**K L University**

**Department of Computer Science and Engineering**

**Course Handout for II Year B. Tech PROGRAM**

**A.Y.2020-21, I Semester**

**Course Name  :**Mathematical Programming-1

**Course Code  :19CS2104(A)**

**L-T-P-S Structure :3-2-2-0**

**Course Credits :**6

**Course Coordinator   :**Dr.E.Vamsidhar

**Course Instructors      : Dr. M.Sreedevi, Dr.M.Narasinga Rao, Dr.K.Bhanuprakash, Dr.Chayan Paul, Dr. S.Srinivas Rao, Dr.Sheela Rani, Dr.Ismail, Dr.Rajesh, Mr. K.V.Raju, Ms. Praveena, Ms. V.Lakshmi, Dr. Suresh Kumar, Dr. Ramana Murthy, Dr. Srimannarayana, Dr.Vijay Prasad, Dr. Bhagavan, Dr.Vedavathi, Dr.Balaji, Dr.Nageswararao**

**Course Teaching Associates : -- NIL**

**Course Objective:** Understand the basic theory and methods for linear programming problems. Apply branch and bound and/or cutting plane algorithms to solve integer programming problems.Apply these techniques constructively to make effective business decisions. Use a computer package to solve a mathematical programing problem that arises in practice.

**Course Rationale:** The course will cover a range of topics inLinear Programming Problems, Transportation and Assignment Problems with the objective of providing an exposure to formulate the problems and solve business problems. The emphasis is on studying and analyzing fundamental issues in LPP. Apply various computational methods and tools, working in teams to solve the problems in real world using the mathematical and computational methods.

**Learning objectives**

At the end of the unit, the students should be able to

* Build a mathematical programming model of a real-life situation
* Understand the basic theory and methods for linear programming problems
* Understand how different ways to formulate optimization problems can affect the practical solvability of the problem
* Structure technical and economical planning problems so that they can be formulated as mathematical programs
* Understand the basic properties of the interior point method and how to use it to solve complex problems
* Apply branch and bound and/or cutting plane algorithms to solve integer programming problems
* Use a computer package to solve a mathematical programming problem that arises in practice
* Work in teams

**Course Outcomes (CO):**

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| --- | --- | --- | --- |
| CO No: | Cos | BTL | PO/PSO |
| CO1 | Solve linear programing problems in engineering and business decision making problems | 3 | PO2, PSO2 |
| CO2 | Make use of Duality and Sensitivity Analysis in Linear Programming models. | 3 | PO2,PSO2 |
| CO3 | Solve network models and LPP using interior point methods. | 3 | PO2,PSO2 |
| CO4 | Apply Cutting plane and Branch and Bound methods to solve Discrete optimization problems. | 3 | PO2,PSO2 |

**Program Outcomes & Program Specific Outcomes (POs/PSOs)**

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| --- | --- | --- |
| PO No. | Keyword | Program Outcome Description |
| 1 | Engineering Knowledge | An ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization for the solution of complex engineering problems. |
| 2 | Problem Analysis | An ability to identify, formulate, research literature, analyse complex engineering problems in mechanical engineering using first principles of mathematics, natural sciences and engineering sciences |
| 3 | Design/ development of solutions | An ability to design solutions for complex engineering problems and system component or processes that meet the specified needs considering public health & safety and cultural, societal & environment |
| 4 | Conduct investigations of complex problems | An ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions. |
| 5 | Modern tool usage | Ability to create, select and apply appropriate techniques, resources and modern engineering activities, with an understanding of the limitations |
| 6 | The engineer and society | Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice |
| 7 | Environment and sustainability | Ability to demonstrate the knowledge of engineering solutions, contemporary issues understanding their impacts on societal and environmental contexts, leading towards sustainable development |
| 8 | Ethics | An ability to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice |
| 9 | Individual and teamwork | An ability to function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings |
| 10 | Communication | An ability to Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| 11 | Project management and finance | Ability to demonstrate knowledge and understanding of the engineering and management principles and apply those one’s own work, as a member and leader in team, to manage projects and in multi-disciplinary environments |
| 12 | Lifelong learning | An ability to recognize the need for and having the preparation and ability to engage independent and life-long learning in broadest context of technological change |

|  |  |
| --- | --- |
| PSO1 | An ability to design and develop software projects as well as to analyse and test user requirements. |
| PSO2 | Working knowledge on emerging software tools and technologies. |

