**2.3 Simulation**

**Q1. A company manufactures around 200 cars. Depending upon the availability of raw materials and other conditions, the daily production has been varying from 196 cars to 204 cars. The probability distribution is as given below:**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Production/day** | **196** | **197** | **198** | **199** | **200** | **201** | **202** | **203** | **204** |
| **Probability** | **0.05** | **0.09** | **0.12** | **0.14** | **0.2** | **0.15** | **0.11** | **0.08** | **0.06** |

**The finished cars are transported in a specially designed three stored lorry that can accommodate only 200 cars. Using the following 15 random numbers 82, 89, 78, 24, 53, 61, 18, 45, 04, 23, 50, 77, 27, 54 and 10. Simulate the process to find out.**

1. **What will be the average number of cars waiting in the factory?**
2. **What will be the number of empty spaces in the lorry?**

**Solution:** We have given probability for the production per day. Now, we will find cumulative probability and random number intervals. Since the probabilities are given in two decimal digits, so the random numbers involving two digits i.e 00 to 99. The cumulative probabilities and random number intervals are as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Production Per day** | **Probability** | **Cumulative Probability** | **Random Number Intervals** |
| 196 | 0.05 | 0.05 | 00-04 |
| 197 | 0.09 | 0.14 | 05-13 |
| 198 | 0.12 | 0.26 | 14-25 |
| 199 | 0.14 | 0.40 | 26-39 |
| 200 | 0.20 | 0.60 | 40-59 |
| 201 | 0.15 | 0.75 | 60-74 |
| 202 | 0.11 | 0.86 | 75-85 |
| 203 | 0.08 | 0.94 | 86-93 |
| 204 | 0.06 | 1.00 | 94-99 |

Now, will simulate for next 15 days for the production of cars and will also find the number of cars waiting in the factory and empty spaces in the lorry.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr. No** | **Random Numbers** | **Production for next 15 days** | **Number of cars waiting in the factory** | **Empty Spaces in the lorry** |
| 1 | 82 | 202 | 2 | - |
| 2 | 89 | 203 | 5 | - |
| 3 | 78 | 202 | 7 | - |
| 4 | 24 | 198 | 5 | - |
| 5 | 53 | 200 | 5 | - |
| 6 | 61 | 201 | 6 | - |
| 7 | 18 | 198 | 4 | - |
| 8 | 45 | 200 | 4 | - |
| 9 | 04 | 196 | 0 | - |
| 10 | 23 | 198 | 0 | 2 |
| 11 | 50 | 200 | 0 | - |
| 12 | 77 | 202 | 2 | - |
| 13 | 27 | 199 | 1 | - |
| 14 | 54 | 200 | 1 | - |
| 15 | 10 | 197 | 0 | 2 |

1. Average number of cars waiting in the factory = 42/15 = 2.8 Cars
2. There will 2-2 empty spaces in the lorry on 10th and 15th day.

**Q 2) The rainfall distribution in monsoon season is as follows**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Rain in Cm** | **0** | **1** | **2** | **3** | **4** | **5** |
| **Frequency** | **50** | **25** | **15** | **5** | **3** | **2** |

**Simulate the rainfall for 10 days using following random numbers: 67, 63, 39, 55, 29 78, 70, 06,78,76. Find the average rainfall.**

**Solution:** We have given frequency for the rainfall in cm. Now, will find the probability of rainfall in cm.

Total Frequency = 50+25+15+5+3+2 = 100

Probability = No. of outcomes/sample space

Probability that rainfall is 0 cm = 50/100=0.5

Probability that rainfall is 1 cm = 25/100=0.25

Probability that rainfall is 2 cm = 15/100=0.15

Probability that rainfall is 3 cm = 5/100=0.05

Probability that rainfall is 4 cm = 3/100=0.03

Probability that rainfall is 5 cm = 2/100=0.02

Now, we will find cumulative probability and random number intervals. Since the probabilities are given in two decimal digits, so the random numbers involving two digits i.e 00 to 99. The cumulative probabilities and random number intervals are as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Rainfall in cm** | **Frequency** | **Probability** | **Cumulative Probability** | **Random Number Intervals** |
| 0 | 50 | 0.50 | 0.50 | 00-49 |
| 1 | 25 | 0.25 | 0.75 | 50-74 |
| 2 | 15 | 0.15 | 0.90 | 75-89 |
| 3 | 5 | 0.05 | 0.95 | 90-94 |
| 4 | 3 | 0.03 | 0.98 | 95-97 |
| 5 | 2 | 0.02 | 1.00 | 98-99 |

Now, we will simulate for next 10 days of rainfall in cm.

|  |  |  |
| --- | --- | --- |
| **Sr. No** | **Random Numbers** | **Rainfall in cm for next 10 days** |
| 1 | 67 | 1 |
| 2 | 63 | 1 |
| 3 | 39 | 0 |
| 4 | 55 | 1 |
| 5 | 29 | 0 |
| 6 | 78 | 2 |
| 7 | 70 | 1 |
| 8 | 06 | 0 |
| 9 | 78 | 2 |
| 10 | 76 | 2 |
| Total | | 10cm |

The average rainfall in cm for next 10 days = 10/10 = 1cm.

