14. a) At a central warehouse, vehicles arrive at the rate of 18 per hour and the arrival rate follows Poisson distribution. The unloading time of the vehicles follows exponential distribution and unloading rate is 6 vehicles per hour. There are 4 unloading crew persons. Determine P_0, p_3, Lq, Ls, Wq, and Ws. **(2+2+2+2+2+3)**

(OR)

b) The arrival rate of customers at the single window booking counter of a two wheeler agency follows Poisson distribution and the service time follows exponential (negative) distribution and hence, the service rate also follows Poisson distribution. The arrival rate and the service rate are 25 customers per hour, and 35 customers per hour, respectively. Find the following :

i) Utilization of the booking clerk

ii) Average number of waiting customers in the queue.

iii) Average number of waiting customers in the system.

iv) Average waiting time per customers in the queue

v) Average waiting time per customers in the system. **(3+2.5+2.5+2.5+2.5)**

15. a) Solve the game optimally using linear programming using the payoff matrix of the Player A is shown in Table Q. 15 a.

		Player B		
		1	2	3
Player A	1	6	8	2
	2	8	2	10
	3	4	10	12

(OR)

b) Solve the following LP problem using dynamic programming technique :

Maximize $Z = 10\,X_1 + 30\,X_2$

Subject to $3X_1 + 6X_2 \leq 168$

$0X_1 + 12X_2 \leq 240$

X_1, and $X_2 \geq 0$

27/04/18 FN

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 41371

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2018
Fourth/Fifth/Sixth/Seventh Semester
Mechanical Engineering
ME 6015 – OPERATIONS RESEARCH

(Common to Mechanical Engineering (Sandwich)/Automobile Engineering/ Manufacturing Engineering/Mechanical and Automation Engineering/ Mechatronics Engineering/Production Engineering/ Robotics and Automation Engineering)
(Regulations 2013)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions.

PART – A **(10×2=20 Marks)**

1. Define an unbounded solution in LP.
2. List the assumptions in linear programming models.
3. Differentiate between PERT and CPM with respect to suitability.
4. Name the algorithm used to find the shortest path in a network model.
5. List the various costs of an inventory system.
6. Write the EOQ formula for purchase model with instantaneous replenishment and without shortages.
7. Define the term jockeying used in queuing theory with an example.
8. Differentiate between the term reneging and balking in queuing theory.
9. What is meant by recursive function in dynamic programming ?
10. Write the criteria for decision making under uncertainty.

PART – B (5×13=65 Marks)

11. a) Solve the following LP problem using two phase simplex method :

Maximize $Z = 20\,X_1 + 10\,X_2 + 15\,X_3$

Subject to $8X_1 + 6X_2 + 2X_3 \leq 60$

$5X_1 + 1X_2 + 6X_3 \geq 40$

$2X_1 + 6X_2 + 3X_3 \leq 30$

X_1, X_2 and $X_3 \geq 0$

(OR)

b) Solve the following LP problem using the results of its dual problem :

Maximize $Z = 40\,X_1 + 30\,X_2 + 25\,X_3$

Subject to $4X_1 + 2X_2 + 5X_3 \geq 30$

$3X_1 + 6X_2 + 1X_3 \geq 20$

$1X_1 + 3X_2 + 6X_3 \geq 36$

X_1, X_2 and $X_3 \geq 0$

12. a) Determine the maximal flow from node 1 to 6 for the pipe network shown in Figure -Q 12 a with flow capacities between various pair of locations in both ways.

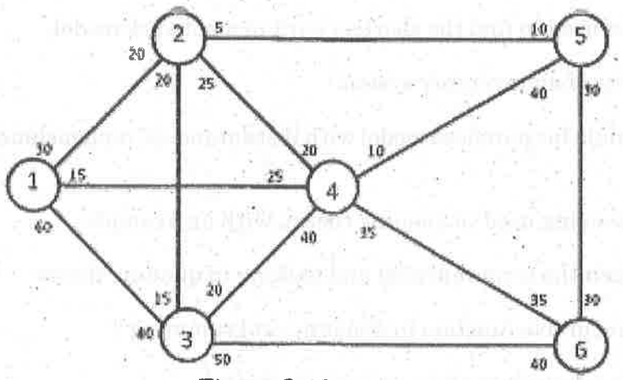

Figure Q 12a

(OR)

b) Construct the project network for project summarized in Table Q12b. Calculate the expected duration and variance of each activity and determine the critical path and expected project completion time. (5+4+4)

