Course Docket

2.6 PRODUCTIONAND OPERATIONS RESEARCH

Term – II Semester

Batch – 2019 - 2021

March 2020 – July 2020

Course Facilitator

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COURSE OUTLINE

Programme	Master of Business Administration
Batch	2019- 2021
Semester	II
Course Title	Production and operation research
Course Code	2.6
Credits	4
Sessions	1 Hour per session (60 Sessions)
Course Facilitator	Dr. Santhosh M Dr. Suresh N Prof. Priya Jain

PART A

INTRODUCTION

Resources are always critical in any organization. They are unavailable in unlimited manner. There are always constraints. Operation research is helpful in the situation of such constraint of resources. Managers have to manage limited available resources in such a way that neither production nor other activities get disturbed in the business. Facility design is a fascinating area for OR. The excitement of operation research lies in the application of Quantitative techniques to real world problems.

COURSE OUTCOMES

Post completion of the course student should able to:

C0-1 Understand the importance of production management and its various aspects.

CO2 Manage the facility and level of inventory in different situations.

CO3 Identify and formulate LP problems using various methods for maximization and minimization problems.

CO4 Apply mathematical techniques in different application areas of Operations Research like transportation, Replacement Models, Assignment models and network models.

CO4 Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained and translate solutions into directives for action.

C05 Apply mathematical techniques to Decision making in business applications.

CO6 Apply the mathematical tools that are needed to solve optimization problems.

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PROGRAM OUTCOMES

PO1: Apply knowledge of management theories and practices to solve business problems.

PO2: Foster Analytical and critical thinking abilities for data-based decision making

PO3: Ability to develop Value based Leadership

PO4: Ability to understand, analyze and communicate global, economic, societal, cultural, legal and ethical aspects of business

PO5: Ability to lead themselves and others in the achievement of organizational goals, contributing effectively to a team environment

PO6: Ability to identify business opportunities, frame innovative solutions and launch new business ventures or be an entrepreneur

PO7: Ability to deal with contemporary issues using multi-disciplinary approach with the help of advanced Management and IT tools and techniques

PO8: Ability to apply domain specific knowledge and skills to build competencies in their respective functional area

PO9: Ability to engage in research and development work with cognitive flexibility to create new knowledge and be a lifelong learner

PO10: Ability to understand social responsibility and contribute to the community for inclusive growth and sustainable development of society through ethical behavior

PO11: Ability to function effectively as individuals and in teams through effective communication and Negotiation skills

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11
CO1	3	1	2	3	1	2	3	1	1	-	1
CO2	1	3	1	1	1	2	3	2	3	1	-
CO3	1	3	1	1	1	2	3	2	3	1	-
CO4	1	3	1	1	-	2	3	3	2	-	-
CO5	3	1	1	1	3	-	-	2	2	2	2
CO6	3	-	2	1	3	-	-	2	2	2	2

LEVEL 3-Substantial 2-Moderate 1-Slight - No Co-relation

KEY CONCEPTS

MODULE 1: PRODCUTION AND OPERATIONS MANAGEMENT

1 Functions of production and material management and various types of production system

2. different methods of forecasting demand

3. Different types of facility layout and various facility location decisions.

4. Six sigma quality control and elimination of wastes.

MODULE 2: FACILITY MANAGEMENT

1 Concepts related to material management like purchase functions, procurement procedures, ethics in purchasing etc.

2 Inventory management and calculation of EOQ, Safety stocks, re-order point etc.

MODULE 3: INTRODUCTION AND LINEAR PROGRAMMING TECHNIQUES

1 Introduction to Operations research and its various models and applications areas of OR in management.

2 LPP Model formulation.

3 Simplex and Graphical Method of solving LPP Problems

MODULE 4: TRANSPORTATION MODEL

1. North West Corner method, Least Cost method and VAM Method for finding Initial basic feasible solution.
2. Unbalanced and Degeneracy in transportation
3. Test for optimality (MODI method only)
4. Maximization problems.

MODULE 5: ASSIGNMENT PROBLEMS

1. Importance and characteristics of assignment problem
2. Minimization and Maximization method of solving problem
3. Balanced and Unbalanced problems and Prohibited route problems
4. Travelling salesman and crew assignment problems.
5. Types of sequencing problems
6. Processing ‘n’ jobs through 2 machines and processing ‘n’ jobs through ‘m’ machines.

