Express your answer as a decimal (so 4/3 would be 1.3333) in the following questions:
Go to the slide “Explanation of the Options” where we use Restaurant A. Say you physically go to the restaurant and options 1 and 2 are presented to you (just like in the slide). Ignore the red colors on the table in that slide for this **new** problem. Say you want to minimize your cost so that your total preference rating is more than 15.5.

1) The optimal solution is to get the drink from option ____,

0.5 points

2) The optimal solution is to get the appetizer from option ____,

0.5 points

3) The optimal solution is to get the main course from option ____,

0.5 points

4) The optimal solution is to get the dessert from option ____.

0.5 points

5) That would result in a cost of $____

0.5 points

6) That would result in a total preference rating ____.

0.5 points

Go to the slide “Restaurant A Scenarios”. Consider that mixing and matching is not allowed. So if options 1 and 2 are revealed, you must select the entire option 1 or option 2. Also, your budget is now $62. If we were to redo the table on that slide here then it would be as shown. Notice that there are four table entries that are blank, fill out the blanks. Also note that we do not need a separate column for drinks choice, appetizer choice, main course choice and dessert choice because the “choice” itself means the corresponding items from that option.

Table 1

Options Revealed	Optimal Score	Choice (for drinks, appetizer, main course and dessert)
1,2	14.4	2
1,3	14.9	None
1,4	14.3	None
1,5	14.5	5
2,3	14.4	2
U,V	X	Y
2,5	14.5	5
3,4	14.9	None
3,5	14.5	5
4,5	14.5	5

7) What is the possible combination of U and V: ***0.5 points***

- (2,1)
- (2,4)
- (4,1)

8) X= ---------

0.5 points

9) Y= ---------

0.5 points

10)Since all the scenarios are equally likely, the expected value of optimal total score is ______.

0.5 points

10)Since all the scenarios are equally likely, the expected value of optimal total score is ______.

0.5 points

Go to the slide “Restaurant B Scenarios”. The app was able to look at historical choices getting revealed. Based on that the app concluded that the pattern is random (no correlations) but the fraction of times they were used were not equal. The app created a column to display the probability each option set would be revealed.

Table 2

Options Revealed	Optimal Score	Probability the option would be revealed
1,2	13.5	0.4
1,3	16.4	0.02
1,4	15.4	0.02
1,5	15.3	0.15
2,3	15.0	0.05
2,4	14.8	0.25
2,5	15.8	0.03
3,4	16.0	0.03
3,5	16.7	0.01
4,5	15.5	0.04

11)In that case, the expected value of optimal total score for Restaurant B is ______.

0.5 points

12)Assuming that the probability of various option sets for restaurant A continues to be equal (you can see Table 1 for reference, i.e. all cases 0.1), then the optimal choice is to pick Restaurant ____ [Hint: fill in A or B (in capital letters only)].

0.5

Go to the slide “Restaurant B Scenarios” but this is a different problem than above and we will consider a

3:46 4G+ 26%

Go to the slide “Restaurant B Scenarios” but this is a different problem than above and we will consider a further modification to the problem we saw in the class video and slides. Say that instead of two, four options are available each day (but everything else is as in the video and slides).

13)The number of different scenarios possible are ______ (for options to be revealed).

0.5 points

14)In that case the expected value of optimal total score for Restaurant B would ______ (write I for increase, D for decrease, R for remain same, and C for can't say)

0.5 points

Recall the Washing Machine problem under Discrete Time Markov Chains. Say we make a minor modification and observe the system at the beginning of a day but this time the inventory at the beginning of the nth day is always between 1 and 5. So the state space becomes S = {1,2,3,4,5}. Everything else is same as what is described in the notes and video. Fill in the blanks in the corresponding P matrix

$$P = \begin{pmatrix} 0.2 & 0 & 0 & 0 & .8 \\ 0.3 & 0.2 & 0 & 0 & 0.5 \\ \_A\_\_ & \_B\_\_ & \_C\_\_ & \_\_D\_ & \_E\_\_ \\ 0.1 & 0.25 & 0.3 & 0.2 & 0.15 \\ 0.1 & 0.1 & 0.25 & 0.3 & 0.25 \end{pmatrix}$$

15)A = -----

0.5 points

16)B = -----

_0.5_

17)C = -----

0.5 points

16)B = -----

0.5 points

17)C = -----

0.5 points

18)D = -----

0.5 points

19)E = -----

0.5 points

Go to the slide titled “Markov Decision Process: Example”. If the probability of going from G to G, D and B in a day are respectively 0.9, 0.07 and 0.03, then the second row of the P matrix in the slide “Policy 1: Do nothing in DG and DD” (without rounding off) would be __A____, ___B____, ___C____, ___D____, ___E____, ___F____. (Answer upto 4 decimal places)

