INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad-500043

MASTER OF BUSINESS ADMINISTRATION

TUTORIAL QUESTION BANK

Course Title	**Quantitative Analysis for Business Decisions**				
Course Code	CMBB29				
Programme	Master of Business Administration				
Semester	III				
Academic Year	2019 - 2020				
Course Type	**IARE - R18**				
Regulation	**Theory**			**Practical**	
Course Structure	**Lectures**			**Tutorials**	
	Theory	**Practical**	**Credits**	**Laboratory**	**Credits**
	4	-	4	-	-
Chief Coordinator	Ms. S. Shireesha, Assistant Professor				
Course Faculty	Ms. S. Shireesha, Assistant Professor				

COURSE OBJECTIVES:

The course should enable the students to:	
I.	Apply the quantitative methods for business decision making.
II.	Maintain fundamental applications in industry and public sector to face uncertainties and scarcity of resources.
III.	Facilitate mathematical and computational modelling of real decision making problems including the use of modelling tools.
IV.	Familiarize with the design implementation and analysis of computational experiments.

COURSE OUTCOMES (COs):

CMBB29.01	Apply quantitative techniques to translate a real-world problem for business decisions using Mathematical tools.
CMBB29.02	Understand the topic of linear programming problem and its use in practical problems for optimization.
CMBB29.03	Develop fundamental applications of those tools in industry and public sector in contexts involving uncertainty and scarce or expensive resources.
CMBB29.04	Illustrating with the design implementation and analysis of computational experiments.
CMBB29.05	Understand the concept of operation research to optimize the solution.

CMBB29.06	Ability to work in a team: specifically to solve larger problems, communicate technical knowledge, partition a problem into smaller tasks, and complete tasks on time.
CMBB29.07	Facilitate to identifying, accessing, evaluating, and interpreting information and data in support of assignments, projects, or research.
CMBB29.08	Develop a report that describes the model and the solving technique, analyze the results and propose recommendations in language understandable to the decision-making processes in Management Engineering.
CMBB29.09	Develop and understand mathematical models for problems that arise in various disciplines.

TUTORIAL QUESTION BANK

UNIT- I				
NATURE AND SCOPRE OF OPERATION RESEARCH				
Part - A (Short Answer Questions)				
S No	**QUESTIONS**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Outcomes (COs)**
1	Identify scope of Operations research.	Understand	CO 1	CMBB29.01
2	Illustrate applications of Operations research.	Understand	CO 1	CMBB29.01
3	List characteristics of Operations research?	Remember	CO 2	CMBB29.02
4	Summarize methodology of Operations research.	Understand	CO 2	CMBB29.02
5	Classify phases of Operations research	Understand	CO 2	CMBB29.02
6	List Operations research models.	Remember	CO 1	CMBB29.01
7	Summarize advanced models of Operation research.	Understand	CO 2	CMBB29.02
8	Identify limitations of Operation research.	Understand	CO 2	CMBB29.02
9	Classify probabilistic models of Operation research.	Understand	CO 2	CMBB29.02
10	List simulation models of Operation research.	Remember	CO 2	CMBB29.02
11	Illustrate analytical models of Operation research.	Understand	CO 1	CMBB29.01
12	List applications of Operations Research Techniques.	Remember	CO 1	CMBB29.01
13	Summarize importance of Operation research in the decision making process?	Understand	CO 2	CMBB29.02
14	List purposes of mathematical model.	Remember	CO 2	CMBB29.02
15	Describe general representation of LPP.	Understand	CO 2	CMBB29.02
16	List objective functions of Operations Research in brief.	Understand	CO 1	CMBB29.01
17	Describe non degenerate basic feasible solution with an example.	Understand	CO 2	CMBB29.02
18	List non- negativity constraints with an example.	Understand	CO 2	CMBB29.02
19	List constraints of a LPP with an example.	Understand	CO 2	CMBB29.02
20	Classify slack variables with examples.	Remember	CO 2	CMBB29.02
Part - B (Long Answer Questions)				
1	Define Operations Research. List characteristics of Operations Research.	Remember	CO 2	CMBB29.02
2	Explain methodology involved in Operations Research while solving problems by using different models.	Understand	CO 2	CMBB29.02
3	List various Operations Research models with their applications.	Remember	CO 2	CMBB29.02
4	Explain limitations of Operations Research.	Understand	CO 2	CMBB29.02
5	Discuss the origin and development of OR.	Understand	CO 2	CMBB29.02
6	How computer has helped in popularizing OR?	Understand	CO 1	CMBB29.01
7	Discuss in brief the role of OR model in decision making.	Understand	CO 1	CMBB29.01
8	Describe the various objectives of OR.	Remember	CO 1	CMBB29.01
9	What are the main characteristics of OR? Explain with suitable examples.	Remember	CO 1	CMBB29.01
10	Give features of OR. Briefly discuss technique and tools of OR.	Understand	CO 1	CMBB29.01
11	What is the role of decision making in OR. Explain its scope.	Understand	CO 2	CMBB29.02
12	Discuss the significance and scope of OR in modern management.	Understand	CO 2	CMBB29.02
13	"Mathematics of OR is mathematics of optimization." Discuss.	Apply	CO 2	CMBB29.02
14	Describe different techniques of O.R.	Remember	CO 2	CMBB29.02
15	Describe the different methods of solving O.R. models.	Understand	CO 2	CMBB29.02
16	Trace the history of Operations Research.	Understand	CO 1	CMBB29.01
17	Discuss the points to justify that the primary purpose of O.R.Models in a big way in Indian organizations.	Understand	CO 1	CMBB29.01
18	"Operations Research is a bunch of mathematical techniques to break industrial problems". Critically comment.	Understand	CO 2	CMBB29.02
19	What is an Operations Research model? Discuss the advantages of limitation of good Operations Research model.	Remember	CO 2	CMBB29.02
20	Discuss the various steps used in solving Operations Research problems.	Remember	CO 1	CMBB29.01
Part - C (Problem Solving and Critical Thinking Questions)				
1	"OR is the application of scientific methods, technique and tool to problems involving the operation of a system so as to provide those in control of the system with optimum solution to the problems."	Understand	CO 1	CMBB29.01
2	Discuss few areas of O.R. applications in an organization or organization you are familiar with.	Understand	CO 2	CMBB29.02