**COURSE OUTCOME INDICATORS (COI):**

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| --- | --- | --- | --- |
|  | COI1 | COI2 | COI3 |
| CO1 | Define Linear programming and basic terminology. | Formulation of linear programming problems(LPP) in engineering and business decision making problems | Solve LPP using graphical and simplex methods. |
| CO2 | Recognize the importance of duality and sensitivity analysis in LPP | Describe the procedure in Duality and sensitivity analysis for LPP | Utilize duality in solving LPP and demonstrate sensitivity analysis. |
| CO3 | List the network models and their importance in decision making problems | Illustrate the procedure for solving network models such as transportation and assignment problems and interior point methods | Apply interior point methods for solving LPP and solve transportation and assignment problems. |
| CO4 | Identify discrete optimization/integer programming problems | Illustrate the algorithm for solving integer programming problems using cutting plan and Branch and bound techniques. | Apply cutting plan and branch and bound methods to solve discrete optimization problems. |

**SYLLABUS (As approved by BoS):**

**Mathematical Programming - I L-T-P-S: 3-2-2-0**

Linear programs formulation through examples from engineering / business decision making problems;Linear Programming in Matrix Form. Preliminary theory and the geometry of linear optimization, Solving Linear Programs, Simplex method,

Sensitivity Analysis

Duality in Linear Programming.

Karmarkar’s interior point method, Interior point methods.

Network Models,Transportation problems.

Discrete optimization formulations and algorithms.

Integer Programming: Cutting plane and Branch and Bound methods.

Solving real world problems with computer software.

Text Books

1. Applied Mathematical Programming by Bradley, Hax, and Magnanti (Addison-Wesley, 1977)
2. Introduction to Linear Optimization by Bertsimas, Dimitris, and John Tsitsiklis. Belmont, MA: Athena Scientific, 1997.

Reference books

1. Numerical Recipes, The art of Scientific Computing by William H. Press, Saul A. Teukolsky, W.T. Vetterling, Brian P. Flannery, 3rd Edition, Cambridge University Press, 2007, UK.
2. Operations Research: An Introduction by H. A. Taha, Prentice Hall.
3. Operations Research by S. D. Sharma, Kedar Nath Ram Nath & Co.
4. LINEAR PROGRAMMING and Network flows by MOKHTAR S. BAZARAA, John J. Jarvis and HANIF D. SHERALI
5. Introduction to Linear Optimization by Dimitris Bertsimas and John Tsitsiklis

**Other Books, References: (As recommended for reference by the course team, if any)**

Web Resources:

1. <http://web.mit.edu/15.053/www/AMP.htm>
2. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-251j-introduction-to-mathematical-programming-fall-2009/index.htm>
3. <https://www.coursera.org/learn/discrete-optimization>
4. <https://www.coursera.org/learn/solving-algorithms-discrete-optimization>
5. <https://www.edx.org/course/convex-optimization>
6. <http://people.brunel.ac.uk/~mastjjb/jeb/or/ip.html>
7. <https://ocw.mit.edu/courses/mathematics/18-433-combinatorial-optimization-fall-2003/>