MODULE 6: NETWORK ANALYSIS

1. PERT and CPM techniques
2. Critical path and float analysis
3. Probabilities in PERT analysis
4. Assumptions of replacement theory and types of replacement problems
5. Replacement of items which deteriorates with time

MODULE WISE OUTCOMES

Post completion of the module student should be able to:

Module 1:

MO1: understand various functions of production and material management

MO2: interpret demand for products by applying various forecasting techniques

MO3: analyze the facility location and will able to classify various facility layouts.

Module 2:

MO4: understand the need and importance of material management

MO5: apply the tools and techniques of inventory management to manage its inventory more effectively and efficiently.

Module 3:

MO6: understand the need of using operations research- a quantitative approach for effective decision making.

MO7: understand the meaning of simples and logic of using simplex method.

MO8: interpret the optimal solution of LP Problems.

Module 4:

MO9: manage effective and cost efficient transportation of goods from the manufacturing sites to the end of customer

MO10: examine multiple optimal solutions and prohibited routes in the transportation problem.

MO11: construct the initial transportation table for a transshipment problem.

Module 5:

MO12: solve a travelling salesman problem

MO13: Will able to do proper sequencing of jobs to each machine.

Module 6:

MO14: understand the importance of using PERT and CPM techniques for project management.

MO15: determine the probability of completing a project by the schedule data.

MO16: realize the need to study replacement and maintenance analysis techniques.

TEACHING PEDAGOGY

- Power point presentations for theoretical concepts
- Numerical through board
- Solving numerical in excel sheet through TORA Software.
- Projects and assignments on various topics
- Use of case study method to understand the real time application of practical concepts

TEXT BOOKS AND REFERENCE MATERIALS

ESSENTIAL READINGS

1. K.K Chawla, Vijay Gupta and Bhushan K Sharma, "OPERATIONS RESEARCH Quantitative Analysis for Management",Kalyani Publishers.
2. N.D. Vohra (2012), "Quantitative techniques in management", Tata McGraw-Hill Publications, 4th Edition.
3. P.C Tulsian and Vishal Pandey (2012), quantitative techniques. Pearson Practice series.
4. J.K.Sharma,Quantitative methods and operation research, Excel publication, 2012

REFERENCES

- David M. Lenine (2012), quantitative techniques for management. Pearson publication.
- Fedric S Hiller and Gerald J Lieberman (2012), introduction to operation research. 8th edition.
- Er. Prem Kumar Guptha and Dr. D.S. Hira (2014), operation research. S.Chand publications.
- VeerabadrappaHarinal (2012),An introduction to operation research. New Age international publishing.
- Anand Sharma (2014), quantitative techniques for decision making. Himalaya Publishing House.
- S. Kalavathi (2013), operation Research. Vikas Publications. 4th edition.
- HamdyATaha (2013), operation research. Pearson publication. 9th edition.
- G.V Shenoy and V.K. Srivathsava (2013), operation research for managerial decision. New Age international publishing.
- PradeepprakashkarPai (2013), operation research principle and practices. Oxford Higher Education.
- P.Rama Murthy (2014), operation Research. New Age international publishing. 2nd Edition.
- C.K. Mustafi (2009), operation Research methods and practices. New Age international publishing.

CASES AND ARTICELS

- A case study application of linear programming and simulation to mine planning.
- Profit Optimization Using Linear Programming Model: A Case Study of Ethiopian Chemical Company
- The Optimization Problem of Product Mix and Linear Programming Applications: Case Study in the Apparel Industry
- A study of Transportation Problem for an Essential Item of Southern Part of North Eastern Region of India as an OR Model and Use of Object Oriented Programming
- Linear programming case studies and solutions
- How can decision makers be supported in the improvement of an emergency department? A simulation, optimization and data mining approach
- Operations Research in Passenger Railway Transportation Dennis Huisman1,2, Leo G. Kroon1,2, Ramon M. Lentink1,3 and Michiel J.C.M. Vromans1,4

SUPPORTING READINGS

- http://www.igi-global.com/journal/...journal-operations-research
- http://www.ifors.org/web/India/
- http://www.inderscience.com/ijmor
- http://www.ijorlu.ir/
- Institute of operation research and management sciences (INFORMS) – interface journal
- International federation of operational research societies (INFORS)
- International conference proceedings/publications and international journals
- Operation research society of India- publications
- International Journal of Operations Research (IJOR)
- International federation of operation research societies (IFORS)
- International Journal of Mathematics in Operational Research
- Operational Research Society of India (ORSI)
- International Journal of Applied Operational Research

COURSE FACILITATOR

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2.6 PRODUCTION AND OPERATIONS RESEARCH

COURSE OBJECTIVES **60 Hours**

1. To provide a formal quantitative approach to problem solving and an intuition about situations where such an approach is appropriate.
2. To introduce some widely-used mathematical models. The understanding of these models will allow the students derive solutions by logic demonstrated through numbers & equip them with techniques for finding solutions.