3	Explain the various steps in the O.R. development process.	Apply	CO 1	CMBB29.01
4	Describe the relationship between the manager and O.R. specialist.	Analysis	CO 2	CMBB29.02
5	"OR is an aid for the executive in making his decision by providing him with the needed quantitative information, based on the scientific method analysis." Discuss the statement in detail, illustrating it with OR methods that you know.	Apply	CO 1	CMBB29.01
6	Give any three definitions of Operations Research and explain. Give three reasons why most definitions of O.R. are not satisfactory.	Analysis	CO 2	CMBB29.02
7	Give the different phases of Operations Research and explain their significance for decision-making.	Apply	CO 1	CMBB29.01
8	Briefly mention the various phases of O.R. and describe in detail the first phase 'Formulation and definition of the problem.	Analysis	CO 2	CMBB29.02
9	It is said that Operations Research increases the creative capabilities of a decision-maker. Do you agree with this view? Defend your point of view with examples.	Apply	CO 1	CMBB29.01
10	Briefly describe the application of Operations Research in the following functional areas of Management, namely, finance, marketing, personnel and production.	Analysis	CO 2	CMBB29.02
	UNIT-II			
	ASSIGNMENT MODEL			
	Part – A (Short Answer Questions)			
1	Define an assignment problem.	Remember	CO 3	CMBB29.03
2	List out the applications of assignment problem?	Understand	CO 3	CMBB29.03
3	Give the mathematical representation of an assignment problem.	Understand	CO 3	CMBB29.03
4	What is the difference between assignment problem and travelling salesman problem?	Remember	CO 4	CMBB29.04
5	Discuss the method of solving assignment problems?	Understand	CO 3	CMBB29.03
6	Show that an assignment problem is a special case of a transportation problem?	Understand	CO 4	CMBB29.04
7	Describe an algorithm to solve an assignment problem?	Understand	CO 3	CMBB29.03
8	Draw flowchart for Hungarian method.	Remember	CO 4	CMBB29.04
9	How to solve unbalanced assignment problem.	Understand	CO 3	CMBB29.03
10	"Assignment Problem is basically a Minimization Problem". Discuss	Evaluate	CO 3	CMBB29.03
11	Why Assignment technique is essentially a minimization technique.	Remember	CO 3	CMBB29.03
12	How do we identify a degeneracy Assignment problem.	Understand	CO 3	CMBB29.03
13	Is an unbalanced assignment problem can be solved using "Hungarian method of assignment".	Apply	CO 3	CMBB29.03
14	If some assignment is infeasible then that assignment can be effectively avoided by putting a large cost in that cell. Discuss.	Analyze	CO 4	CMBB29.04
15	Write the assumptions of Assignment model.	Evaluate	CO 3	CMBB29.03
16	Briefly explain the applications of Assignment model.	Remember	CO 4	CMBB29.04
17	Write procedure for solving travelling salesmen Problem.	Understand	CO 3	CMBB29.03
18	Draw a flow chart for the steps in Hungarian method.	Apply	CO 4	CMBB29.04
19	State the linear programming formulation of an assignment problem.	Analyze	CO 3	CMBB29.03
20	How can you maximize an objective function in assignment problem.	Evaluate	CO 3	CMBB29.03
	Part - B (Long Answer Questions)			
1	The productivity of operators A, B, C, D, and E on different machines P, Q, R, S, and T are given in the matrix below. Assign machine to operators of maximum productivity.	Remember	CO 3	CMBB29.03

Operators	P	Q	R	S	T
A	9	14	10	7	12
B	8	11	12	--	13
C	10	10	8	11	--
D	12	14	11	10	7
E	13	10	12	13	10

<table>
<tr><td>2</td><td>An airline that operates flights between Delhi and Bombay has the following timetable. Pair the flights, so as to minimize the total layover time for the crew. The plane, which reaches its destination, cannot leave that place before 4 hours of rest.
<table>
<tr><td>Flight No.</td><td>Departure</td><td>Arrival</td><td>Flight No.</td><td>Departure</td><td>Arrival</td></tr>
<tr><td>101</td><td>9.00 a.m</td><td>11.00 a.m</td><td>201</td><td>10.00 a.m</td><td>12.00 Nn.</td></tr>
<tr><td>102</td><td>10.00 a.m</td><td>12.00 Nn</td><td>202</td><td>12.00 Nn</td><td>2.00 p.m</td></tr>
<tr><td>103</td><td>4.00 p.m</td><td>6.00 p.m</td><td>203</td><td>3.00 p.m</td><td>5.00 p.m</td></tr>
<tr><td>104</td><td>7.00 p.m</td><td>9.00 p.m</td><td>204</td><td>8.00 p.m</td><td>10.p.m.</td></tr>
</table></td><td>Understand</td><td>CO 4</td><td>CMBB29.04</td></tr>
<tr><td>3</td><td>Solve the traveling salesman problem given below for minimizing the total distance traveled. Distance in Km.
<table>
<tr><td>Cities</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td>A</td><td>M</td><td>10</td><td>8</td><td>29</td><td>12</td></tr>
<tr><td>B</td><td>16</td><td>14</td><td>12</td><td>10</td><td>9</td></tr>
<tr><td>C</td><td>6</td><td>3</td><td>17</td><td>14</td><td>12</td></tr>
<tr><td>D</td><td>12</td><td>19</td><td>17</td><td>14</td><td>12</td></tr>
<tr><td>E</td><td>11</td><td>8</td><td>16</td><td>13</td><td>M</td></tr>
</table></td><td>Apply</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>4</td><td>Four engineers are available to design four projects. Engineer 2 is not competent to design the project B. Given the following time estimates needed by each engineer to design a given project, find how should the engineers be assigned to projects so as to minimize the total design time of four projects.
<table>
<tr><td rowspan="2">ENGINEERS</td><td colspan="4">PROJECTS</td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td></tr>
<tr><td>1</td><td>12</td><td>10</td><td>10</td><td>8</td></tr>
<tr><td>2</td><td>14</td><td>Not Eligible</td><td>15</td><td>11</td></tr>
<tr><td>3</td><td>6</td><td>10</td><td>16</td><td>4</td></tr>
<tr><td>4</td><td>8</td><td>10</td><td>9</td><td>7</td></tr>
</table></td><td>Analyze</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>5</td><td>Given the set up costs below, show how to sequence the production so as to minimize the total setup cost per cycle.
<table>
<tr><td>Jobs</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td>A</td><td>M</td><td>2</td><td>5</td><td>7</td><td>1</td></tr>
<tr><td>B</td><td>6</td><td>M</td><td>3</td><td>8</td><td>2</td></tr>
<tr><td>C</td><td>8</td><td>7</td><td>M</td><td>4</td><td>7</td></tr>
<tr><td>D</td><td>12</td><td>4</td><td>6</td><td>M</td><td>5</td></tr>
<tr><td>E</td><td>1</td><td>3</td><td>2</td><td>8</td><td>M</td></tr>
</table></td><td>Analyze</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>6</td><td>On a given day District head quarter has the information that one ambulance van is stationed at each of the five locations A, B, C, D and E. The district quarter is to be issued for the ambulance van to reach 6 locations namely, P, Q, R, S, T and U, one each. The distances in Km. between present locations of ambulance vans and destinations are given in the matrix below. Decide the assignment of vans for minimum total distance, and also state which destination should not expect ambulance van to arrive.
To (distance in Km.)
<table>
<tr><td>FROM</td><td>P</td><td>Q</td><td>R</td><td>S</td><td>T</td><td>U</td></tr>
<tr><td>A</td><td>18</td><td>21</td><td>31</td><td>17</td><td>26</td><td>29</td></tr>
<tr><td>B</td><td>16</td><td>20</td><td>18</td><td>16</td><td>21</td><td>31</td></tr>
<tr><td>C</td><td>30</td><td>25</td><td>27</td><td>26</td><td>18</td><td>19</td></tr>
<tr><td>D</td><td>25</td><td>33</td><td>45</td><td>16</td><td>32</td><td>20</td></tr>
<tr><td>E</td><td>36</td><td>30</td><td>18</td><td>15</td><td>31</td><td>30</td></tr>
</table></td><td>Evaluate</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>7</td><td>Four different jobs are to be done on four machines, one job on each machine, as set up costs and times are too high to permit a job being worked on more than one machine. The matrix given below gives the times of producing jobs on different</td><td>Create</td><td>CO 3</td><td>CMBB29.03</td></tr>
</table>