**Deviations (if any) from BoS approved syllabus and the topics planned:**

**COURSE DELIVERY PLAN:**

| **Sess. No.** | **CO** | **COI** | **Topic (s)** | **Book No [CH No] [Page No]** | **Teaching-Learning Methods** | **Evaluation Components** |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 | Introduction to Mathematical Programming | B.No.-1 [CH 1] [Page No. 1-5] | **PPT, Board &Marker** | Test-1;ALM; ATTENDANCE; End Exam |
| 2 | 1 | 1 | Mathematical Modeling of Linear Programming Problem | B. No.-1 [CH 1] [Page No. 5-10] | **PPT, Board &Marker** | Test-1;ALM; ATTENDANCE; End Exam |
| 3 | 1 | 1 | The Geometry of Linear Optimization | B. No.-1 [CH 1] [Page No. 11-15] | **PPT, Board &Marker** | Test-1;ALM; ATTENDANCE; End Exam |
| 4 | 1 | 1 | Special cases that arise the application of the graphical method | B. No.-1 [CH 1] [Page No. 16-20] | **PPT, Board &Marker** | Test-1;ALM; ATTENDANCE; End Exam |
| 5 | 1 | 2 | Simplex Method | B. No.-1 [CH 2] [Page No. 44-70] | **PPT, Board &Marker** | Test-1;ALM; ATTENDANCE; End Exam |
| 6 | 1 | 2 | Simplex Method (Problem solving) | B. No.-1 [CH 2] [Page No. 44-70] | **PPT, Board &Marker** | Test-1;ALM; ATTENDANCE; End Exam |
| 7 | 1 | 2 | Big - M Method | B. No.-1 [CH 2] [Page No. 44-70] | **PPT, Board &Marker** | Test-1;ALM; ATTENDANCE; End Exam |
| 8 | 1 | 2 | Big - M Method (Problem solving) | B. No.-1 [CH 2] [Page No. 44-70] | **PPT, Board &Marker** | Test-1;ALM; ATTENDANCE; End Exam |
| 9 | 2 | 1 | Explain Duality and Primal linear Programming Problem | 1[CH.4] [P.130] | **PPT, &Virtual classroom** | Test-1;ALM; ATTENDANCE; End Exam |
| 10 | 2 | 1 | Formulation of Dual Problem | 1[CH.4] [P.134] | **PPT, &Virtual classroom** | Test-1;ALM; ATTENDANCE; End Exam |
| 11 | 2 | 2 | Solve LPP using Dual Simplex Method | 1[CH.4] [P.147] | **PPT, &Virtual classroom** | Test-1;ALM; ATTENDANCE; End Exam |
| 12 | 2 | 2 | Solve LPP using Dual Simplex Method | 1[CH.4] [P.147] | **PPT, &Virtual classroom** | Test-1;ALM; ATTENDANCE; End Exam |
| 13 | 2 | 3 | Explain Sensitivity Analysis and Solve LPP by changing right-hand side constants of the constraints | 1[CH.3] [P.76,84] | **PPT, &Virtual classroom** | Test-1;ALM; ATTENDANCE; End Exam |
| 14 | 2 | 3 | Solve LPP by making changes in the objective function coefficients | 1[CH.3] [P.81-84] | **PPT, &Virtual classroom** | Test-1;ALM; ATTENDANCE; End Exam |
| 15 | 2 | 3 | Solve LPP by adding a new constraint and by adding a new variable | 1[CH.3] [P.86] | **PPT, &Virtual classroom** | Test-1;ALM; ATTENDANCE; End Exam |
| 16 | 3 | 1 | Network Models- transportation problems | T Book [3],  T Book [4] | Explanation including Evaluation | In Semester Exam-II and Semester End Exam |
| 17 | 3 | 2 | Transportation Problems- Balanced Case- Initial solution Methods | T Book [3],  T Book [4] | Lecturing,  Discussion | In Semester Exam-II and Semester End Exam |
| 18 | 3 | 2 | Vogel Approximation Method | T Book[1],  Pp 248 - Pp 250 | PPT,  Lecturing ,  Discussion | In Semester Exam-II, ALM, Attendence and Semester End Exam |
| 19 | 3 | 3 | Transportation Problems- Balanced Case- Obtaining Optimal solution by using UV Method | T Book [3],  T Book [4] | Lecturing,  Discussion | In Semester Exam-II and Semester19End Exam |
| 20 | 3 | 3 | Transportation Problems- Un Balanced Case- Optimal solution by UV Method | T Book [3],  T Book [4] | Lecturing,  Discussion | In Semester Exam-II and Semester End Exam |
| 21 | 3 | 3 | Solving transportation problem using Mody method | T Book [3],  T Book [4] | Lecturing,  Discussion | In Semester Exam-II and Semester End Exam |
| 22 | 3 | 3 | Assignment Problems - Balanced and Unbalanced Cases | T Book [3],  T Book [4] | Lecturing,  Discussion | In Semester Exam-II and Semester End Exam |
| 23 | 3 | 1 | Interior point methods and their applications | T Book [3],  T Book [4] | Lecturing,  Discussion | In Semester Exam-II and Semester End Exam |
| 24 | 3 | 3 | Interior point methods algorithms | T Book [3],  T Book [4] | Lecturing,  Discussion | In Semester Exam-II and Semester End Exam |
| 25 | 3 | 3 | Karmarkar's interior point method and algorithm | T Book [3],  T Book [4] | Lecturing,  Discussion, | In Semester Exam-II and Semester End Exam |
| 26 | 4 | 1 | Introduction to Integer programming problems. | B.No.1  [CH No. 9] [Page No. 272-276] | **PPT, Virtual classroom** | Test-2; ALM; ATTENDANCE; End Exam |
| 27 | 4 | 1 | Formulation of Integer programming problems. | B.No.1  [CH No. 9] [Page No. 276-280] | **PPT, Virtual classroom** | Test-2; ALM; ATTENDANCE; End Exam |
| 28 | 4 | 3 | Algorithm to solve I.P.P. by using Gomory (cutting plane) method | B.No.1  [CH No. 9] [Page No. 287-289] | **PPT, Virtual classroom** | Test-2; ALM; ATTENDANCE; End Exam |
| 29 | 4 | 3 | Problems on Gomory cutting plane method | B.No.1  [CH No. 9] [Page No. 301-305] | **PPT, Virtual classroom** | Test-2; ALM; ATTENDANCE; End Exam |
| 30 | 4 | 3 | Algorithm to solve I.P.P. by using branch and bound method | B.No.1  [CH No. 9] [Page No. 289-292] | **PPT, Virtual classroom** | Test-2; ALM; ATTENDANCE; End Exam |
| 31 | 4 | 3 | Problems on branch and bound method | B.No.1  [CH No. 9] [Page No. 292-297] | **PPT, Virtual classroom** | Test-2; ALM; ATTENDANCE; End Exam |
| 32 | 4 | 3 | Introduction zero-one Programming problems | B.No.1  [CH No. 9] [Page No. 297-301] | **PPT, Virtual classroom** | Test-2; ALM; ATTENDANCE; End Exam |
| 33 | 4 | 3 | **Necessary requirements Rules for Additive Algorithm** | B.No.1  [CH No. 9] [Page No. 302-303] | **PPT, Virtual class room** | Test-2; ALM; ATTENDANCE; End Exam |
| 34 | 4 | 3 | **Problems on Additive Algorithm method** | B.No.1  [CH No. 9] [Page No. 303-307] | **PPT, Virtual class room** | Test-2; ALM; ATTENDANCE; End Exam |
| 35 | 4 | 3 | **Revision on Co-4** | - | **-** | Test-2; ALM; ATTENDANCE; End Exam |

