POSTAL Book Package 2021

Mechanical Engineering

Objective Practice Sets

Industrial Engineering

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5 CHAPTER

Queuing Theory

Q.1 In complete random arrival in a queue system
(a) number of arrivals in unit time has Poisson distribution and intervals between successive arrivals are distributed negative exponentially.
(b) number of arrivals in unit time has Poisson distribution and intervals between successive arrivals are distributed positive exponentially
(c) number of arrivals in unit time has Poisson distribution and the intervals between successive arrival follow beta distribution.
(d) the number of arrival in unit time has a beta distribution and the intervals between successive arrivals has a Poisson distribution.

Q.2 In a single server, infinite capacity, "first come first serve" queue in which arrival and departure have Poisson distribution, the probability distribution of queue length is given by
(a) $P_n = \dfrac{1-\rho}{\rho^n}$ (b) $P_n = \dfrac{\rho^n}{1-\rho}$
(c) $P_n = \rho^n$ (d) $P_n = \rho^n (1-\rho)$
where, $\rho = \lambda/\mu$ and symbols have usual notation.
λ = mean arrival rate; μ = mean service rate

Q.3 In a single server queue customers are served a at rate of μ. If W and W_q represent the mean waiting time in the system and mean waiting time in the queue respectively, then W will be equal to
(a) $W_q - \mu$ (b) $W_q + \mu$
(c) $W_q + 1/\mu$ (d) $W_q - 1/\mu$

Q.4 For A M/M/1:∞/FCFS queue, the mean arrival rate is equal to 10 per hour and the mean service rate is 15 per hour: The expected queue length is
(a) 1.33 (b) 1.53
(c) 2.75 (d) 3.20

Q.5 Which one of the following statements is NOT correct?
(a) Assignment model is a special case of a linear programming problem.
(b) In queuing models, Poisson arrivals and exponential services are assumed.
(c) In transportation problems, the non-square matrix is made square by adding a dummy row or a dummy column
(d) In linear programming problems, dual of a dual is a primal

Q.6 Match **List-I** with **List-II** and choose the correct answer using the codes given below the lists:

List-I	List-II
A. L_s	1. $\dfrac{\rho}{1-\rho}$
B. L_q	2. $\dfrac{\lambda}{\mu(\mu-\lambda)}$
C. W_s	3. $\dfrac{\rho^2}{1-\rho}$
D. W_q	4. $\dfrac{1}{\mu-\lambda}$

Codes:

	A	B	C	D
(a)	4	1	3	2
(b)	1	4	2	3
(c)	2	4	1	3
(d)	1	3	4	2

Symbols have usual notation

Q.7 Consider the following statement.
1. Under the Poisson assumption two arrivals can occur during a very small interval of time.
2. The arrival in the Poisson distribution equals the mean of the exponential inter arrival time
3. In a single server queuing model, steady state can be reached after sufficiently long period only if the arrival rate is less than the service rate, unless the capacity of the queue size is limited

(a) only 2 is correct (b) only 3 are correct
(c) 1 and 3 are correct (d) 1 and 2 are correct

Q.20 No. of hours for which the cashier remains busy in an 8-hour day
(a) 7 hours (b) 6.8 hours
(c) 7.2 hours (d) 6.6 hours

Q.21 Average length of non-empty queue is
(a) 9 (b) 10
(c) 11 (d) 12

Q.22 Average cost due to waiting on a part of cashier if the cashier is valued at ₹ 50/- per hour.
(a) ₹ 30/day (b) ₹ 40/day
(c) ₹ 50/day (d) ₹ 60/day

Q.23 **Assertion (A):** In waiting line model, it is assumed that arrival rate is described by a Poisson probability distribution.
Reason (R): The arrival rate is a probabilistic variable and queue discipline is first come first served.
(a) Both A and R are true and R is a correct explanation of A.
(b) Both A and R are true but R is not a correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

Q.24 A TV repair man finds that the time spend on his job has an exponential distribution with mean 30 minutes. If he repairs sets in the order in which they come in and if the arrival of sets is approximately Poisson with average rate of 10 per 8-hour day. The repair man's expected idle time each day (in hours) is ________.