<table>
<tr><td></td><td>machines. Assign the jobs to machine so that total time of production is minimized.
Machines (time in hours)
<table>
<tr><td>Jobs</td><td>A</td><td>B</td><td>C</td><td>D</td></tr>
<tr><td>P</td><td>10</td><td>14</td><td>22</td><td>12</td></tr>
<tr><td>Q</td><td>16</td><td>10</td><td>18</td><td>12</td></tr>
<tr><td>R</td><td>8</td><td>14</td><td>20</td><td>14</td></tr>
<tr><td>S</td><td>20</td><td>8</td><td>16</td><td>6</td></tr>
</table></td><td></td><td></td><td></td></tr>
<tr><td>8</td><td>A salesman has to visit five cities A,B,C,D,E. The intercity distances are tabulated below.
<table>
<tr><td></td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td>A</td><td>-</td><td>12</td><td>24</td><td>25</td><td>15</td></tr>
<tr><td>B</td><td>6</td><td>-</td><td>16</td><td>18</td><td>7</td></tr>
<tr><td>C</td><td>10</td><td>11</td><td>-</td><td>18</td><td>12</td></tr>
<tr><td>D</td><td>14</td><td>17</td><td>22</td><td>-</td><td>16</td></tr>
<tr><td>E</td><td>12</td><td>13</td><td>23</td><td>25</td><td>-</td></tr>
</table>Find the shortest route covering all the cities.</td><td>Remember</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>9</td><td>Find Solution of Assignment problem using Hungarian method.
<table>
<tr><td>Work\Job</td><td>I</td><td>II</td><td>III</td></tr>
<tr><td>A</td><td>6</td><td>3</td><td>5</td></tr>
<tr><td>B</td><td>5</td><td>9</td><td>2</td></tr>
<tr><td>C</td><td>5</td><td>7</td><td>8</td></tr>
</table></td><td>Understand</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>10</td><td>Different machines can do any of the five required jobs, with different profits resulting from each assignment as shown in the table. Find out maximum profit possible through optimal assignment.
<table>
<tr><td rowspan="2">Jobs</td><td colspan="5">Machines</td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td>1</td><td>30</td><td>37</td><td>40</td><td>28</td><td>40</td></tr>
<tr><td>2</td><td>40</td><td>24</td><td>27</td><td>21</td><td>36</td></tr>
<tr><td>3</td><td>40</td><td>32</td><td>33</td><td>30</td><td>35</td></tr>
<tr><td>4</td><td>25</td><td>38</td><td>40</td><td>36</td><td>36</td></tr>
<tr><td>5</td><td>29</td><td>62</td><td>41</td><td>34</td><td>39</td></tr>
</table></td><td>Apply</td><td>CO 4</td><td>CMBB29.04</td></tr>
<tr><td>11</td><td>Solve the following assignment problem to minimize the total time of the operator
<table>
<tr><td colspan="6">Jobs</td></tr>
<tr><td>Operator</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>1</td><td>6</td><td>2</td><td>5</td><td>2</td><td>6</td></tr>
<tr><td>2</td><td>2</td><td>5</td><td>8</td><td>7</td><td>7</td></tr>
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<tr><td>5</td><td>9</td><td>3</td><td>8</td><td>9</td><td>7</td></tr>
<tr><td>6</td><td>4</td><td>7</td><td>4</td><td>6</td><td>8</td></tr>
</table></td><td>Remember</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>12</td><td>“A major constraint in the use of assignment method is that number of jobs must equal the number of machines”. Discuss.</td><td>Understand</td><td>CO 4</td><td>CMBB29.04</td></tr>
<tr><td>13</td><td>Write the Mathematical representation of an assignment model? Briefly explain about the assignment problems in OR and applications of assignment in OR?</td><td>Apply</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>14</td><td>What is an unbalanced assignment problem? How is the Hungarian assignment method applied in respect of such a problem?</td><td>Analyze</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>15</td><td>Differentiate Transportation problem and Assignment Problem and also explain the similarities.</td><td>Analyze</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>16</td><td>Enumerate the similarities and differences between assignment and transportation techniques.</td><td>Evaluate</td><td>CO 3</td><td>CMBB29.03</td></tr>
</table>

<table>
<tr><td>17</td><td>How will you handle the following situations in an assignment problem.
a. Maximization
b. Unbalanced problem
c. Impossible assignment</td><td>Create</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>18</td><td>Describe the approach of the Hungarian method. What is meant by matrix reduction?</td><td>Remember</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>19</td><td>State the linear programming formulation of an assignment problem.</td><td>Understand</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>20</td><td>Give an example to show that an assignment problem can be formulated as a linear programming problem.</td><td>Apply</td><td>CO 4</td><td>CMBB29.04</td></tr>
<tr><td colspan="5">Part - C (Problem Solving and Critical Thinking Questions)</td></tr>
<tr><td>1</td><td>Solve the following assignment problem to minimize the total time of the operator
<table>
<tr><td></td><td colspan="5">Jobs</td></tr>
<tr><td>Operator</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>1</td><td>6</td><td>2</td><td>5</td><td>2</td><td>6</td></tr>
<tr><td>2</td><td>2</td><td>5</td><td>8</td><td>7</td><td>7</td></tr>
<tr><td>3</td><td>7</td><td>8</td><td>6</td><td>9</td><td>8</td></tr>
<tr><td>4</td><td>6</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>5</td><td>9</td><td>3</td><td>8</td><td>9</td><td>7</td></tr>
<tr><td>6</td><td>4</td><td>7</td><td>4</td><td>6</td><td>8</td></tr>
</table></td><td>Remember</td><td>CO 3</td><td>CMBB29.03</td></tr>
<tr><td>2</td><td>Different machines can do any of the five required jobs, with different profits resulting from each assignment as shown in the adjusting table. Find out maximum profit possible through optimal assignment.
<table>
<tr><td rowspan="2">Jobs</td><td colspan="5">Machines</td></tr>
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<tr><td>5</td><td>29</td><td>62</td><td>41</td><td>34</td><td>39</td></tr>
</table></td><td>Understand</td><td>CO 4</td><td>CMBB29.04</td></tr>
<tr><td>3</td><td>A typical assignment problem, presented in the classic manner. Here there are five machines to be assigned to five jobs. The numbers in the matrix indicate the cost of doing each job with each machine. Jobs with costs of M are disallowed assignments. The problem is to find the minimum cost matching of machines to jobs.
<table>
<tr><td></td><td>J1</td><td>J2</td><td>J3</td><td>J4</td><td>J5</td></tr>
<tr><td>M1</td><td>M</td><td>8</td><td>6</td><td>12</td><td>1</td></tr>
<tr><td>M2</td><td>15</td><td>12</td><td>7</td><td>M</td><td>10</td></tr>
<tr><td>M3</td><td>10</td><td>M</td><td>5</td><td>14</td><td>M</td></tr>
<tr><td>M4</td><td>12</td><td>M</td><td>12</td><td>16</td><td>15</td></tr>
<tr><td>M5</td><td>18</td><td>17</td><td>14</td><td>M</td><td>13</td></tr>
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<tr><td>4</td><td>A salesman has to visit five cities A, B, C, D, E. The intercity distances are tabulated below.
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<tr><td>A</td><td>-</td><td>12</td><td>24</td><td>25</td></tr>
<tr><td>B</td><td>6</td><td>-</td><td>16</td><td>18</td></tr>
<tr><td>C</td><td>10</td><td>11</td><td>-</td><td>18</td></tr>
<tr><td>D</td><td>14</td><td>17</td><td>22</td><td>-</td></tr>
<tr><td>E</td><td>12</td><td>13</td><td>23</td><td>25</td></tr>
</table>
Find the shortest route covering all the cities.</td><td>Understand</td><td>CO 4</td><td>CMBB29.04</td></tr>
</table>