**Lecture with Problem Solving**

**Session wise Teaching – Learning Plan**

**Session Number: 1**

**Session Outcome:** Explain Introduction to Mathematical Programming

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | PPT&VirtualClass Room |  |
| 15 | Explain Introduction to Mathematical Programming | 1 | PPT & Virtual Classroom |  |
| 5 | Questions on Mathematical programming | 1 | PPT & Virtual Classroom | Q&A |
| 20 | Real life examples on Mathematical linear programming problem | 1 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 1 | PPT & Virtual Classroom |  |

**Session Number: 2**

**Session Outcome:** Mathematical Modeling of Linear Programming Problem

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | PPT & Virtual Classroom |  |
| 15 | Mathematical Modeling of Linear Programming Problem | 1 | PPT & Virtual Classroom |  |
| 5 | Questions on linear programming problem | 1 | PPT & Virtual Classroom | Q&A |
| 20 | Problems on Mathematical Modeling of Linear Programming Problem | 1 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 1 | PPT & Virtual Classroom |  |

**Session Number: 3**

**Session Outcome: The Geometry of Linear Optimization**

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 2 | PPT & Virtual Classroom |  |
| 15 | The Geometry of Linear Optimization | 2 | PPT & Virtual Classroom |  |
| 5 | Questions on the Geometry of Linear Optimization | 2 | PPT & Virtual Classroom | Q&A |
| 20 | Problems on Graphical method | 2 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 2 | PPT & Virtual Classroom |  |

**Session Number: 4**

**Session Outcome: Special cases that arise the application of the graphical method**

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 2 | PPT & Virtual Class Room |  |
| 15 | Special cases that arise the application of the graphical method | 2 | PPT & Virtual Class Room |  |
| 5 | Questions on Graphical method | 2 | PPT & Virtual Class Room | Q&A |
| 20 | Problems on unbounded and infeasible region | 2 | PPT & Virtual Class Room |  |
| 5 | Problems Discussion | 2 | PPT & Virtual Class Room |  |

**Session Number: 5**

**Session Outcome: Simplex Method**

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 3 | PPT & Virtual Class Room |  |
| 15 | Explain Simplex Method | 3 | PPT & Virtual Class Room |  |
| 5 | Questions on Simplex method | 3 | PPT & Virtual Class Room | Q&A |
| 20 | Problems on Simplex Method | 3 | PPT & Virtual Class Room |  |
| 5 | Problems Discussion | 3 | PPT & Virtual Class Room |  |