20)A =

0.5 points

21)B =

0.5 points

22)C =

0.5 points

23)D =

22)C =

0.5 points

23)D =

0.5 points

24)E =

0.5 points

25)F =

0.5 points

You can use the Octave codes and modify them to answer the following

Modify the octave code to evaluate the pi values (dtmc_demo.m) for this. Consider a DTMC {Xn, n ≥0} with state space is S = {1,2,3,4} and transition probability matrix

$$P = \begin{pmatrix} 0 & 0.5 & 0.4 & 0.1 \\ 0 & 0 & 0 & 1 \\ 0.2 & 0.4 & 0.2 & 0.2 \\ 0.3 & 0.2 & 0.5 & 0 \end{pmatrix}$$

that needs to be entered into the Octave code. Save the modified code. Run the program by typing dtmc_demo on the command prompt after confirming the program is in the current directory. On the command prompt type (without quotes) "pi_val*P" and hit enter. Write below in the blanks what you get (__A_____, ___ B_____, ___ C_____, ___ D____). [Answer upto 4 decimal places] that needs to be entered into the Octave code. Save the modified code. Run the program by typing dtmc_demo on the command prompt after confirming the program is in the current directory. On the command prompt type (without quotes) “pi_val*P” and hit enter. Write below in the blanks what you get (__A____, ___ B____, ___ C____, ___ D____). [Answer upto 4 decimal places]

26)A = ------

0.5 points

27)B = ------

0.5 points

28)C = ------

0.5 points

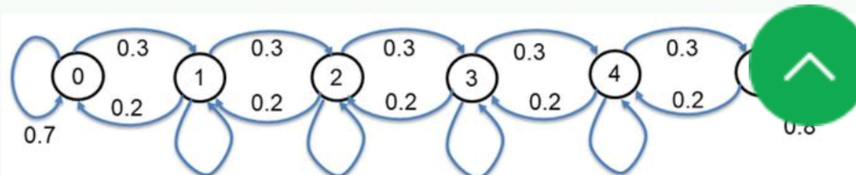
29)D = ------

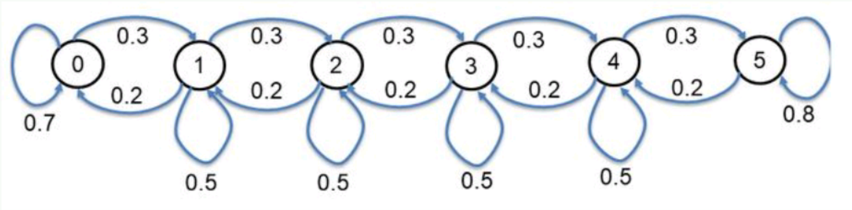
0.5 points

30)Next on the command prompt type (without quotes) “sum(pi_val)” and hit enter. Write down what you get __________.

0.5 points

The transition diagram of a special type of DTMC is drawn below and such a DTMC is known as a random walk. Modify the octave code to evaluate the pi values (dtmc_demo.m) for this. The random walk DTMC $\{X_n, n \geq 0\}$ has state space is $S = \{0, 1, 2, 3, 4, 5\}$.





In case the arrows are not clear, the probability of going from $X_n = i$ to $X_{n+1} = i + 1$ is 0.3 for i = 0 to 4. Also, the probability of going from $X_n = i$ to $X_{n+1} = i - 1$ is 0.2 for $i = 1$ to 5. Obtain the transition probability matrix and enter into the Octave code. Save the modified code. Run the program by typing dtmc_demo on the command prompt after confirming the program is in the current directory.

The long-run probabilities to 4 decimal places: $(\pi_0, \pi_1, \pi_2, \pi_3, \pi_4, \pi_5)$ = (__A____, ___B_____, ____C____, ____D____, ____E____, _____F____).

31)A = --------

0.5 points

32)B = --------

0.5 points

33)C = --------

0.5 points

34)D = --------

0.5 points

35)E = --------

0.5 points

36)F = --------

0.5 points

37)If it costs 8 units every time the system is observed in state 0, a cost of 1 every time the system is observed in state 3, a cost of 2 every time the system is observed in state 5 (with zero costs in other states), the long-run average cost incurred per observation is 8 π_0 + 1π_3 + 2π_5 for which on the command prompt type (without quotes) **"pi_val*[8 0 0 1 0 2]'"** and hit enter. Write down what you get ________ (Answer upto 4 decimal places).