<table>
<tr>
<td>5</td>
<td>The assignment cost of assigning any one operator to any one machine is given in the following table.
<table>
<tr><td rowspan="2">Machine</td><td colspan="5">Operators</td></tr>
<tr><td></td><td>I</td><td>II</td><td>III</td><td>IV</td></tr>
<tr><td></td><td>A</td><td>10</td><td>5</td><td>13</td><td>15</td></tr>
<tr><td></td><td>B</td><td>3</td><td>9</td><td>18</td><td>3</td></tr>
<tr><td></td><td>C</td><td>10</td><td>7</td><td>3</td><td>2</td></tr>
<tr><td></td><td>D</td><td>5</td><td>11</td><td>9</td><td>7</td></tr>
</table>
</td>
<td>Remember</td>
<td>CO 3</td>
<td>CMBB29.03</td>
</tr>
<tr>
<td>6</td>
<td>Crew assignment problem.
An airlines that operates seven days a week has a time table shown below. Crews must have a minimum layover of 6 hours between flights. Obtain the pairing of flights that minimizes layover time away from home.
Mumbai - Delhi
<table>
<tr><td>Flight No</td><td>Departure</td><td>Arrival</td></tr>
<tr><td>101</td><td>8.00</td><td>9.00</td></tr>
<tr><td>102</td><td>09.00</td><td>10.00</td></tr>
<tr><td>103</td><td>12.00</td><td>13.00</td></tr>
<tr><td>104</td><td>17.00</td><td>18.00</td></tr>
</table>
Delhi - Mumbai
<table>
<tr><td>Flight No</td><td>Departure</td><td>Arrival</td></tr>
<tr><td>1</td><td>7.00</td><td>8.00</td></tr>
<tr><td>2</td><td>8.00</td><td>9.00</td></tr>
<tr><td>3</td><td>13.00</td><td>14.00</td></tr>
<tr><td>4</td><td>18.00</td><td>19.00</td></tr>
</table>
</td>
<td>Understand</td>
<td>CO 4</td>
<td>CMBB29.04</td>
</tr>
<tr>
<td>7</td>
<td>Find Solution of Travelling salesman problem
<table>
<tr><td>W\J</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>1</td><td>x</td><td>4</td><td>9</td><td>5</td></tr>
<tr><td>2</td><td>6</td><td>x</td><td>4</td><td>8</td></tr>
<tr><td>3</td><td>9</td><td>4</td><td>x</td><td>9</td></tr>
<tr><td>4</td><td>5</td><td>8</td><td>9</td><td>x</td></tr>
</table>
</td>
<td>Remember</td>
<td>CO 3</td>
<td>CMBB29.03</td>
</tr>
<tr>
<td>8</td>
<td>Find Solution of Assignment problem using Hungarian method
<table>
<tr><td>Work \ Job</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td>M1</td><td>9</td><td>11</td><td>15</td><td>10</td><td>11</td></tr>
<tr><td>M2</td><td>12</td><td>9</td><td>-</td><td>10</td><td>9</td></tr>
<tr><td>M3</td><td>-</td><td>11</td><td>14</td><td>11</td><td>7</td></tr>
<tr><td>M4</td><td>14</td><td>8</td><td>12</td><td>7</td><td>8</td></tr>
</table>
</td>
<td>Understand</td>
<td>CO 4</td>
<td>CMBB29.04</td>
</tr>
<tr>
<td>9</td>
<td>Find Solution of Assignment problem using Hungarian method
<table>
<tr><td>Work \ Job</td><td>I</td><td>II</td><td>III</td><td>IV</td></tr>
<tr><td>A</td><td>42</td><td>35</td><td>28</td><td>21</td></tr>
<tr><td>B</td><td>30</td><td>25</td><td>20</td><td>15</td></tr>
<tr><td>C</td><td>30</td><td>25</td><td>20</td><td>15</td></tr>
<tr><td>D</td><td>24</td><td>20</td><td>16</td><td>12</td></tr>
</table>
</td>
<td>Remember</td>
<td>CO 3</td>
<td>CMBB29.03</td>
</tr>
</table>