**Session Number: 6**

**Session Outcome: Simplex Method (Problem solving)**

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 3 | PPT & Virtual Class Room |  |
| 15 | Explain simplex method for minimization problem | 3 | PPT & Virtual Class Room |  |
| 5 | Questions on Simplex method | 3 | PPT & Virtual Class Room | Q&A |
| 20 | Problems simplex method for minimization problem | 3 | PPT & Virtual Class Room |  |
| 5 | Problems Discussion | 3 | PPT & Virtual Class Room |  |

**Session Number: 7**

**Session Outcome: Big - M Method**

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 3 | PPT & Virtual Classroom |  |
| 15 | Explain of Big - M Method | 3 | PPT & Virtual Classroom |  |
| 5 | Questions on Big - M Method | 3 | PPT & Virtual Classroom | Q&A |
| 20 | Problems on Big - M Method | 3 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 3 | PPT&Virtual Classroom |  |

**Session Number: 8**

**Session Outcome: Big - M Method (Problem solving)**

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 3 | PPT & Virtual Classroom |  |
| 15 | Explain of Big - M Method problems | 3 | PPT & Virtual Classroom |  |
| 5 | Questions on Big - M Method | 3 | PPT & Virtual Classroom | Q&A |
| 20 | Problems on Big - M Method | 3 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 3 | PPT&Virtual Classroom |  |

**Session wise Teaching – Learning Plan**

**Session Number: 9**

**Session Outcome:** Explain Duality and Primal linear Programming Problem

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap;Poll/Pop Question | 1 | PPT&Virtual Classroom |  |
| 15 | Explain Duality and Primal linear Programming Problem | 1 | PPT & Virtual Classroom |  |
| 5 | Questions on Duality | 1 | PPT & Virtual Classroom | Q&A |
| 20 | Problems on Duality and Primal LPP to students | 1 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 1 | PPT & Virtual Classroom |  |

**Session Number: 10**

**Session Outcome:** Formulation of Dual Problem

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | PPT & Virtual Classroom |  |
| 15 | Formulation of Dual Problem | 1 | PPT & Virtual Classroom |  |
| 5 | Questions on primal dual problem | 1 | PPT & Virtual Classroom | Q&A |
| 20 | Problems on Duality and Primal LPP to students | 1 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 1 | PPT & Virtual Classroom |  |

**Session Number: 11**

**Session Outcome:** Solve LPP using Dual Simplex Method

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 2 | PPT & Virtual Classroom |  |
| 15 | Solve LPP using Dual Simplex Method | 2 | PPT & Virtual Classroom |  |
| 5 | Questions on Dual Simplex Method | 2 | PPT & Virtual Classroom | Q&A |
| 20 | Problems on LPP using Dual Simplex Method | 2 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 2 | PPT & Virtual Classroom |  |

**Session Number: 12**

**Session Outcome:** Solve LPP using Dual Simplex Method

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 2 | PPT & Virtual Classroom |  |
| 15 | Solve LPP using Dual Simplex Method | 2 | PPT & Virtual Classroom |  |
| 5 | Questions on Dual Simplex Method | 2 | PPT & Virtual Classroom | Q&A |
| 20 | Problems on LPP using Dual Simplex Method | 2 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 2 | PPT & Virtual Classroom |  |

**Session Number: 13**

**Session Outcome:** Explain Sensitivity Analysis and Solve LPP by changing right-hand side constants of the constraints

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 3 | PPT & Virtual Classroom |  |
| 15 | Explain Sensitivity Analysis | 3 | PPT & Virtual Classroom |  |
| 5 | Questions on Sensitivity Analysis | 3 | PPT & Virtual Classroom | Q&A |
| 20 | Problems on LPP changing right-hand side constants of the constraints | 3 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 3 | PPT & Virtual Classroom |  |

**Session Number: 14**

**Session Outcome:** Solve LPP by making changes in the objective function coefficients

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 3 | PPT & Virtual Classroom |  |
| 15 | Explain changes in the objective function coefficients | 3 | PPT & Virtual Classroom |  |
| 5 | Questions | 3 | PPT & Virtual Classroom | Q&A |
| 20 | Problems on LPP changes in the objective function coefficients | 3 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 3 | PPT & Virtual Classroom |  |

**Session Number: 15**

**Session Outcome:** Solve LPP by adding a new constraint and by adding a new variable

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 3 | PPT & Virtual Classroom |  |
| 15 | Explain adding a new constraint and by adding a new variable | 3 | PPT & Virtual Classroom |  |
| 5 | Questions | 3 | PPT & Virtual Classroom | Q&A |
| 20 | Problems on LPP adding a new constraint and by adding a new variable coefficient | 3 | PPT & Virtual Classroom |  |
| 5 | Problems Discussion | 3 | PPT& Virtual Classroom |  |