Table – Q 12b

Activity	Predecessor (s)	Duration (week)		
		a	m	b
A	–	6	7	8
B	–	1	2	9
C	–	1	4	7
D	A	1	2	3
E	A,B	1	2	9
F	C	1	5	9
G	C	2	2	8
H	E,F	4	4	4
I	E, F	4	4	10
J	D, H	2	5	14
K	I, G	2	2	8

13. a) An industry produces a particular product with a demand rate r = 14,000 units /year, production rate k = 35,000 units/year, set up cost C_o = Rs. 500 per set-up and carrying cost C_c = Rs. 15/unit/year. Find the EBQ and cycle time.

(OR)

b) A company currently purchases one of its items for Rs. 2/unit without quantity discount. The ordering cost is Rs. 20/order and the carrying cost is 20% of its purchase price/unit/year. The annual demand is 2500 units. A new vendor offers quantity discount for the same item as per the following quantity discount scheme in Table – Q 13b. Find the best order quantity.

Table Q. 13b :

Quantity	Price (Rs)/Unit
$0 \leq Q_1 \leq 1500$	p
$1500 \leq Q_2 \leq 2500$	97 % of p
$2500 \leq Q_3$	95% of p

PART – C (1×15=15 Marks)

16. a) A transportation problem involving three sources and four destinations is shown in Table- Q. 16 a. The cell entries represent the cost of transportation per unit. Determine the initial basic feasible solution using the following methods :

i) Northwest corner method. (4)

ii) By lest cost cell method. (5)

iii) Vogel's Approximation Method (VAM)/ penalty method. (6)

Table – Q. 16 a

Source \ Destination	1	2	3	4	Supply
1	3	1	7	4	300
2	2	6	5	9	400
3	8	3	3	2	500
Demand	250	350	400	200	1200

(OR)

b) Determine the minimum spanning tree of the distance network as shown in Figure – Q 16b using PRIM algorithm.

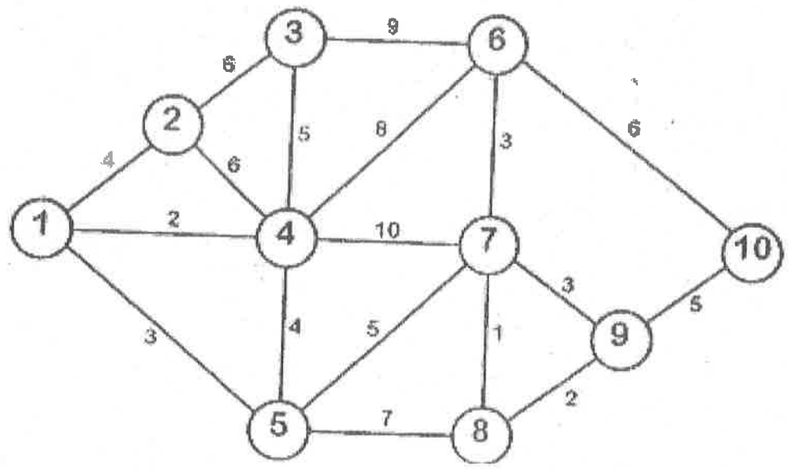

Figure – Q 16b

08/04/19

Reg. No. :

Question Paper Code : 53292

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2019.

Fourth/Fifth/Sixth/Seventh/Eighth Semester

Mechanical Engineering

ME 6015 – OPERATIONS RESEARCH

(Common to Mechanical Engineering (Sandwich), Automobile Engineering, Manufacturing Engineering, Mechanical and Automation Engineering, Mechatronics Engineering, Production Engineering, Robotics and Automation Engineering)

(Regulation 2013)

(Also common to PTME 6015 — Operations Research for B.E. (Part-Time) Seventh Semester – Mechanical Engineering)

(Regulation 2014)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is sensitivity analysis? Why it is needed?
2. Define a dual problem?
3. What is the difference between transportation and assignment problem?
4. Define the following terms associated with network models?
   (a) Spanning tree
   (b) Critical path
5. Differentiate all unit and marginal unit quantity discounts in inventory?
6. What are the selective inventory control models used in practice?
7. What are the applications of simulation?
8. Write few types of queue discipline?
9. Write the applications of game theory?
10. Differentiate individual and group replacement policy?