LEARNING OUTCOMES

1. The students acquire quantitative tools, and use these tools for the analysis and solution of business problems.
2. The emphasis will be on the concepts and application rather than derivations.

MODULE 1: PRODUCTION AND OPERATIONS MANAGEMENT 10 Hours

Functions of Production and material management, Types of production Systems.
Forecasting – Forecasting types, Exponential smoothening, Measurement of errors, Box-Jenkins Method.
Facility Planning – Facilities location decisions
Facility layout planning: Layout, types of plant layouts – product layout, process layout, fixed position layout, cellular manufacturing layouts, hybrid layouts
Quality – Six Sigma, and elimination of 7 wastes (Mudas), Lean operations, JIT, KANBAN

MODULE 2: FACILITY MANAGEMENT 10 Hours

Productivity and types of productivity
Materials Management – Purchase functions, Procurement procedures including bid systems, Vendor selection and development, Vendor rating, ethics in purchasing.
Concepts of lead time, purchase requisition, purchase order, amendments, forms used and records maintained.
Inventory Management: Classification, ABC, VED and FSN analysis. Inventory costs, Inventory models – EOQ, safety stocks, Re order point, Quantity discounts
Maintenance: TPM, breakdown maintenance, continuous maintenance.

MODULE 3: INTRODUCTION AND LINEAR PROGRAMMING TECHNIQUES 10 Hours

Introduction Decision Making, Quantitative Approach to Decision Making, Nature and Significance of OR in Decision Making, Scientific Methods in Operations Research, Models in Operations Research, Application Areas of OR in Management.
Linear Programming: Model Formulation, Graphical Methods, Simplex Method, Maximization and Minimization of L.P.P, Degeneracy in L.P.P.

MODULE 4: TRANSPORTATION MODEL 10 Hours

General Structure; Various methods for finding initial solution: North West Comer Method, Least Cost Method, Vogel's Approximation Method; Test for optimality (MODI method only) Alternate Optimal solutions**.** Variations: Balanced Transportation Problem, Maximization problem**,** Degenerate Solution.

MODULE 5: ASSIGNMENT PROBLEMS 10 Hours

Concepts, Mathematical Formulation of an Assignment Problem, The Assignment Algorithm (Hungarian Assignment method), Balanced and Unbalanced Assignment Problems, Travelling Salesman Problem as an Assignment Problem.

Sequencing: Terminology and notations, types of sequencing problems, processing n jobs through 2 machines, processing N jobs in N Machine.

MODULE 6: NETWORK ANALYSIS 10 Hours

Terminology; Networking Concepts; Rules for drawing network diagram; CPM Computations: CPM Terminology, Finding critical path – Different Floats; PERT Computations: Probability of meeting the scheduled dates; difference between PERT and CPM.

Replacement Models Types of Failure, Replacement of Items whose efficiency deteriorates with Time, Replacement of Items that Fail Completely

SKILL DEVELOPMENT EXERCISES

1. Linear programming is a general method usable for a wide range of problems. Visit any nutrition center which sells health-food. Bring into play the applications of LP in formation and building
2. Transportation programming techniques facilitates in maintaining traffic rules. Apply with the help of illustrations
3. Visit your nearest fast moving consumer goods manufacturing company like LG, Samsung, Videocon etc. and apply the concept of assignment model to increase its produce line.
4. Visit one of the construction companies and analyze its modus-operandi to function. Apply the concept of network model (PERT and CPM) to proper completion of work in time
5. Apply the queueing theory to regulate the problem of huge waiting lines at the railway reservation counters

PEDAGOGY

Use of case studies and Methods to solve the problems of OR using MS Excel or TORA.