**Session wise Teaching – Learning Plan**

**Session Number: 16**

**Session Outcome:** Understand Network Models in engineering science.

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| **5** | Attendance/Recap ;Poll/Pop Question | **1** |  |  |
| 15 | Network Models- transportation problems | 2 | Discussion |  |
| 5 | Breakout room | 1 |  |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat | 2 | Discussion and interaction |  |
| 5 | Problems for practice/ Discussion | 2 | Discussion and interaction |  |
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**Session wise Teaching – Learning Plan**

**Session Number: 17**

**Session Outcome:** Solve initial basic feasible solution of Transportation Problem.

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| **5** | Attendance/Recap ;Poll/Pop Question | **1** |  |  |
| 15 | Transportation Problems- Balanced Case- Initial solution Methods | 2 | Discussion |  |
| 5 | Breakout |  |  |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat | 2 | Discussion and interaction |  |
| 5 | Problems for practice/ Discussion | 2 | Discussion and interaction |  |
|  | | | | |

**Session Number: 18**

**Session Outcome:**  Solve initial basic feasible solution of Transportation Problem using Vogel approximation method.

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| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| **5** | Attendance/Recap ; Poll/Pop Question | **1** |  |  |
| 15 | Transportation Problems- Initial basic feasible solution-Vogel approximation method | 2 | Discussion |  |
| 5 | Breakout |  |  |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat | 3 | Discussion and interaction |  |
| 5 | Problems for practice/ Discussion | 2 | Discussion and interaction |  |
|  | | | | |

**Session wise Teaching – Learning Plan**

**Session Number: 19**

**Session Outcome:** Find optimal solution of the balanced Transportation Problem

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| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| **5** | Attendance/Recap ;Poll/Pop Question | **1** |  |  |
| 15 | Transportation Problems- Balanced Case- Obtaining Optimal solution by using UV Method | 3 | Discussion |  |
| 5 | Breakout time |  |  |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat | 3 | Discussion and interaction |  |
| 5 | Problems for practice/ Discussion | 2 | Discussion and interaction |  |
|  | | | | |

**Session wise Teaching – Learning Plan**

**Session Number: 20**

**Session Outcome:** Find optimal solution of the balanced Transportation Problem

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| **5** | Attendance/Recap ;Poll/Pop Question | **3** |  |  |
| 15 | Transportation Problems- Un Balanced Case- Optimal solution by UV Method | 3 | Discussion |  |
| 5 | Breakout time |  |  |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat | 2 | Discussion and interaction |  |
| 5 | Problems for practice | 3 | Discussion and interaction |  |
|  | | | | |

**Session wise Teaching – Learning Plan**

**Session Number: 21**

**Session Outcome:** Use of Mody method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| **5** | Attendance/Recap ;Poll/Pop Question | **1** |  |  |
| 15 | Transportation Problems- Un Balanced Case- Mody method | 2 | Discussion |  |
| 5 | Breakout time |  |  |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat | 3 | Discussion and interaction |  |
| 5 | Problems for practice | 3 | Discussion and interaction |  |
|  | | | | |

**Session wise Teaching – Learning Plan**

**Session Number: 22**

**Session Outcome:** Solve assignment problems

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| **5** | Attendance/Recap ;Poll/Pop Question | **1** |  |  |
| 15 | Assignment Problems - Balanced and Unbalanced Cases | 2 | Discussion |  |
| 5 | Breakout time |  |  |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat | 2 | Discussion and interaction |  |
| 5 | Problems for practice / Discussionz | 2 | Discussion and interaction |  |
|  | | | | |

**Session wise Teaching – Learning Plan**

**Session Number: 23**

**Session Outcome:** Understanding Interior point methods and their importance.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| **5** | Attendance/Recap ;Poll/Pop Question |  |  |  |
| 15 | Interior point methods - problems & illustration | 2 | Discussion |  |
| 5 | Breakout time |  |  |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat | 2 | Discussion and interaction |  |
| 5 | Problems for practice/ Discussions | 1 | Discussion and interaction |  |
|  | | | | |

**Session wise Teaching – Learning Plan**

**Session Number: 24**

**Session Outcome:** Describe the algorithm for interior point methods

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| **5** | Attendance/Recap ;Poll/Pop Question | **1** |  |  |
| 15 | Interior point methods algorithm and illustration | 2 | Discussion |  |
| 5 | Breakout time |  |  |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat | 2 | Discussion and interaction |  |
| 5 | Problems for practice / Discussion | 2 | Discussion and interaction |  |
|  | | | | |