10	Find Solution of Assignment problem using Hungarian method Work \ Job: I 42 35 28 21; II 30 25 20 15; III 30 25 20 15; IV 24 20 16 12	Understand	CO 4	CMBB29.04
	UNIT -III			
	LINEAR PROGRAMMING METHOD			
	Part - A (Short Answer Questions)			
1	Summarize mathematical model of a transportation problem.	Understand	CO 5	CMBB29.5
2	List methods to solve transportation problems to get Basic feasible solution?	Remember	CO 5	CMBB29.5
3	Why is LCM is optimal than NWCR in solving transportation problem?	Understand	CO 6	CMBB29.6
4	Why does Vogel's approximation method provide a good initial feasible solution than other methods?	Remember	CO 5	CMBB29.5
5	List methods to test for optimality in transportation problem.	Remember	CO 6	CMBB29.6
6	What is degeneracy in transportation problem?	Remember	CO 6	CMBB29.6
7	List assumptions used in solving transportation problem.	Understand	CO 6	CMBB29.6
8	What is unbalance problem in transportation model.	Understand	CO 6	CMBB29.6
9	Define feasible, basic feasible and optimal solution in transportation model.	Understand	CO 5	CMBB29.5
10	Define constraints of a transportation problem?	Understand	CO 5	CMBB29.5
11	Describe general representation of LPP.	Understand	CO 5	CMBB29.5
12	List objective functions of Operations Research in brief.	Understand	CO 5	CMBB29.5
13	Describe non degenerate basic feasible solution with an example.	Understand	CO 6	CMBB29.6
14	List non- negativity constraints with an example.	Understand	CO 5	CMBB29.5
15	List constraints of a LPP with an example.	Understand	CO 6	CMBB29.6
16	Classify slack variables with examples.	Remember	CO 6	CMBB29.6
17	Classify surplus variables with examples.	Remember	CO 6	CMBB29.6
18	List artificial variables with an illustration.	Understand	CO 6	CMBB29.6
19	Describe basic feasible solution with an example.	Remember	CO 5	CMBB29.5
20	Describe optimal solution with an illustration.	Remember	CO 5	CMBB29.5
	Part – B (Long Answer Questions)			
1	Explain mathematical model of a transportation problem with an example.	Understand	CO 5	CMBB29.5
2	What are different methods of solving transportation problems to get basic feasible solution? Explain steps involved in VAM method.	Remember	CO 5	CMBB29.5
3	Why is LCM is optimal than NWCR in solving transportation problem? Explain with an example.	Understand	CO 6	CMBB29.6
4	Why does Vogel's approximation method provide a good initial feasible solution than other methods? Explain with an example.	Remember	CO 6	CMBB29.6
5	What are the methods to test for optimality in transportation problem? Explain steps involved in MODI method.	Remember	CO 6	CMBB29.6
6	What is degeneracy in transportation problem? Explain how it will be solved.	Remember	CO 5	CMBB29.5
7	List methods to find optimal solution of transportation problem. Explain steps involved in u-v method.	Understand	CO 5	CMBB29.5
8	Show that an assignment problem is a special case of a transportation problem? Explain with an illustration.	Understand	CO 6	CMBB29.6
9	Explain about mathematical representation and assumptions made in transportation problem with an example.	Understand	CO 6	CMBB29.6
10	Solve the following LPP by using graphical method Maximize $Z=3x1+4x2$ Subject to $x1+x2\leq 450$ $x1+2x2\leq 600$ where $x1, x2 \geq 0$	Evaluate	CO 6	CMBB29.6
11	Solve the following LPP by using graphical method Maximize $Z=2x1+3x2$ Subject to $x1+x2\leq 30$	Remember	CO 5	CMBB29.5

	$x2 \geq 3$ $x2 \leq 12$ $x1 - x2 \geq 0$ $0 \leq x1 \leq 20$ where $x_1, x_2 \geq 0$			
12	Solve the following LPP by using graphical method Minimize Z= - x1+2x2 Subject to $-x1+3x2 \leq 10$ $x1+x2 \leq 6$ $x1 - x2 \leq 2$ where $x_1, x_2 \geq 0$	Understand	CO 5	CMBB29.5
13	Solve the following LPP by using Simplex method Maximize Z=3x1+4x2 Subject to $x1+x2 \leq 450$ $x1+2x2 \leq 600$ where $x_1, x_2 \geq 0$	Apply	CO 6	CMBB29.6
14	Solve the following LPP by using Big M method Minimize Z=12x1+20x2 Subject to $6x1+8x2 \geq 100$ $7x1+12x2 \geq 120$ where $x_1, x_2 \geq 0$	Analyze	CO 6	CMBB29.6
15	Solve the following LPP by using Simplex method Maximize Z=12x1+15x2+14x3 Subject to $-x1 + x2 \leq 0$ $-x2+2x3 \leq 0$ $x1+x2+x3 \leq 100$ where $x_1, x_2, x_3 \geq 0$	Evaluate	CO 6	CMBB29.6
16	Solve the following LPP by using Simplex method Minimize Z=x1-3x2+3x3 Subject to $3x1 - x2+2x3 \leq 7$ $2x1+4x2 \geq -12$ $-4x1+3x2+8x3 \leq 10$ where $x_1, x_2, x_3 \geq 0$	Remember	CO 5	CMBB29.5
17	Solve the following LP problem graphically Maximize $z = -x_1 + 2x_2$ S.T $x_1 - x_2 \leq -1$, $-0.5x_1 - x_2 \leq 2$, $x_1, x_2 \geq 0$	Understand	CO 5	CMBB29.5
18	Solve the following LP Problem by graphical method Maximize Z=5x1+3x2 Subject to $2x1+x2 \leq 1$ $x1+4x2 \geq 6$ where $x_1, x_2 \geq 0$	Apply	CO 6	CMBB29.6
19	Solve the following LP problem by simplex method. Maximize $z = -x_1 + 2x_2$ S.T $x_1 - x_2 \leq -1$, $-0.5x_1 - x_2 \leq 2$, $x_1, x_2 \geq 0$	Analyze	CO 6	CMBB29.6
20	Solve the following LP problem by two phase method. Maximize $z = 5x_1 + 8x_2$ Subject to $3x_1 + 2x_2 \geq 3$ $x_1 + 4x_2 \geq 0\ 4\ x_1 + x_2$	Evaluate	CO 6	CMBB29.6

	≤ 0 $5x_1 + x_2 \geq 0$ where $x_1, x_2 \geq 0$			
	Part – C (Problem Solving and Critical Thinking)			
1	A Company has three plants at locations A,B and C which supply to warehouses located at D,E,F,G and H. monthly plant capacities are 800,500and900respectively.Monthly warehouse requirements are400,500,400and800unitsrespectively.Unittransportation cost in rupees are given below. D E F G H A 5 8 6 6 3 B 4 7 7 6 5 C 8 4 6 6 4 Determine an optimum distribution for the company in order to minimize the total transportation cost by NWCR.	Understand	CO 5	CMBB29.5
2	A company has factories at F1, F2 and F3 that supply products to ware houses at W1, W2 and W3 .The weekly capacities of the factories are 200,160 and 90 units. The weekly warehouse requirements are 180,120 and 150/units respectively. The unit shipping costs in rupees are as follows. Find the optimal solution W1 W2 W3 Supply F1 16 20 12 200 F2 14 8 18 160 F3 26 24 16 90 Demand 180 120 150 450	Understand	CO 6	CMBB29.6
3	A company has factories at A, B and C which supply warehouses at D, E and F. Weekly factory capacities are 200, 160 and 90 units respectively. Weekly warehouse requirements (demands) are 180, 120 and 150 units respectively. Unit shipping costs are as follows: Factory D E F Capacity A 16 20 12 200 B 14 8 18 160 C 26 24 16 90 Demand 180 120 150 450 Determine the optimum distribution for this company to minimize shipping costs.	Understand	CO 5	CMBB29.5
4	Factories X, Y and Z of a business have a monthly production capacity of a chemical product 22, 15 and 8 tons respectively. This production covers the needs of four consumer centers, which need 7, 12, 17 and 8 tons per month. The cost of transporting one tone (in €) from the factories in the centers of consumption is indicated in the following table. Consumer center Factory I II III IV X 5 2 4 3 Y 4 8 1 6 Z 4 6 7 5	Understand	CO 6	CMBB29.6
5	Solve the following LP problem graphically Maximize $z = 2x_1 + x_2$ Subject to $x_1 + 2x_2 \leq 10$, $x_1 + x_2 \leq 6$, $x_1 - x_2 \leq 2$, $x_1 - 2x_2 \leq 1$ where $x_1, x_2 \geq 0$	Understand	CO 5	CMBB29.5
06	Solve the following LP problem using Simplex method. Maximize $Z = 2x_1 + 5x_2$ $x_1 + 4x_2 \leq 24$, $3x_1 + x_2 \leq 21$,	Understand	CO 6	CMBB29.6