RECOMMENDED BOOKS (Latest Editions)

1. Hillier, Lieberman, Nag & Basu, “Introduction to Operations Research”, McGraw Hill Education(India)
2. Ravindran, Phillips & Solberg , “Operations Research – Principles & Practice”, Wiley India
3. Hamdy A. Taha, “Operations Research: An Introduction”, Pearson
4. H.M. Wagner, “Principles of Operations Research with Application to Managerial Decisions” , Prentice Hall of India

REFERENCE BOOKS (Latest Editions)

1. Srinivas Reddy, “Operations Research”, Cengage Learning
2. J. K. Sharma, “Operations Research-Theory & Applications”, MacMillan. India Ltd
3. V. K. Kapoor, “Operations Research-Techniques for Management”, Sultan Chand & Sons

4. Hiller & Lieberman, “Introduction to Operations Research-Concepts & Cases”, Tata-McGraw Hill
5. Gupta & Hira , “Operations Research”, S.Chand& Co
6. Chawla, “Operation Research”, Kalyani Publishers
7. Mahadevan B, “Production and Operations Management”, Pearson Education India, 2010
8. J.P Saxena, “Production and Operations Management”, Tata Mcgraw-Hill Education Pvt Ltd.,
9. Ajay K.Garg, “Production and Operations Management”, Tata McGraw-Hill Education Pvt Ltd.,
10. Norman Gaither and Greg Frazier, “Operations Management”, South – Western College Pub.1999
11. Clifford Gray and Larson, “Project Management”, MC Graw-Hill/Irwin,2008

PG – 873

II Semester M.B.A. Degree Examination, July 2017
(CBCS Scheme)
MANAGEMENT
2.6 : Quantitative Techniques and Operation Research

Time : 3 Hours Max. Marks : 70

Instructions : *Answer **all** the Sections.*
*Calculators and normal distribution tables are **allowed**.*

SECTION – A

Answer **any five** of the following questions, **each** question carries **five** marks. **(5×5=25)**

1. Explain the role of queuing theory in decision-making and discuss its application.
2. Write a detailed note on role of operations research models in decision making.
3. Solve the following game theory using dominance principle.

		Firm B			
		B_1	B_2	B_3	B_4
Firm A	A_1	35	65	25	05
	A_2	30	20	15	00
	A_3	40	50	00	10
	A_4	55	60	10	15

4. The captain of a cricket team has to allot five middle batting positions to five batsmen. The average runs scored by each batsman at these positions are as follows :

		Batting positions				
		I	II	III	IV	V
Batsmen	P	40	40	35	25	50
	Q	42	30	16	25	27
	R	50	48	40	60	50
	S	20	19	20	18	25
	T	58	60	59	55	53

Find the assignment of batsman to positions which would give the maximum number of runs.

P.T.O.

5. The Crux Honda Ltd. manufactures around 150 scooters. The daily production varies from 146 to 154 depending upon the availability of raw materials and other working conditions.

Production per day	146	147	148	149	150	151	152	153	154
Probability	0.04	0.09	0.12	0.14	0.11	0.10	0.20	0.12	0.08

The finished scooters are transported in a specially arranged lorry accommodating 150 scooters, using the following random numbers :

80, 81, 76, 75, 64, 43, 18, 26, 10, 12, 65, 68, 69, 61, 57. Simulate the process to find out :

a) What will be the average number of scooters waiting in the factory ?

b) What will be the average number of empty space on the lorry ?

6. Find the sequence of the following eight jobs, that will minimize the total elapsed time for the completion of all the jobs. Each job is processed in the same order CAB. Entries given are time in hours on the machines.

Jobs

Machines	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8
A	4	6	7	4	5	3	6	2
B	8	10	7	8	11	8	9	13
C	5	6	2	3	4	9	15	11

7. What is linear programming ? What is its importance in today's business ?

SECTION – B

Answer **any three** of the following questions, **each** question carries **ten** marks. **(3×10=30)**

8. Discuss the significance and scope of operation research in modern business management.

9. A publisher has rest signed a contract for the publication of a book. What is the earliest time that the book can be ready for distribution ? The tasks in the table are involved, with the estimates given in weeks.

Activity	A	B	C	D	E	F	G	H	I	J
Precedence	–	–	A, B	A	C, D	E	E	C, D	F, G	I, H
Most likely	8	2	2	6	4	3	4	6	8	1
Optimistic	4	2	1	4	3	3	3	4	6	1
Pessimistic	10	2	3	12	5	3	5	9	16	1

i) Draw a network and find the critical path, what is the expected length of the critical path and what is its variance ?

ii) What is the probability that the length of the critical path does not exceed

a) 32 weeks

b) 36 weeks.