**Session wise Teaching – Learning Plan**

**Session Number: 25**

**Session Outcome:** Describe Karmarkar's interior point method algorithm.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| **5** | Attendance/Recap ;Poll/Pop Question | **1** |  |  |
| 15 | Karmarkar's interior point method - algorithm & illustration | 3 | Discussion |  |
| 5 | Breakout time |  |  |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat | 3 | Discussion and interaction |  |
| 5 | Problems for practice/ Discussion | 2 | Discussion and interaction |  |
|  | | | | |

**Lecture with Problem Solving**

**Session wise Teaching – Learning Plan**

**Session Number: 26**

**Session Outcome: Introduction to Integer programming problems.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | **PPT, Virtual class room** |  |
| 15 | **Introduction to Integer programming problems.** | 1 | **PPT, Virtual class room** |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | **PPT, Virtual class room** |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat | 1 | **PPT, Virtual class room** | Q & A |
| 5 | Problems Discussion | 1 | **PPT, Virtual class room** |  |

**Lecture with Problem Solving**

**Session wise Teaching – Learning Plan**

**Session Number: 27**

**Session Outcome: Formulation of Integer programming problems.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | **PPT, Virtual class room** |  |
| 15 | **Formulation of Integer programming problems.** | 2 | **PPT, Virtual class room** |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | **PPT, Virtual class room** |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat |  | **PPT, Virtual class room** | Q & A |
| 5 | Problems Discussion |  | **PPT, Virtual class room** |  |

**Lecture with Problem Solving**

**Session wise Teaching – Learning Plan**

**Session Number: 28**

**Session Outcome: Algorithm to solve I.P.P. by using Gomory (cutting plane) method**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | **PPT, Virtual class room** |  |
| 15 | **Algorithm to solve I.P.P. by using Gomory (cutting plane) method** | 2 | **PPT, Virtual class room** |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | **PPT, Virtual class room** |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat |  | **PPT, Virtual class room** | Q & A |
| 5 | Problems Discussion |  | **PPT, Virtual class room** |  |

**Session wise Teaching – Learning Plan**

**Session Number: 29**

**Session Outcome: Problems on Gomory cutting plane method**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | **PPT, Virtual class room** |  |
| 15 | **Problems on Gomory cutting plane method** | 3 | **PPT, Virtual class room** |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | **PPT, Virtual class room** |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat |  | **PPT, Virtual class room** | Q & A |
| 5 | Problems Discussion |  | **PPT, Virtual class room** |  |

**Session wise Teaching – Learning Plan**

**Session Number: 30**

**Session Outcome: Algorithm to solve I.P.P. by using branch and bound method**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | **PPT, Virtual class room** |  |
| 15 | **Algorithm to solve I.P.P. by using branch and bound method** | 2 | **PPT, Virtual class room** |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | **PPT, Virtual class room** |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat |  | **PPT, Virtual class room** | Q & A |
| 5 | Problems Discussion |  | **PPT, Virtual class room** |  |

**Session wise Teaching – Learning Plan**

**Session Number: 31**

**Session Outcome: Problems on branch and bound method**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | **PPT, Virtual class room** |  |
| 15 | **Problems on branch and bound method** | 3 | **PPT, Virtual class room** |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | **PPT, Virtual class room** |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat |  | **PPT, Virtual class room** | Q & A |
| 5 | Problems Discussion |  | **PPT, Virtual class room** |  |

**Session wise Teaching – Learning Plan**

**Session Number: 32**

**Session Outcome: Introduction zero-one Programming problems**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | **PPT, Virtual class room** |  |
| 15 | **Introduction zero-one Programming problems** | 2 | **PPT, Virtual class room** |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | **PPT, Virtual class room** |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat |  | **PPT, Virtual class room** | Q & A |
| 5 | Problems Discussion |  | **PPT, Virtual class room** |  |

**Session wise Teaching – Learning Plan**

**Session Number: 33**

**Session Outcome: Introduction-Additive Algorithm method**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ; Poll/Pop Question | 1 | **PPT, Virtual class room** |  |
| 15 | **Introduction Additive Algorithm method** | 2 | **PPT, Virtual class room** |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | **PPT, Virtual class room** |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat |  | **PPT, Virtual class room** | Q & A |
| 5 | Problems Discussion |  | **PPT, Virtual class room** |  |