**Q3) At a bus terminal every bus should leave with driver. At the terminus they keep 2 drivers as reserved if anyone on scheduled duty is sick and could not come. Following is the probability that the driver becomes sick.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Number of Sick Drivers** | **0** | **1** | **2** | **3** | **4** | **5** |
| **Probability** | **0.3** | **0.2** | **0.15** | **0.1** | **0.13** | **0.12** |

**Simulate for 10 days and find utilization of reserved drivers. Also find how many days and how many buses cannot run because of non-availability of drivers. Use the following random numbers: 30, 54, 34, 72, 20, 02, 76,74,48,22.**

**Solution:** We have given probability for the production per day. Now, we will find cumulative probability and random number intervals. Since the probabilities are given in two decimal digits, so the random numbers involving two digits i.e 00 to 99. The cumulative probabilities and random number intervals are as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Number of sick drivers** | **Probability** | **Cumulative Probability** | **Random Number Intervals** |
| 0 | 0.30 | 0.30 | 00-29 |
| 1 | 0.20 | 0.50 | 30-49 |
| 2 | 0.15 | 0.65 | 50-64 |
| 3 | 0.10 | 0.75 | 65-74 |
| 4 | 0.13 | 0.88 | 75-87 |
| 5 | 0.12 | 1.00 | 88-99 |

Now, will simulate for next 10 days for number of sick drivers and will also find utilization of reserved drivers and buses didn’t run due to non-availability of drivers..

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr. No** | **Random Numbers** | **Number of sick drivers for next 10 days** | **Utilization of reserved drivers (2)** | **Buses didn’t run due to non availability of drivers** |
| 1 | 30 | 1 | 1 | - |
| 2 | 54 | 2 | 2 | - |
| 3 | 34 | 1 | 1 | - |
| 4 | 72 | 3 | 2 | 1 |
| 5 | 20 | 0 | 0 | - |
| 6 | 02 | 0 | 0 | - |
| 7 | 76 | 4 | 2 | 2 |
| 8 | 74 | 3 | 2 | 1 |
| 9 | 48 | 1 | 1 | - |
| 10 | 22 | 0 | 0 | - |

**Conclusion:** The column number three and four shows the number of sick drivers and the utilization of reserved drivers for next 10 days. Also column number five shows that on 4th and 8th day o***ne –on*e** bus will not run and on 7th day ***two buses*** will not run due to non-availability of drivers.

Q4. A confectioner sells confectionary items. Past data of demand per week in hundred kilograms with frequency is given below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand per week (in hundred Kg)** | **0** | **5** | **10** | **15** | **20** | **25** |
| Frequency | 2 | 11 | 8 | 21 | 5 | 3 |

Generate the demand for next 10 weeks using random numbers given below. Also find average demand per week. Random Numbers from table of random numbers 78, 99, 43, 62, 44, 02, 67, 32, 54, 75.

**Solution:** We have given frequency of demand per week. Now, we will find the probability of demand per week.

Total Frequency = 2+11+8+21+5+3 = 50

Probability = No. of outcomes/sample space

Probability that the demand per week is 0 kg = 2/50=0.04

Probability that the demand per week is 5 kg = 11/50= 0.22

Probability that the demand per week is 10 kg = 8/50=0.16

Probability that the demand per week is 15 kg = 21/50=0.42

Probability that the demand per week is 20 kg = 5/50=0.10

Probability that the demand per week is 25 kg = 3/50=0.06

Now, we will find cumulative probability and random number intervals. Since the probabilities are given in two decimal digits, so the random numbers involving two digits i.e 00 to 99. The cumulative probabilities and random number intervals are as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Demand per week in hundred Kgs** | **Frequency** | **Probability** | **Cumulative Probability** | **Random Number Intervals** |
| 0 | 2 | 0.04 | 0.04 | 00-03 |
| 5 | 11 | 0.22 | 0.26 | 04-25 |
| 10 | 8 | 0.16 | 0.42 | 26-41 |
| 15 | 21 | 0.42 | 0.84 | 42-83 |
| 20 | 5 | 0.10 | 0.94 | 84-93 |
| 25 | 3 | 0.06 | 1.00 | 94-99 |

Now, we will simulate the demand for next 10 weeks.

|  |  |  |
| --- | --- | --- |
| **Sr. No** | **Random Numbers** | **Demand for next 10 weeks** |
| 1 | 78 | 15 |
| 2 | 99 | 25 |
| 3 | 43 | 15 |
| 4 | 62 | 15 |
| 5 | 44 | 15 |
| 6 | 02 | 0 |
| 7 | 67 | 15 |
| 8 | 32 | 10 |
| 9 | 54 | 15 |
| 10 | 75 | 15 |
| Total | | 140 |

The average demand for the next 10 weeks = 140/10 = 14kg. The data is in 100kgs. Hence, the demand will be 14\*100 = 1400kgs.