Stock in hand at the beginning of simulation exercise was 20 units. You are required to carry out simulation run over a period of 10 days with the objective of evaluating the following inventory rule :

Order 15 units when present inventory plus any outstanding order falls below 15 units. The sequence of random nos used is 0, 9, 1, 1, 5, 1, 8, 6, 3, 5, 7, 1, 2, 9 using the first one for day one. Your calculation should include the total cost of operating this inventory rule for 10 days.

15. (a) A manufacturer is offered two machines A and B. A has cost price of Rs. 2,500. Its running cost is Rs. 400 for each of the first 5 years and increases by Rs. 100 every subsequent year. Machine 'B' having the same capacity as 'A' costs Rs. 1250 and has a running cost of Rs. 600 for 6 years, increasing by Rs. 100 per year thereafter. If money is worth 10% per year, which machine should be purchased? Scrap value of both the machines are assumed to be negligible. (13)

Or

(b) Solve the game given in Table 15 (b) by graphical method. (13)

	Y_1	Y_2	Y_3	Y_4
X_1	19	6	7	5
X_2	7	3	14	6
X_3	12	8	18	4
X_4	8	7	13	–1

Table 15 (b)

PART C — (1 × 15 = 15 marks)

16. (a) A maintenance engineer estimates the number of the service technicians needed over the next five weeks to be 5, 7, 8, 4, 6 respectively. Excess number of service technician will cost Rs. 300/technician/week. Hiring the service technician in any week will incur a fixed cost of Rs. 400/- and an additional Rs. 200 per technician per week. Find the optimal service technician to be maintained. (15)

Or

(b) A company manufacturing air-coolers has two plants located at Mumbai and Kolkata with a capacity of 200 units and 100 units per week respectively. The company supplies the air-coolers to its four show rooms situated at Ranchi, Delhi, Lucknow and Kanpur which have a maximum demand of 75, 100, 100 and 30 units respectively. Due to the difference in raw material cost and transportation cost, the profit per unit in rupees differs which is shown in the table below.

Table

	Ranchi	Delhi	Lucknow	Kanpur
Mumbai	90	90	100	110
Kolkatta	50	70	130	85

Plan the production programme so as to maximize the profit. The company may have its production capacity at both plants partly or wholly unused.

PART B — (5 × 13 = 65 marks)

11. (a) Solve the following Linear Programming problem : (13)

Maximize $Z = 4x_1 + 3x_2 + 6x_3$

Subject to

$2x_1 + 3x_2 + 2x_3 \leq 440$

$4x_1 + 3x_3 \leq 470$

$2x_1 + 5x_2 \leq 430$

$x_1, x_2, x_3 \geq 0.$

Or

(b) Write the dual of the following Linear Programming problem and solve by simplex method (13)

Maximize $Z = 5x_1 + 12x_2 + 4x_3$

Subject to

$x_1 + 2x_2 + x_3 \leq 10$

$2x_1 - x_2 + x_3 = 8$

$x_1, x_2, x_3 \geq 0.$

12. (a) Five jobs are to be assigned to five workers in a job shop. The number of hours each worker would take to accomplish the jobs are shown in table 12(a). Determine the optimal assignment to minimize the time. (13)

Workers	Job				
	1	2	3	4	5
1	16	13	17	19	20
2	14	12	13	16	17
3	14	11	12	17	18
4	5	5	8	8	11
5	5	3	8	8	10

Table 12(a)

Or

(b) Activities of a maintenance project are shown in Table 12(b). Draw the network, find the critical path and compute the floats? (13)

Activity :	1-2	1-3	2-3	2-5	3-4	3-6	4-5	4-6	5-6	6-7
Duration :	15	15	3	5	8	12	1	14	3	14

Table 12(b)

13. (a) Annual demand for an item is 9000 units. Ordering cost is 100/order. Inventory carrying cost is Rs. 2.40 / unit / year. Unit price is Rs. 1/unit. Shortage cost is Rs. 5 / unit / year. Find optimum order quantity, optimum shortages, maximum inventory and total cost. Would you recommend back ordering considering the total cost when back ordering is not allowed? (13)

Or

(b) Annual demand for an item is Rs. 12,000/per year. Ordering cost is Rs. 20/order. Holding cost is 16% of the price / unit / year. Price breaks are given below. (13)

(i) Find EOQ,

(ii) Find EOQ if ordering cost is changed to Rs. 30/order.