	$x_1 + x_2 \leq 9$, where $x_1, x_2 \geq 0$			
07	Solve the following LPP by using Simplex method Minimize Z=x1 - 3x2+3x3 Subject to 3x1 - x2+2x3≤7 2x1+4x2 ≥ - 12 - 4x1+3x2+8x3≤10 where x1, x2, x3 ≥ 0	Understand	CO 5	CMBB29.5
08	Solve the following LPP by using Big-M method Maximize Z=3x1 - x2 Subject to 2x1 + x2≤2 x1+3x2 ≥3 x2≤4 where x1, x2 ≥ 0	Understand	CO 6	CMBB29.6
09	Solve the following LPP by using Two Phase simplex method Maximize Z=5x1 - 4x2+3x3 Subject to 2x1 +x2 - 6x3=20 6x1+5x2+10x3≤ 76 8x1 - 3x2+6x3≤50 where x1, x2, x3 ≥ 0	Understand	CO 5	CMBB29.5
10	A firm produces three types of biscuits A, B, C it packs them in arrestments of two sizes 1 and 11. The size 1 contains 20 biscuits of type A, 50 of type B and 10 of type C. the size 11 contains 10 biscuits of the A, 80 of type B and 60 of type C. A buyer intends to buy at least 120 biscuits of type A, 740 of type B and 240 of type C. Determine the least number of packets he should buy. Solve the problem by using Simplex method and also verify result graphically.	Understand	CO 6	CMBB29.6
	UNIT–IV			
	DECISION THEORY			
	Part – A (Short Answer Questions)			
1	Define Decision theory? Explain with example.	Remember	CO 8	CMBB29.8
2	Give various decision rules or strategies relevant to decision problem. Describe the meaning of EMV, EOI and EVPI.	Understand	CO 8	CMBB29.8
3	Provide an example in which EVPI can help a manager.	Apply	CO 7	CMBB29.7
4	What is the chief characteristic of Bayesian decision making?	Analyze	CO 7	CMBB29.7
5	What is a payoff matrix?	Evaluate	CO 8	CMBB29.8
6	Write a short note on decision tree.	Remember	CO 7	CMBB29.7
7	Explain the process of backward induction for solving decision trees.	Understand	CO 7	CMBB29.7
8	Give an opportunity loss table, is it possible to compute the corresponding payoff table? Explain why or why not?	Apply	CO 8	CMBB29.8
9	Explain the process of backward induction for solving decision trees.	Analyze	CO 8	CMBB29.8
10	Explain clearly the various ingredients of a decision problem. What are the basic steps of a decision making process?	Evaluate	CO 8	CMBB29.8
	Part – B (Long Answer Questions)			
1	A large steel manufacturing company has three options with regard to production (a) Produce commercially (b) Build pilot plant and (c) Stop producing steel. The management has estimated that their pilot plant, if built, has 0.8 chance of high yield and 0.2 chance of low yield. If the pilot plant does show a high yield, management assigns a probability of 0.75 that the commercial plant will also have a high yield. If the pilot plant shows a low yield, there is only a 0.1 chance that the commercial plant will show a high yield. Finally, management's best assessment of the yield on a commercial-size plant without building a pilot plant first has a 0.6 chance of high yield. A pilot plant will cost Rs. 3,00,000/. The profits earned under high and low yield conditions are Rs. 1,20,00,000/- and – Rs. 12,00,000/- respectively. Find the optimum decision for the company.	Remember	CO 8	CMBB29.8
2	A complex airborne navigating system incorporates a sub-assembly, which unrolls a map of the flight, plan synchronously with the movement of the aeroplane. This subassembly is bought on very good terms from a subcontractor, but is not always	Understand	CO 7	CMBB29.7

	in perfect adjustment on delivery. The subassemblies can be readjusted on delivery to guarantee accuracy at a cost of Rs. 50/- per subassembly. It is not, however, possible to distinguish visually those sub-assemblies that need adjustment. Alternatively, the sub-assemblies can each be tested electronically at a cost of Rs. 10/- per subassembly tested. Past experience shows that about 30 % of those supplied are defective; the probability of the test indicating a bad test indicates a good adjustment when the sub-assembly is found to be faulty when the system has its final check, the cost of subsequent rectification will be Rs. 140/-. Draw up an appropriate decision tree to show the alternatives open to the purchaser and use it to determine its appropriate course of action.			
3	Three strategies and three states of nature are given and payoffs represent profits. (*i*) What is the optimal strategy if we apply the criterion of pessimism? (*ii*) Develop a regret matrix and apply the minimax regret criterion to identify the optimal strategy. State of nature *Strategy* | N1 | N2 | N3 S1 | 47 | 49 | 33 S2 | 32 | 25 | 41 S3 | 51 | 30 | 14	Apply	CO 7	CMBB29.7
4	Explain the concept of expected value. Give general formula for calculating the expected value when we are a finite number of outcomes.	Analyze	CO 8	CMBB29.8
5	Define the term Decision theory. Describe decision models based on the criterion of degree of certainty.	Evaluate	CO 7	CMBB29.7
6	What is a decision? Differentiate between programmed and non-programmed decisions.	Remember	CO 7	CMBB29.7
7	"Decisions that are meant to solve repetitive and well structured problems are known as Programmed decisions". Discuss briefly	Understand	CO 7	CMBB29.7
8	Explain the overall purpose of utility theory. How is a utility curve used in selecting the best decision for a particular problem?	Apply	CO 8	CMBB29.8
9	Identify, define and compare the five characteristics common to all decision problems.	Analyze	CO 8	CMBB29.8
10	Discuss the differences between decision-making under certainty, decision-making under risk and decision-making under uncertainty.	Evaluate	CO 8	CMBB29.8
11	State the basic steps involved in decision making process. Write a brief note on different environments in which decisions are made.	Remember	CO 8	CMBB29.8
12	An oil company may bid for only one of the two contracts for oil drilling in two different areas. It is estimated that a profit of Rs. 30,000 would be realized from the first field and Rs. 40,000 from the second field. These profit amounts have been determined ignoring the costs of bidding which amount to Rs.2,500 for the first field and Rs. 5,000 for the second field. Which oilfield the company should bid for if the probability of getting contract for first field is 0.7 and that of second field is 0.6?	Understand	CO 7	CMBB29.7
13	Let U(x) denote the patient's utility function, where x is the number of months to live. Assuming that U(12) = 1.0 and U(0) = 0, how low can the patient's utility for living 3 months be and still have the operation be preferred? For the rest of the problem, assume that U(3) = 0.8.	Apply	CO 7	CMBB29.7
14	Find out that there is a less risky test procedure that will provide uncertain information that predicts whether or not the patient will survive the operation. When this test is positive, the probability that the patient will survive the operation is increased. The test has the following characteristics: i. True-positive rate: The probability that the results of this test will be positive if the patient will survive the operation is 0.90. ii. False-positive rate: The probability that the results of this test will be positive if the patient will not survive the operation is 0.10. What is the patient's probability of surviving the operation if the test is positive?	Analyze	CO 8	CMBB29.8
15	Although the basic strategy B is appealing, ABC's management has the option of asking the marketing research group to perform a market research study. Within a month, this group can report on whether the study was encouraging (E) or	Evaluate	CO 7	CMBB29.7