10. Solve the given LPP by simplex method.

Maximize $Z = 5x_1 + 10x_2 + 8x_3$

Subject to $3x_1 + 5x_2 + 2x_3 \leq 60$

$4x_1 + 4x_2 + 4x_3 \leq 72$

$2x_1 + 4x_2 + 5x_3 \leq 100$

$x_1, x_2, x_3 \geq 0.$

11. The following mortality rates have been observed for a certain types of fuses :

Week	1	2	3	4	5
% failing by the end of week	5	15	35	75	100

There are 1000 fuses in use and it costs Rs. 5 to replace on individual fuse. If all fuse were replaced simultaneously it would cost Rs. 1.25 per fuse. At what intervals the groups replacement should be done ? Which policy is better ?

SECTION – C

12. Case study (**compulsory**) : **(1×15=15)**

Solve the transportation problem to maximise profits and give criterion for optimality.

		Destinations				
		D_1	D_2	D_3	D_4	Capacity
Plants	P_1	40	25	22	33	100
	P_2	44	35	30	30	30
	P_3	38	38	28	30	70
Requirement		40	20	60	30	200 / 150

PG – 923

II Semester M.B.A. Degree Examination, July 2016
(CBCS)
MANAGEMENT
2.6 : Quantitative Techniques and Operation Research

Time : 3 Hours Max. Marks : 70

SECTION – A

Answer **any five** of the following. **Each** question carries **five** marks. **(5x5=25)**

1. Distinguish between Analytical and Simulation Models.

2. A firm is considering replacement of a machine whose cost price is Rs. 12,200 and the scrap value is Rs. 200. The maintenance costs are found from experience to be as follows :

Year	1	2	3	4	5	6	7	8
Maintenance Cost (Rs.)	200	500	800	1200	1800	2500	3200	4000

What is the optimal replacement interval for this machine ?

3. Five jobs are to be processed and five machines are available. Any machine can process any job with resulting. Profit (in Rs.) as follows. Find assignment pattern that maximizes the sales.

		Machines				
		A	B	C	D	E
Jobs	1	70	75	71	60	80
	2	55	57	64	61	50
	3	60	54	80	71	55
	4	80	72	75	65	70
	5	50	56	70	51	72

4. Explain the essential features of queuing system.

P.T.O.

5. What is degeneracy ? How it can be resolved in case of Transportation ?

6. Find out the sequence that minimizes the total elapsed time required in performing the following tasks on machine M_1 and M_2 in the order M_1, M_2. Also, find the minimum total elapsed time.

Task	A	B	C	D	E	F	G	H	I
M_1	2	5	4	9	6	8	7	5	4
M_2	6	8	7	4	3	9	3	8	11

7. Moon Light Bakery keeps stock of a popular brand of cake. Previous experience indicates the daily demand as given here.

Daily Demand	0	10	20	30	40	50
Probability	.01	.20	.15	.50	.12	.02

Consider the following sequence of random numbers.

R. No. 48, 78, 19, 51, 56, 77, 15, 14, 68, 09.

Simulate the demand for next 10 days. Find out the stock situation if the owner of the bakery decides to make 30 cakes every day. Also estimate the daily average demand for the cakes on the basis of simulated data.

SECTION – B

Answer **any three** of the following questions **each** question carries **ten** marks. **(10×3=30)**

8. National Oil Co. has three refineries and 4 depots. Transaction costs per barrel and requirements are given below. Determine optimal allocation of output.

	D_1	D_2	D_3	D_4	Capacity
R_1	5	7	13	10	700
R_2	8	6	14	13	400
R_3	12	10	9	11	800
Requirement	300	600	700	400	

9. "Operation Research is the application of Scientific Methods, techniques and tools to problems involving in the operations of a system so as to provide those in control of the systems with optimum solution to the problems." Discuss with suitable examples.