Order size	Cost/unit (Rs.)
<2000	3
2000 – 3999	2.9
4000 or more	2.85

14. (a) Workers come to tool store room to receive tools for accomplishing a particular operation. The average time between two arrivals is 60 seconds and the arrivals are assumed to be in Poisson distribution. The average service time is 40 seconds. Determine

(i) The average queue length

(ii) Average length of non empty queue

(iii) Mean waiting time of an arrival

(iv) Assume the charge of a skilled worker is Rs. 4/hour and that of tool store room attendant is Rs. 0.75/hour. Determine whether to go in for an additional tool store room attendant which will minimize the combined cost of attendant's idle time and the cost of worker's waiting time. (13)

Or

(b) A company trading in motor vehicle spares wishes to determine the level of stock it should carry for the items in its range. Demand is not certain and there is a lead time for stock replenishment. For one item X, the following information is obtained. (13)

Demand (units/day) :	3	4	5	6	7
Probability :	0.1	0.2	0.3	0.3	0.1

Carrying cost per unit per day = 20 paise

Ordering cost per order = Rs. 5

Ideal time for replenishment = 3 days

15. (a) A manufacturer is offered two machines A and B. A has cost price of Rs. 2500. Its running cost is Rs. 400 for each of the first 5 years and increases by Rs. 100 every subsequent year. Machine 'B' having the same capacity as 'A' costs Rs. 1,250 and has a running cost of Rs. 600 for 6 years, increasing by Rs. 100 per year thereafter If money is worth 10% per year, which machine should be purchased? Scrap value of both the machines are assumed to be negligible. (13)

Or

(b) Solve the game given in table 15(b) by graphical method.

Table 15 (b)

	Y_1	Y_2	Y_3	Y_4
X_1	19	6	7	5
X_2	7	3	14	6
X_3	12	8	18	4
X_4	8	7	13	–1

PART C — (1 × 15 = 15 marks)

16. Alfa associates produce mini computers. The company maintains a constant workforce of 40 employees and there are no Subcontractors available. The company can however go on overtime if necessary and encourage customers to back-order computers. The demand pattern, available production capacities during regular time and overtime, as well as other data are as follows: Formulate this production Planning problem as a transportation model and determine the initial solution using any method. Number of quarter = 4; 60 days/quarter and 8 hours/day. Demand for quarters 1-4 (units) = 2000, 1500, 1700, 2000; Beginning inventory = 400; Desired final inventory = 150 units; The overtime for each employee is limited to 4 hours a day. Standard labor hours per unit = 15 hours; Inventory carrying cost = 10/period/unit; Backorder cost = Rs. 5/unit/period; Regular Time cost = Rs. 10 / hour; Over Time cost = Rs. 15/ hour; Material and overhead (Regular time) = Rs. 100 / unit; Material and overhead (Over time) = Rs. 60 / unit; Cost of unused capacity during regular time = Rs. 60 / unit. (15)

23/11/18 FN

Reg. No. :

Question Paper Code : 20795

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2018.

Fourth/Fifth/Sixth/Seventh Semester

Mechanical Engineering

ME 6015 — OPERATIONS RESEARCH

(Common to Mechanical Engineering (Sandwich), Aeronautical Engineering, Manufacturing Engineering, Mechanical and Automation Engineering)

(Regulations 2013)

(Also Common to PTME 6015 – Operations Research for B.E. Part Time – Seventh Semester – Mechanical Engineering – Regulations 2014)

Time : Three hours Maximum : 100 marks

(Use of statistical table is permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Write the mathematical formulation of a generalized LP model.
2. What is a redundant constraint in LPP?
3. Differentiate transportation and transshipment problem.
4. Define the following terms associated with network models.
   (a) Critical path
   (b) Spanning tree
5. Differentiate all unit and marginal unit quantity discounts in inventory.
6. Write the cost components involved in an inventory problem.
7. What are the elements of a queuing system?
8. What are the applications of simulation?
9. Write the applications of game theory.
10. What are the characteristics of dynamic programming?

