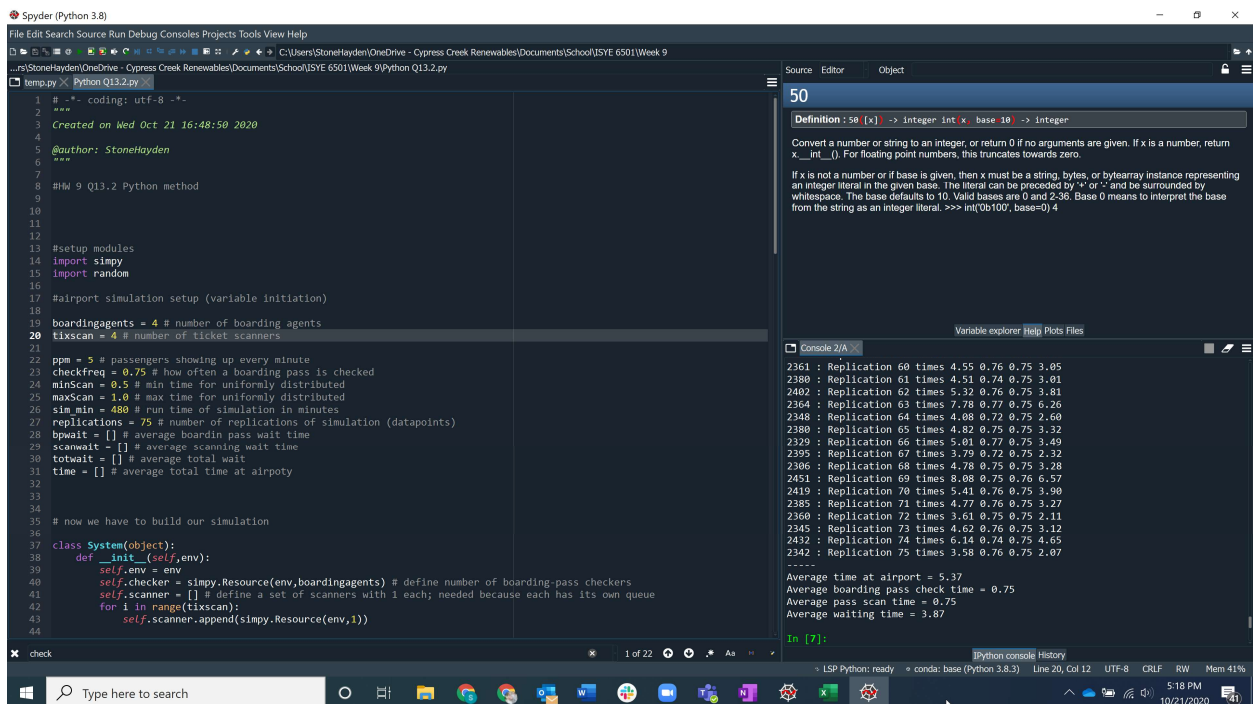


Question 13.2

In this problem you, can simulate a simplified airport security system at a busy airport. Passengers arrive according to a Poisson distribution with $\lambda_1 = 5$ per minute (i.e., mean interarrival rate $\mu_1 = 0.2$ minutes) to the ID/boarding-pass check queue, where there are several servers who each have exponential service time with mean rate $\mu_2 = 0.75$ minutes. [Hint: model them as one block that has more than one resource.] After that, the passengers are assigned to the shortest of the several personal-check queues, where they go through the personal scanner (time is uniformly distributed between 0.5 minutes and 1 minute).

Use the Arena software (PC users) or Python with SimPy (PC or Mac users) to build a simulation of the system, and then vary the number of ID/boarding-pass checkers and personal-check queues to determine how many are needed to keep average wait times below 15 minutes. [If you're using SimPy, or if you have access to a non-student version of Arena, you can use $\lambda_1 = 50$ to simulate a busier airport.]

Summary: Found that having 4 boarding agents and 4 ticket scanners was the most optimal amount for my simulation considering that the benefits of adding more were small compared to cost of paying for more people. Any less than 4 each caused a much longer wait time for passengers. For 80 replications of my simulation, the average wait time was 3.87 minutes with total time to get through security at 5.37. This was using the small airport model of people arriving every 5 minutes (not 50 minutes).



The screenshot shows the Spyder Python IDE with a file named 'temp.py' open. The script defines a simulation environment with 4 boarding agents and 4 ticket scanners. It uses SimPy for resource management and random for uniform distribution. The simulation runs for 480 minutes with 75 replications. The output in the console shows the results for each replication, including the average time at the airport, average boarding pass check time, average pass scan time, and average waiting time.

```

1 # -*- coding: utf-8 -*-
2 """
3 Created on Wed Oct 21 16:48:50 2020
4
5 @author: StoneHayden
6 """
7
8 HW9 Q13.2 Python method
9
10
11
12
13 #setup modules
14 import simpy
15 import random
16
17 #airport simulation setup (variable initiation)
18
19 boardingagents = 4 # number of boarding agents
20 tixscan = 4 # number of ticket scanners
21
22 ppm = 5 # passengers showing up every minute
23 checkfreq = 0.75 # how often a boarding pass is checked
24 minScan = 0.5 # min time for uniformly distributed
25 maxScan = 1.0 # max time for uniformly distributed
26 sim_min = 480 # run time of simulation in minutes
27 replications = 75 # number of replications of simulation (datapoints)
28 bpswait = [] # average boardin pass wait time
29 scanwait = [] # average scanning wait time
30 totwait = [] # average total wait
31 time = [] # average total time at airpoty
32
33
34
35 # now we have to build our simulation
36
37 class System(object):
38     def __init__(self, env):
39         self.env = env
40         self.checker = simpy.Resource(env, boardingagents) # define number of boarding-pass checkers
41         self.scanner = [] # define a set of scanners with 1 each; needed because each has its own queue
42         for i in range(tixscan):
43             self.scanner.append(simpy.Resource(env, 1))
44
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```

Console output:

```

2361 : Replication 60 times 4.55 0.76 0.75 3.05
2380 : Replication 61 times 4.51 0.74 0.75 3.01
2402 : Replication 62 times 5.32 0.76 0.75 3.81
2364 : Replication 63 times 7.78 0.77 0.75 6.26
2348 : Replication 64 times 4.08 0.72 0.75 2.60
2380 : Replication 65 times 4.82 0.75 0.75 3.32
2329 : Replication 66 times 5.01 0.77 0.75 3.49
2395 : Replication 67 times 3.79 0.72 0.75 2.32
2306 : Replication 68 times 4.78 0.75 0.75 3.28
2451 : Replication 69 times 8.08 0.75 0.76 6.57
2419 : Replication 70 times 5.41 0.76 0.75 3.90
2385 : Replication 71 times 4.77 0.76 0.75 3.27
2360 : Replication 72 times 3.61 0.75 0.75 2.11
2345 : Replication 73 times 4.62 0.76 0.75 3.12
2412 : Replication 74 times 6.14 0.74 0.75 4.65
2342 : Replication 75 times 3.58 0.76 0.75 2.07
-----
Average time at airport = 5.37
Average boarding pass check time = 0.75
Average pass scan time = 0.75
Average waiting time = 3.87

```