Q.25 At a self service store, a cashier can serve 10 customers in 5 minutes. On an average 15 customers arrive every 10 minutes. If the arrivals are as per Poisson distribution, the probability that the cashier would be idle is________.

Q.26 Patients arrive at a doctor's clinic according to the Poisson distribution. Check up time by the doctor follows exponential distribution. If on an average 9 patients/hour arrive at the clinic and the doctor takes on an average 5 minutes to check a patient, the number of patients in the queue will be ________.

Q.27 On an average, there are 30 customers in a queue. If the arrival rate of customers into the system is 16 customers per hour and on average 32 customers leave the system per hour, then the average number of customers in the system is ________.

Q.28 A repair shop is manned by a single worker. Customers arrive at the rate of 30 per hour. Time required to provide service is exponentially distributed with mean of 100 seconds. The mean waiting time (in min.) of a customer, needing repair facility in the queue is ________.

Q.29 American Vending Inc (AVI) supplies vended food to a large university. Because students of kick the machines out of anger and frustration, management has a constant repair problem. The machine breakdown on an average of three per hour and the breakdowns are distributed in a Poisson's manner. Downtime costs the company ₹25 per hour per machine, and each maintenance worker gets ₹4 per hour. One worker can service machine at an average rate of five per hour, distributed exponentially, two workers working together can service 7 per hour, distributed exponentially. The total cost per hour (in ₹) for two workers is_______.

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Answers Queuing Theory

1. (a)	2. (d)	3. (c)	4. (a)	5. (c)	6. (d)	7. (a)	8. (b)	9. (b)
10. (b)	11. (b)	12. (d)	13. (b)	14. (c)	15. (c)	16. (a)	17. (a)	18. (c)
19. (b)	20. (c)	21. (b)	22. (b)	23. (a)	24. (3)	25. (0.25)	26. (2.25)	
27. (30.5)	28. (8.33)	29. (26.75)						

Explanations Queuing Theory

1. (a)

In complete random arrival in a queue system, number of arrivals in unit time has poisson distribution and the intervals between successive arrivals are distributed negative exponentially.

2. (d)

Probability of having exactly '*n*' customer in the system,

$$P_n = \rho^n \cdot P_o$$

where $P_o = 1 - \rho$

= Probability that a customer does not have to wait in the queue

∴ Probability distribution fo queue length,

$$P_n = \rho^n (1 - \rho)$$

3. (c)

W = Mean waiting time in the system

W_q = Mean waiting time in the queue

$$W = \frac{L_s}{\lambda} \quad \text{and} \quad W_q = \frac{L_q}{\lambda} = \frac{L_s - \rho}{\lambda}$$

$$\therefore \quad W_q = \frac{L_s}{\lambda} - \frac{(\lambda/\mu)}{\lambda} = W - \frac{1}{\mu}$$

$$\Rightarrow \quad W = W_q + \frac{1}{\mu}$$

4. (a)

$$\rho = \frac{\lambda}{\mu} = \frac{10}{15}$$

$$L_s = \frac{\rho}{1-\rho} = 2$$

$$L_q = L_s - \frac{\lambda}{\mu} = 1.33$$

5. (c)

In transportation problems, dummy row or dummy column is added to make balanced problem, not for the purpose of changing a non-square matrix into a square one.

6. (d)

$$L_s = \frac{\rho}{1-\rho}$$

$$L_1 = L_s - \rho = \frac{\rho^2}{1-\rho}$$

$$W_s = \frac{L_s}{\lambda} = \frac{1}{\lambda}\frac{\lambda}{(\mu-\lambda)} = \frac{1}{(\mu-\lambda)}$$

$$W_q = \frac{L_q}{\lambda} = \frac{1}{\lambda}\frac{\lambda^2}{\mu(\mu-\lambda)} = \frac{\lambda}{\mu(\mu-\lambda)}$$

7. (a)

- Under Poission assumptions the customer arrive for service at a single service facility at random according to poission distribution.
- The results of steady state condition in the simulation would be closed enough to the queuing theory is the two of them use the same assumption (such as the same arrival distribution, the same service time distribution and queuing discipline etc.)