PART B — (5 × 13 = 65 marks)

11. (a) Solve the following Linear Programming problem (13)

Maximize $Z = 4x_1 + 3x_2 + 6x_3$

Subject to $2x_1 + 3x_2 + 2x_3 \leq 440$

$4x_1 + 3x_3 \leq 470$

$2x_1 + 5x_2 \leq 430$

$x_1, x_2, x_3 \geq 0$

Or

(b) Write the dual of the following Linear Programming problem and solve by simplex method. (13)

Maximize $Z = 5x_1 + 12x_2 + 4x_3$

Subject to $x_1 + 2x_2 + x_3 \leq 10$

$2x_1 - x_2 + x_3 = 8$

$x_1, x_2, x_3 \geq 0$

12. (a) A stell company is distributing imported ore from three ports to four steel mills. The supplies of ore arriving at ports, demand at the steel mills and distance between ports and steel mills are given in Table 12 (a). Transportation cost is Rs.05/ton/km. Solve the given transportation problem to minimize the total cost. (13)

Table 12 (a)

Ports	Steel mills				
	1	2	3	4	Supply
A	50	60	100	50	20000
B	80	40	70	50	38000
C	90	70	30	50	16000
Demand	10000	18000	22000	24000	

Or

(b) The routes and their lengths in Km between city 1 (node 1) and four other cities (node 2 to 5) are shown in figure 12(b). Use Dijkstra's algorithm to find the shortest route between city 1 and the remaining four cities. (13)

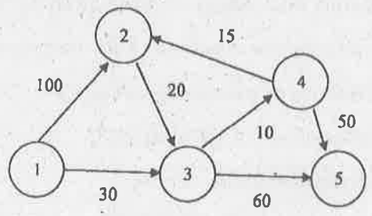

Figure 12 (b)

13. (a) Annual demand for an item is 10000 units. Ordering cost is 10 /order. Inventory carrying cost is Rs. 4 /unit/year. Unit price is Rs. 20 /unit. Shortage cost is Rs. 5 /unit/year. Find optimum order quantity, optimum shortages, maximum inventory and total cost. Would you recommend back ordering considering the total cost when back ordering is not allowed? (13)

Or

(b) Annual demand for an item is Rs. 12000/per year. Ordering cost is Rs. 20/lot. Holding cost is 16% of the price/unit/year. Price breaks are given in Table 15(a). (13)

(i) Find EOQ,

(ii) Find EOQ if ordering cost is changed to Rs. 30/lot.

Table 13 (b)

Order size	Cost/unit (Rs.)
<2000	3
2000-3999	2.9
4000 or more	2.85

14. (a) Workers come to tool store room to receive tools for accomplishing a particular operation. The average time between two arrivals is 60 seconds and the arrivals are assumed to be in Poisson distribution. The average service time is 40 seconds. Determine

(i) The average queue length

(ii) Average length of non empty queue

(iii) Mean waiting time of an arrival

(iv) Assume the charge of a skilled worker is Rs. 4/hour and that of tool store room attendant is Rs. 0.75/hour. Determine whether to go in for an additional tool store room attendant which will minimize the combined cost of attendant's idle time and the cost of worker's waiting time (13)

Or

(b) A company manufactures 30 items per day. The sale of these items depends upon demand which has the distribution shown in table 14(b). The production cost and sale price of each unit are Rs. 40 and Rs. 50 respectively. Any unsold product is to be disposed of at a loss of Rs. 15/ unit. There is a penalty of Rs. 5/unit if the demand is not met. Using the following random numbers determine the total profit/loss for the company for the next 10 days. 10, 99, 65, 99, 95, 01, 79, 11, 16, 20. (13)

Table 14(b)

Sale (units):	27	28	29	30	31	32
Probability:	0.10	0.15	0.20	0.35	0.15	0.05

25/11/19 | FN

15. a) Solve the following game graphically :

		B			
		Y1	Y2	Y3	Y4
A	X1	19	6	7	5
	X2	7	3	14	6
	X3	12	8	18	4
	X4	8	7	13	–1

(OR)

b) An equipment costs Rs. 500. Operation and maintenance costs are nil for the first year and increases by Rs. 100 per year thereafter. If money is worth 5% every year, determine the best age for replacement of the equipment. Assume resale value as negligible.

PART – C **(1×15=15 Marks)**

16. a) Solve the following transportation problem by Vogel's approximation method :

		Destination				Availability
		1	2	3	4	
Sources	I	21	16	25	13	11
	II	17	18	14	24	13
	III	32	27	18	41	19
	Demand	6	10	12	15	43

(OR)

b) A family is making a trip from place 1 to place 10. The family is having a choice of routes and haltages between the two places. Data on cost is as follows :

	1	2	3	4	5	6	7	8	9	10
1	-	7	5	4	-	-	-	-	-	-
2	-	-	-	-	8	3	9	-	-	-
3	-	-	-	-	10	7	6	-	-	-
4	-	-	-	-	4	5	6	-	-	-
5	-	-	-	-	-	-	-	6	8	-
6	-	-	-	-	-	-	-	7	4	-
7	-	-	-	-	-	-	-	3	6	-
8	-	-	-	-	-	-	-	-	-	5
9	-	-	-	-	-	-	-	-	-	4

Find the route of minimum cost.