	discouraging (D). In the past, such studies have tended to be in the right direction: When market ended up being strong, such studies were encouraging 60% of the time and they were discouraging 40% of the time. Whereas, when market ended up being weak, these studies were discouraging 70% of the time and encouraging 30% of the time. Such a study would cost $500,000. Should management request the market research study or not?			
16	An art dealer has a client who will buy the masterpiece Rain Delay for $50,000. The dealer can buy the painting now for $40,000 (making a prot of $10,000). Alternatively, he can wait one day, when the price will go down to $30,000. The dealer can also wait another day when the price will be $25,000. If the dealer does not buy by that day, then the painting will no longer be available. On each day, there is a 2/3 chance that the painting will be sold elsewhere and will no longer be available. (a) Draw a decision tree representing the dealers decision making process. (b) Solve the tree. What is the dealers expected prot? When should he buy the painting? (c) What is the Expected Value of Perfect Information (value the dealer would place on knowing when the item will be sold)?	Remember	CO 7	CMBB29.7
17	The Scrub Professional Cleaning Service receives preliminary sales contracts from two sources: its own agent and building managers. Historically, 3 8 of the contracts have come from the Scrub agent and 5 8 from building managers. Unfortunately, not all preliminary contracts result in actual sales contracts. Actually, only 1 2 of those preliminary contracts received from building managers result in a sale, whereas 3 4 of those received from the Scrub agent result in a sale. The net return to Scrub from a sale is $6400. The cost of processing and following up on a preliminary contract that does not result in a sale is $320. What is the expected return associated with a preliminary sales contract?	Understand	CO 7	CMBB29.7
19	A finance manager is considering drilling a well. In the post, only 70% of wells drilled were successful at 20 meters depth in that area. Moreover on finding no water at 20 meters, some persons in that area drilled in further up to 25 meters but only 20% struck water at that level. The prevailing cost of drilling is Rs. 500 per meter. The finance manager in his own well, he will have to pay Rs.15,000 to buy water from outside for the same period of getting water from the well. Draw on appropriate decision tree and determine the finance manager's optimal strategy.The following decisions are considered: i. Do not drill any well, ii. Drill up to 20 meters and iii. If no water is found at 20 meters, drill further up to 25 meters.	Apply	CO 8	CMBB29.8
20	A TV dealer finds that the cost of a TV in stock for a week is Rs.30 and the cost of a unit storage is Rs.70. For one particular model of TV the probability distribution of weekly sales is 0, 1, 2, 3, 4, 5, 6 with probability of 0.1, 0.1, 0.2, 0.25, 0.15, 0.15, 0.05 respectively. How many units per week should the dealer order? Also, find E.V.P.I.	Analyze	CO 8	CMBB29.8
	UNIT-V			
	QUEUING THEORY			
	Part - B (Long Answer Questions)			
1	Explain the terms Balking, Reneging, Jockeying.	Remember	CO 9	CMBB29.9
2	Explain the terms single server and multiple server queue length and finite and infinite queue length.	Understand	CO 9	CMBB29.9
3	Customers arrive at box office windows being manned by a single individual, according to a poison input process with a mean rate of 20/hr. the time required to see a customer has an exponential distribution with a mean of 90 sec. Find the avg waiting time of customers. Also determine the avg number of customers in the system and avg queue length.	Apply	CO 9	CMBB29.9
4	A road transport company has one reservation clerk on duty at a time. He handles information of bus schedules and makes reservations customers arrive at a rate of 8 per hour and the clerk can, on an average, service 12 customers per hour. After starting your assumptions determine.	Analyze	CO 10	CMBB29.10

	a. What is the avg number of customer waiting for the service of the clerk b. What is the avg time a customer has to wait before being used?			
5	Consider a single semen queuing system with poisons input and exponential service times. Suppose that mean arrival rate is 3 calling units per hour, the expected service time is 0.25 hours and the maximum permissible calling units is the system is two. Derive the steady state probability distribution of the number of calling units in the system. And then calculate the expected number in the system.	Evaluate	CO 10	CMBB29.10
6	At a railway station only one train is handled at a time. The railway track is sufficient only for two trains to wait while others are given signal to leave the station. Trains arrive at the station at an average rate of 6 per/hours and the railway station can handle them on an average of 12 per/hours. Assuming posission arrivals and exponential service distribution find the steady state probability of the various numbers of trains in the system. Also find the average number of trains in the system.	Remember	CO 10	CMBB29.10
7	Explain the application of Queuing systems?	Understand	CO 10	CMBB29.10
8	In a departmental store one cashier is there to serve the customers. And the customers pick up their needs by themselves the arrival rate is 9 customers for every 5 minutes and the cashier can serve 10 customers in 5 minutes. Assuming poisons arrival rate and exponential distribution for service rate. Find a. Average number of customers in the system b. Average number of customers in the queue of average queue length? c. Average time a customer spends in the systems d. Average time a customer waits before being served.	Apply	CO 10	CMBB29.10
9	A bank has two tellers working on the savings accounts. The first teller only handles withdrawals. The second teller only handles deposits. It has been found that the service time distributions for the deposits and withdrawals both are exponential with mean service time 3 min per customer. Deposition are found to arrive in a poisons fashion throughout the day with a mean arrival rate of 16/hr withdrawals also arrive in a poisons fashion with a mean arrival rate of 14/hr. what would be the effect on the average waiting time for depositors and withdrawals if each teller could handle both the withdrawals and deposits what would be the effect if this could only be accomplished by increasing the service time to 3.5 minutes?	Analyze	CO 10	CMBB29.10
10	A television repairman finds that the time spent on his jobs has an exponential distribution with a mean of 30 minutes. If he repairs the sets in the order in which they came in, and if the arrival of sets follows a poission distribution with an approximate average rate of 10 per 8 hour day, what is the repairman's expected idle time each day? How many jobs are ahead of the average, set just brought in?	Evaluate	CO 10	CMBB29.10
11	Explain with suitable examples about the queue. Why do you consider the study of waiting line as an important aspect?	Remember	CO 9	CMBB29.9
12	Explain with suitable examples about Poisson arrival pattern and exponential service pattern.	Understand	CO 9	CMBB29.9
13	Explain the various types of queues by means of a sketch and also give the situations for which each is suitable.	Apply	CO 9	CMBB29.9
14	Customers arrive at one window drive in a bank according to a Poisson distribution with a mean of 10 per hour. Service time per customer is exponential with a mean of 5 minutes. The space in front of the window, including that for the serviced car can accommodate a maximum, of three cars. Other cars can wait outside the space. (*a*) What is the probability that an arriving customer can drive directly to the space in front of the window? (*b*) What is the probability that an arriving customer will have to wait outside the indicated space? (*c*) How long an arriving customer is expected to wait before starting service? (*d*) How much space should be provided in front of the window so that all the arriving customers can wait in front of the window at least 90 percent of the time?	Analyze	CO 10	CMBB29.10
15	A barber with a one-man shop takes exactly 25 minutes to complete one hair cut. If customers arrive in a Poisson fashion at an average rate of every 40 minutes, how long on the average must a customer wait for service?	Evaluate	CO 10	CMBB29.10
16	At a public telephone booth in a post office arrivals are considered to be Poisson with an average inter-arrival time of 12 minutes. The length of phone call may be assumed to be distributed exponentially with an average of 4 minutes. Calculate	Remember	CO 10	CMBB29.10