8. (b)

$$L_q' = \frac{1}{1-\rho}$$

$$\rho = \frac{\lambda}{\mu} = \frac{8}{10} = 0.8$$

Length of non-empty queue,

$$L_q' = \frac{1}{1-0.8} = \frac{1}{0.2} = 5$$

9. (b)

- Brand and Bound technique – Integer approach programming
- Expected value – Decision theory
- Smoothing and levelling – PERT and CPM
- Exponential distribution – Queuing theory

10. (b)

- Linear programming – Product mix decision
- Transportation model – Warehouse location
- Assignment model – Machine allocation
- Queuing theory – Number of servers decision

11. (b)

$$\lambda = \frac{1}{10} \text{ per min}$$

$$\mu = \frac{1}{3} \text{ per min}$$

Probability that a person has to wait

$$= 1 - P_0 = \rho = 0.3$$

20. (c)

No of hours for which cashier remains busy in an 8 – hour day

$$= 8\left(\frac{\lambda}{\mu}\right) = 8\left(\frac{1.8}{2}\right) = 7.2 \text{ hours}$$

21. (b)

Average length of non-empty queue

$$= \frac{\mu}{(\mu-\lambda)} = \frac{2}{(2-1.8)} = 10$$

22. (b)

Average cost due to waiting on a part of cashier

$$= 8\left(1-\frac{\lambda}{\mu}\right) \times 50 = ₹\ 40$$

23. (a)

In waiting line model, the arrival rate is a probabilistic variable and queue discipline is first come first served, then the arrival rate is described by a Poisson probability distribution.

24. (3)

$$\lambda = 10 \text{ per day}$$

$$\mu = \frac{8\times 60}{30} = 16 \text{ per day}$$

$$\rho = \frac{\lambda}{\mu} = \frac{10}{16}$$

$$\text{Work time} = \frac{10}{16}\times 8 = 5 \text{ hours}$$

$$\therefore \quad \text{idle time} = 8-5 = 3 \text{ hours}$$

25. (0.25)

$$\mu = \frac{10}{5} = 2 \text{ per minutes}$$

$$\lambda = \frac{15}{10} = 1.5 \text{ per minutes}$$

$$\rho = \frac{\lambda}{\mu} = \frac{1.5}{2} = 0.75$$

$$\text{idle probability} = 1-\rho = 1-0.75 = 0.25$$

26. (2.25)

$$\lambda = 9\ /\text{hour}$$

$$\mu = 12\ /\text{hour}$$

$$\rho = \frac{\lambda}{\mu} = \frac{9}{12} = 0.75$$

$$L_q = \frac{\delta^2}{1-\delta} = \frac{0.75^2}{1-0.75} = 2.25$$

27. (30.5)

$$\lambda = 16$$

$$\mu = 32$$

$$L_q = 30$$

$$L_s = L_q + \frac{\lambda}{\mu} = 30 + \frac{16}{32}$$

$$= 30.5$$

28. (8.33)

$$\lambda = 30 \text{ per hour},$$

$$\mu = \frac{60\times 60}{100} = 36 \text{ per hour}$$

$$W_q = \frac{\lambda}{\mu(\mu-\lambda)} = \frac{30}{36(36-30)}$$

$$= \frac{5}{36} \text{ hour} = \frac{5}{36}\times 60$$

$$= 8.33 \text{ min.}$$

29. (26.75)

$$L_s = \frac{\lambda}{\mu-\lambda} = \frac{3}{7-3}$$

$$= 0.75 \text{ machines}$$

Downtime cost = 0.75 × 25 = ₹18.75 per hour

Labor cost = 2 × 4.0 = ₹8 per hour

Total cost/hour = 18.75 + 8 = 26.75 = ₹26.75

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