Reg. No. :

Question Paper Code : 91827

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2019
Fourth/Fifth/Sixth/Seventh/Eighth Semester
Mechanical Engineering
ME 6015 – OPERATIONS RESEARCH
(Common to Mechanical Engineering (Sandwich)/Automobile Engineering/ Manufacturing Engineering/Mechanical and Automation Engineering/ Mechatronics Engineering/Production Engineering/Robotics and Automation Engineering)
(Regulations 2013)
(Also Common to PTME 6015 – Operations Research for B.E. (Part-Time) – Seventh Semester – Mechanical Engineering – Regulations – 2014)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions

PART – A **(10×2=20 Marks)**

1. What is sensitivity analysis of LP models ?
2. Distinguish between primal and dual LPs.
3. State the simplifying assumptions made in sequencing in relation to machines.
4. What is total float ?
5. What are deterministic inventory models ?
6. A component has a demand of 9,000 units/year. The cost of one procurement is Rs. 100/- and the holding cost per unit per year is Rs. 2.40. Find the economic order quantity.
7. What is service discipline ? Mention the most common service discipline.
8. List the methods to generate random numbers.
9. What is mixed strategy ?
10. What is dynamic programming ?

PART – B (5×13=65 Marks)

11. a) Solve the following LPP graphically.

Maximize $Z = 0.1\ x_1 + 0.5\ x_2$

Subject to $2x_1 + 5x_2 \leq 80$

$x_1 + x_2 \leq 20$

$x_1, x_2 \geq 0.$

(OR)

b) Solve the following LPP by simplex method.

$Z = x_1 - x_2 + 3x_3$

Subject to $2x_1 + x_2 + x_3 \leq 10$

$2x_1 - x_3 \leq 2$

$2x_1 - 2x_2 + 3x_3 \geq 0$

$x_1, x_2, x_3 \geq 0.$

12. a) Draw the network for the following project :

Activity	A	B	C	D	E	F	G	H	I	J	K	L
Immediate Predecessor	–	A	A	B	B	C	C	F	D	G, H	E	I
Duration (Weeks)	10	9	7	6	12	6	8	8	4	11	5	7

Find the critical path and the project duration.

(OR)

b) A machine operator has to do turning and threading on a number of different jobs. Time to perform these operation in minutes are as follows :

Job	1	2	3	4	5	6
Time for turning	3	12	5	2	9	11
Time for threading	8	10	9	6	3	1

Find the sequence of processing the jobs to minimize the total time. Also find the elapsed time and idle time for the two operations.

13. a) Find the optimal order quantity for a product for which the price breaks are as follows :

Quantity	$0 \leq q \leq 500$	$500 \leq q \leq 750$	$750 \leq q$
Unit cost in Rs.	10	9.25	8.75

The monthly demand for the product is 200 units, storage cost is 2% of the unit cost per year and ordering cost is Rs. 10 per order.

(OR)

b) Data on inventory of 3 items are as follows :

Item	Holding Cost in Rs./Year	Ordering Cost in Rs./Order	Unit cost in Rs.	Demand in units per year
1	20	50	6	10,000
2	20	40	7	12,000
3	20	60	5	7,500

Determine approximately the economic order quantities for a total average of the inventory of these items of Rs. 1,000.

14. a) Trucks arrive at the depot every 18 minutes for service, the service time is 34 min. Determine :

i) The probability that the depot is empty.

ii) Average queue length assuming that the capacity of the depot is limited to 3 trucks only.

(OR)

b) A company is manufacturing small boring machines. The average daily production is 15 machines. There is deviation in production due to variation in supply of raw materials by vendors. The probability distribution of the production per day is as follows :

Production per day	11	12	13	14	15	16	17	18	19
Probability	0.05	0.07	0.08	0.15	0.30	0.15	0.08	0.07	0.05

The daily production is transported by a truck which can house not more than 15 machines. The truck is operated only once a day.

Find :

i) Average number of machines waiting in the company due to lack of space on the truck.

ii) Average empty space on the truck due to reduced production by simulation for next 15 days.

Use the following random numbers :

76 59 17 86 78 42 56 19 58 25
61 44 24 38 12