	the following: (*a*) What is the probability that a fresh arrival will not have to wait for phone? (*b*) What is the probability that an arrival will have to wait more than 10 minutes before the phone is free? (*c*) What is the average length of queues that form from time to time? (*d*) What is the fraction of time is the phone busy? (*e*) What is the probability that an arrival that goes to the post office to make a phone call will take less than 15 minutes to complete his job? (*f*) The telephone company will install a second booth when convinced that an arrival would expect to have to wait at least 5 minutes for the phone?			
17	At what average rate must a clerk at a super market work in order to ensure a probability of 0.90 that the customer will not wait longer than 12 minutes? It is assumed that there is only one counter at which customer arrive in a Poisson fashion at an average rate of 15 per hour. The length of service by the clerk has an exponential distribution.	Understand	CO 10	CMBB29.10
18	Consider a self-service store with one cashier; assume Poisson arrivals and exponential service times. Suppose that nine customers arrive on the average every 5 minutes and the cashier can serve 10 in 5 minutes. Find: (*a*) The average number of customers queuing for service, (*b*) The probability of having more than 10 customers in the system, (*c*) The probability that a customer has to queue for more than 2 minutes. If the service can be speeded up to 12 in 5 minutes, by using a different cash register, what will be the effect on the quantities of (*a*), (*b*) and (*c*) above?	Apply	CO 10	CMBB29.10
19	The mean rate of arrival of planes at an airport during the peak period is 20 per hour, but the actual number of arrivals in an hour follows the Poisson distribution. The airport can land 60 planes per hour on an average in good weather, or 30 per hour in bad weather, but the actual number landed in any hour follows a Poisson distribution with the respective averages.When there is congestion, the planes are forced to fly over the field in the stock awaiting the landing of other planes that arrived earlier. (*a*) How many planes would be flying over the field in the stack on an average in good weather and in bad weather? (*b*) How long a plane would be in the stack and the process of landing in good and bad weather? (*c*) How much stack and landing time to allow so that priority to land out of order would have to be requested only one time in twenty.	Analyze	CO 10	CMBB29.10
20	Customers arrive at a booking office window, being manned by a single individual at a rate of 25 per hour. Time required to serve a customer has exponential distribution with a mean of 120 seconds. Find the average time of a customer.	Evaluate	CO 10	CMBB29.10
	Part – C (Problem Solving and Critical Thinking)			
1	Repair shop attended by a single machine has average of four customers an hour who bring small appliances for repair. The mechanic inspects them for defects and quite often can fix them right away or otherwise render a diagnosis. This takes him six minutes, on the average. Arrivals are Poisson and service time has the exponential distribution. You are required to: (*a*) Find the proportion of time during which the shop is empty. (*b*) Find the probability of finding at least one customer in the shop? (*c*) What is the average number of customers in the system? (*d*) Find the average time spent, including service.	Analyze	CO 9	CMBB29.9
2	The belt snapping for conveyors in an open cast mine occur at the rate of 2 per shift. There is only one hot plate available for vulcanizing; and it can vulcanize on an average 5 belts snap per shift. (*a*) What is the probability that when a belt snaps, the hot plate is readily available? (*b*) What is the average number in the system? (*c*) What is waiting time of an arrival? (*d*) What is the average waiting time plus vulcanizing time?	Apply	CO 10	CMBB29.10
3	A repairman is to be hired to repair machines which breakdown at an average rate of 6 per hour. The breakdown follows Poisson distribution. The productive time of a machine considered costing Rs. 20/- per hour. Two repairmen, Mr. X and Mr. Y have been interviewed for this purpose. Mr. X charges Rs. 10/- per hour and he services breakdown machines at the rate of 8 per hour. Mr. Y demands Rs. 14/- per hour and he services on an average rate of 12 per hour. Which repairman should be hired? Assume 8- hour shift per day.	Analyze	CO 9	CMBB29.9

4	A super market has two girls ringing up sales at counters. If the service time for each customer is exponential with mean of 4 minutes, and if people arrive in a Poisson fashion at the rate of 10 per hour. Find (*a*) What is the probability of having to wait for service? (*b*) What is the expected percentage of idle time for each girl? (*c*) If a customer has to wait, what is the expected length of waiting time?	Apply	CO 10	CMBB29.10
5	Given an arrival rate of 20 per hour, is it better for a customer to get service at a single channel with mean service rate of 22 customers or at one of two channels in parallel, with mean service rate of 11 customers for each of the two channels? Assume that both queues are of M/M/S type.	Analyze	CO 9	CMBB29.9
6	In machine maintenance, a mechanic repairs four machines. The mean time between service requirement is 5 hours for each machine and forms an exponential distribution. The men repair time is one hour and also follows the same distribution pattern. Machine down time cost Rs. 25/- per hour and the mechanic costs Rs 55/- per day of 8 hours. (*a*) Find the expected number of operating machines. (*b*) Determine expected down time cost per day (*c*) Would it be economical to engage two mechanics each repairing two machines?	Apply	CO 10	CMBB29.10
7	Four counters are being run on the frontier of a country to check the passports and necessary papers of the tourists. The tourists choose a counter at random. If the arrivals at the frontier is Poisson at the rate λ and the service is exponential with parameter μ, what is the steady state average queue at each counter?	Analyze	CO 9	CMBB29.9
8	In a huge workshop tools are store in a tool crib. Mechanics arrive at the tool crib for taking the tools and lend them back after they have used them. It is found that the average time between arrivals of mechanics at the crib is 35 seconds. A clerk at the crib has been found to take on an average 50 seconds to serve a mechanic (either hand him the tools if he requests them or receive tools if he is returning the tools). If the labour cost of a clerk is Re. 1/- per hour and that of a mechanic is Rs. 2.50 per hour, find out how many clerks should be appointed at the tool crib to minimize the total cost of mechanic.s waiting time plus clerk.s idle time.	Apply	CO 10	CMBB29.10
9	A barber runs his own saloon. It takes him exactly 25 minutes to complete on haircut. Customers arrive in a Poisson fashion at an average rate of one every 35 minutes. (*a*) For what percent of time would the barber be idle? (*b*) What is the average time of a customer spent in the shop?	Analyze	CO 9	CMBB29.9
10	Explain the various types of queues by means of a sketch and also give the situations for which each is suitable.	Apply	CO 10	CMBB29.10

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