery scheduler, the will close to 1 but never equal to 1.