0.5 points

At the beginning of each hour with probability 0.5 a robot brings a product to be repaired at a station. If the station already has two products when the robot arrives, the robot does not leave the new product for repair but takes it to a different facility. If there are zero or one product in the station when the robot arrives, the robot drops off the product it brings at the station for repair. The manager of the station has two types of service configurations available to perform repairs. After the time the robot is expected to arrive, the manager can look at the number of products in the station and then she can select a configuration for that hour.

If she uses the "slow" configuration at a cost of 300 rupees that hour, with probability 0.6, a repair would be complete by the end of that hour (and with probability 0.4 no repair would be complete). If she uses the "fast" configuration at a cost of 900 rupees that hour, with probability 0.8, a repair would be complete by the end of that hour (and with probability 0.2 no repair would be complete). A profit of 5000 rupees is earned when a repair is complete. We use a Markov Decision Process approach to determine whether she should use the "fast" or "slow" configuration during each case of having 1 or 2 products to repair at the start of each hour.

There are four policies for the manager to consider: Policy 1 – whether there are one or two products, use "fast"; Policy 2 – whether there are one or two products, use "slow"; P
3 - if there is one product use "fast" and when there a
use "slow"; Policy 4 – if there is one product, use "slow" and

There are four policies for the manager to consider: Policy 1 – whether there are one or two products, use “fast”; Policy 2 – whether there are one or two products, use “slow”; Policy 3 - if there is one product use “fast” and when there are two use “slow”; Policy 4 – if there is one product, use “slow” and when there are two, use “fast”. In all four policies if there are zero products during an hour, then the manager need not use any configuration and also there would be no repairs compete, so there are neither costs incurred nor profits made in such an hour. Let r_1 and r_2 be the expected revenue per hour when there are 1 and 2 products during an hour respectively. What we want is to identify which among the four policies maximizes the long-run average revenue per unit time.

For that, let X_n be the number of products at the station when the manager is about to make a decision about the configuration at the start of each hour (this is immediately after a potential robot arrival time). Then for all four policies we can create a DTMC $\{X_n, n \geq 0\}$ with state space is $S = \{0, 1, 2\}$ and transition probability matrix

$$P = \begin{pmatrix} 0.5 & 0.5 & 0 \\ 0.5p_1 & 0.5 & 0.5(1-p_1) \\ 0 & 0.5p_2 & 1-0.5p_2 \end{pmatrix}$$

where p_1 and p_2 are the probabilities that when there are one and two products respectively, a repair would be completed that hour. Under policy 2, p_1=p_2=0.6 while under policy 4, p_1=0.6 and p_2=0.8. Modify the octave code (dtmc_demo.m) to evaluate the pi values under all four policies.

Then obtain the long-run average revenue per unit time as $0\pi_0 + r_1\pi_1 + r_2\pi_2$ where $r_1 = 5000p_1 - c_1$ and $r_2 = 5000p_2 - c_2$ where c_1 and c_2 are the costs of operation per hour when there are 1 and 2 products respectively (so in Policy 1, $c_1 = c_2 = 900$ while in P 3, $c_1 = 900$ and $c_2 = 300$). Add this revenue calcula to the code and run the program once for each policy. For

Then obtain the long-run average revenue per unit time as $0\pi_0 + r_1\pi_1 + r_2\pi_2$ where $r_1 = 5000p_1 - c_1$ and $r_2 = 5000p_2 - c_2$ where c_1 and c_2 are the costs of operation per hour when there are 1 and 2 products respectively (so in Policy 1, $c_1 = c_2 = 900$ while in Policy 3, $c_1 = 900$ and $c_2 = 300$). Add this revenue calculation to the code and run the program once for each policy. For policy 4, answer the following:,

38)The long-run average revenue per hour is ________ (correct to 1 decimal).

0.5 points

39)π_0 = ______ (all pi values to 4 decimal places)

0.5 points

40)π_1 = _____ (all pi values to 4 decimal places)

0.5 points

41)π_2 = _____ (all pi values to 4 decimal places)

0.5 points

42)Among the four policies the optimal one is ___ (write 1, 2, 3 or 4).

0.5 points

There is only one right answer in the following multiple choice questions:

43)In the example setting of the two restaurants ***0.5 points*** A and B under stochastic optimization, which of the following is TRUE based on what is stated?

- ( ) You are required to get any three out of four items drinks, appetizer, main course and dessert
- (•) You can select options from restaurant A and B at the same time