**Q5) In a cricket season for a one day match a bowler bowled 50 balls. The frequency distribution of runs scored per ball is given below:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Runs/Ball** | **0** | **1** | **2** | **3** | **4** | **5** | **6** |
| Number of balls | 15 | 10 | 10 | 4 | 8 | 1 | 2 |

**Simulate the system for 2 overs and find the average runs per 2 overs by him. Use the following random numbers: 88,03,05,29,28,48,65,19,55,17,37,82.**

**Solution:** We have given frequency of runs per ball. Now, we will find the probability of runs on given number of balls.

Total Frequency = 15+10+10++5+8+1+2= 50

Probability = No. of outcomes/sample space

Probability that there will be 0 run = 15/50=0.3

Probability that there will be 1 run = 10/50=0.2

Probability that there will be 2 runs = 10/50=0.2

Probability that there will be 3 runs = 4/50=0.08

Probability that there will be 4 runs = 8/50=0.16

Probability that there will be 5 runs = 1/50=0.02

Probability that there will be 6 runs = 2/50=0.04

Now, we will find cumulative probability and random number intervals. Since the probabilities are given in two decimal digits, so the random numbers involving two digits i.e 00 to 99. The cumulative probabilities and random number intervals are as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Number of runs per ball** | **Frequency** | **Probability** | **Cumulative Probability** | **Random Number Intervals** |
| 0 | 15 | 0.30 | 0.30 | 00-29 |
| 1 | 10 | 0.20 | 0.50 | 30-49 |
| 2 | 10 | 0.20 | 0.70 | 50-69 |
| 3 | 4 | 0.08 | 0.78 | 70-77 |
| 4 | 8 | 0.16 | 0.94 | 78-93 |
| 5 | 1 | 0.02 | 0.96 | 94-95 |
| 6 | 2 | 0.04 | 1.00 | 96-99 |

Now, we will simulate the runs of 2 over.

|  |  |  |
| --- | --- | --- |
| **Sr. No** | **Random Numbers** | **Runs in coming 2 Over (12 balls)** |
| 1 | 88 | 4 |
| 2 | 03 | 0 |
| 3 | 05 | 0 |
| 4 | 29 | 0 |
| 5 | 28 | 0 |
| 6 | 48 | 1 |
| 7 | 65 | 2 |
| 8 | 19 | 0 |
| 9 | 55 | 2 |
| 10 | 17 | 0 |
| 11 | 37 | 1 |
| 12 | 82 | 4 |
| Total | | 14 |

The average runs per 2 over = 14 runs, average runs per over = 14/2 = 7 runs, average runs per ball = 14/12 = 1.16 runs.

Q6. Following the daily demand of a coca cola bottle as per the past experience

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Daily Demand | 0 | 10 | 20 | 30 | 40 | 50 |
| Probability | 0.02 | 0.19 | 0.16 | 0.45 | 0.13 | 0.05 |

Estimate average balance stock, if the manager decides to keep 30 coca cola bottles per day. Use the following random numbers 47, 88, 15, 91, 57, 67, 11, 54, 60 and 89.

**Solution:** We have given probability for the daily demand of coca cola bottles. Now, we will find cumulative probability and random number intervals. Since the probabilities are given in two decimal digits, so the random numbers involving two digits i.e 00 to 99. The cumulative probabilities and random number intervals are as follow:

|  |  |  |  |
| --- | --- | --- | --- |
| **Daily demand of coca cola bottles** | **Probability** | **Cumulative Probability** | **Random Number Intervals** |
| 0 | 0.02 | 0.02 | 00-01 |
| 10 | 0.19 | 0.21 | 02-20 |
| 20 | 0.16 | 0.37 | 21-36 |
| 30 | 0.45 | 0.82 | 37-81 |
| 40 | 0.13 | 0.95 | 82-94 |
| 50 | 0.05 | 1.00 | 95-99 |

Now, will simulate for next 10 days for the demand of coca cola bottles and will also find the balance stock.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr. No** | **Random Numbers** | **Demand of coca cola bottles for next 10 days** | **Balance stock per day if he orders 30 bottles daily** |
| 1 | 47 | 30 | - |
| 2 | 88 | 40 | - |
| 3 | 15 | 10 | 20 |
| 4 | 91 | 40 | 10 |
| 5 | 57 | 30 | 10 |
| 6 | 67 | 30 | 10 |
| 7 | 11 | 10 | 30 |
| 8 | 54 | 30 | 30 |
| 9 | 60 | 30 | 30 |
| 10 | 89 | 40 | 20 |
| Total | | | 160 |

**Conclusion:** The average balance stock of coca cola bottles for next 10 days = 160/10 = 16 bottles.