10. Determine the dominance principle of game theory using the following :

		Firm B			
		B_1	B_2	B_3	B_4
Firm A	A_1	15	35	25	5
	A_2	10	20	5	0
	A_3	20	50	10	5
	A_4	25	55	15	20

11. A project consists of eight activities with the following relevant information :

Activities	Immediate Predecessor	Estimated Duration (Days)		
		Optimistic	Most Likely	Pessimistic
A	–	1	1	7
B	–	1	4	7
C	–	2	2	8
D	A	1	1	1
E	B	2	5	14
F	C	2	5	8
G	D,E	3	6	15
H	F,G	1	2	3

1) Draw the PERT network and determine critical path.

2) If a 30 days deadline is imposed, what is the probability that the project will be finished within the time ?

3) If the project manager wants to be 99% sure that the project is completed on the scheduled date, how many Weeks before that date should he start the project work ?

SECTION – C

12. Case Study (**Compulsory**) : **(1×15=15)**

A company manufactures three types of parts which use precious metals platinum and gold. Due to shortage of these precious metals, the govt. regulates the amount that may be used per day. The relevant data with respect to supply requirements and profit are summarized in the table shown below :

Product	Platinum Per Unit (gm)	Gold Required Per Unit (gm)	Profit Per Unit (Rs.)
A	2	3	500
B	4	2	600
C	6	4	1200

Daily allotment of platinum and gold are 160 gm and 120 gm respectively. Determine the optimum profit under Simplex Method.

PG – 1001

II Semester M.B.A. Degree Examination, June/July 2015
(2007-08 Scheme)
Management
2.6 : QUANTITATIVE METHODS AND OPERATIONS RESEARCH

Time : 3 Hours Max. Marks : 75

Instruction *: Scientific calculators are* ***allowed****.*

SECTION – A

Answer **any six** questions. **Each** question carries **two** marks. **(6×2=12)**

1. a) Define linear programming problem.
   b) What is unbalanced assignment ?
   c) What is group replacement ?
   d) What are the significance of VAM ?
   e) Define critical path.
   f) What is simulation ?
   g) What do you mean by degeneracy ?
   h) Mention the assumptions of EOQ model.

SECTION – B

Answer **any three** questions. **Each** question carries **8** marks. **(3×8=24)**

2. "Operation research replaces management by personality". Discuss.
3. What is sequencing problem ? Give its essential characteristics.
4. A company for one of the z-class items, placed 10 orders each of size 300 in a year. Given ordering cost Rs. 750, holding cost 45%, cost per unit Rs. 35. Find out the loss to the company in not operating scientific inventory policy.

P.T.O.

5. There are 6 jobs each of which must go through machines A, B and C in the order ABC processing time (in hours) given in the following table.

Job / Machine	1	2	3	4	5	6
A	8	3	7	10	5	4
B	6	4	8	2	1	7
C	8	7	6	9	10	9

Determine the optimal sequence and total elapsed time.

6. Solve the problem of assignment for the given table to maximise the sales.

		Machines				
		A	B	C	D	E
	1	32	38	40	28	40
	2	40	24	28	21	36
Jobs	3	41	27	33	30	37
	4	22	38	41	36	36
	5	29	33	40	35	39

SECTION – C

Answer **any two** of the following : **(2×12=24)**

7. Explain the different models of O.R. How are these models useful in day to day operation ?

8. Use the simplex method to solve the following L.P.P.

Maximize $Z = 3x_1 + 5x_2 + 4x_3$

S.T. $2x_1 + 3x_2 \leq 8$

$2x_2 + 5x_3 \leq 10$

$3x_1 + 2x_2 + 4x_3 \leq 15$

and $x_1, x_2, x_3 \geq 0$.

9. Simulation of demand forecasting.

A dealer sells a particular model of washing machine for which the probability distribution of daily demand is as given below.

Demand/Week :	20	30	35	40	45	50
Probability :	0.05	0.25	0.20	0.25	0.10	0.15

Find average demand of washing machine for 10 weeks. Random numbers for 10 weeks are given below.

89 34 78 63 61 81 39 16 13 73.

SECTION – D

10. Case study **compulsory** : **(1×15=15)**

Below given table has a list of activities and time estimates.

Activity	**Predecessor Activity**	t_o	t_m	t_p
A	–	2	4	10
B	–	3	4	5
C	A	1	2	3
D	A	4	6	14
E	B	4	5	12
F	C	3	4	6
G	D, E	1	1	8

1) Construct a PERT network and determine the critical path.
2) What is the probability that the project shall be complete within a period of 15 weeks ?
3) What is the probability that the project is completed within 10 and 18 weeks ?