**Session wise Teaching – Learning Plan**

**Session Number: 34**

**Session Outcome: Problems on Additive Algorithm method**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ; Poll/Pop Question | 1 | **PPT, Virtual class room** |  |
| 15 | **Problems on Additive Algorithm method** | 2 | **PPT, Virtual class room** |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | **PPT, Virtual class room** |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat |  | **PPT, Virtual class room** | Q & A |
| 5 | Problems Discussion |  | **PPT, Virtual class room** |  |

**Session wise Teaching – Learning Plan**

**Session Number: 35**

**Session Outcome: Revision on CO-4 Algorithms**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ; Poll/Pop Question | 1 | **PPT, Virtual class room** |  |
| 15 | **Revision on CO-4 Algorithms** | 2 | **PPT, Virtual class room** |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | **PPT, Virtual class room** |  |
| 20 | Problems as Assignment/Quiz (ALM) Doubts can be asked in Public Chat |  | **PPT, Virtual class room** | Q & A |
| 5 | Problems Discussion |  | **PPT, Virtual class room** |  |

**TUTORIAL COMPONENT**

List of Experiments supposed to finish in Open Lab Sessions: The student must implement these programs in the Lab.

|  |  |  |
| --- | --- | --- |
| **Tutorial session no** | **Tutorial** | **CO-Mapping** |
| 1 | Demonstrate the Graphical method in Linear Programming. | CO1 |
| 2 | Demonstrate the Simplex method in Linear Programming. | CO1 |
| 3 | Demonstrate Two Phase Simplex method in Linear Programming. | CO2 |
| 4 | Demonstrate the Duality in Linear Programming | CO2 |
| 5 | Demonstrate the Initial Basic Solution in Transportation problem using NW method in Linear Programming (Stepping stone). | CO3 |
| 6 | Demonstrate the Initial Basic Solution in Transportation problem using Vogel method in Linear Programming (U-V method). | CO3 |
| 7 | Demonstrate the Initial Basic Solution in Transportation problem using NW method in Linear Programming (U-V method). | CO3 |
| 8 | Demonstrate the Initial Basic Solution in Transportation problem using Row Minimum method in Linear Programming. | CO3 |
| 9 | Demonstrate the Initial Basic Solution in Transportation problem using Column Minimum method in Linear Programming. | CO3 |
| 10 | Demonstrate the Transportation problem using Modi method (Initial solution can be of any method) in Linear Programming. | CO3 |
| 11 | Demonstrate the Assignment problem using Hungarian method. | CO3 |
| 12 | Demonstrate the Interior point method in Linear Programming. | CO4 |
| 13 | Demonstrate the Discrete Optimization using Cutting Plane method. | CO4 |
| 14 | Demonstrate the Discrete Optimization using Branch and Bound method. | CO4 |
| 15 | Demonstrate the Discrete Optimization using Additive algorithm. | CO4 |

**Lecture+ Problem Solving using Software Tool(s) or Design Courses(Tutorial)**

**Each session indicates 2 Class hours**

**Session 1:** Graphical Method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Graphical Method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving graphical problem | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the graphical problem using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 2:** Simplex Method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Simplex Method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving simplex problem | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the simplex problem using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 3:** Two Phase Simplex method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Two Phase Simplex method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Two Phase Simplex problem | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Two Phasesimplex problem using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 4:** Duality in Linear Programming.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Duality in Linear Programming. | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Duality in Linear Programming problem | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Duality in Linear Programmingusing Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 5:** Transportation problem using NW method(Stepping stones).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Transportation problem using NW method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Transportation problem using NW method | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Transportation problem using NW method using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 6:** Transportation problem using vogel method(U-V Method).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Transportation problem using vogel method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Transportation problem using vogel method | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Transportation problem using vogel method using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 7:** Transportation problem using NW method(U-V Method).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Transportation problem using NW method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Transportation problem using NW method | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Transportation problem using NW method using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 8:** Transportation problem using Row Minimum method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap; Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Transportation problem using row minimum method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Transportation problem using row minimum method | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Transportation problem using row minimum method using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 9:** Transportation problem using Column Minimum method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Transportation problem using column minimum method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Transportation problem using column minimum method | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Transportation problem using column minimum method using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 10:** Transportation problem using Modi method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap; Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Transportation problem using Modi method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Transportation problem using Modi method | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Transportation problem using Modi methodusing Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 11:** Assignment problem using Hungarian method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Assignment problem using Hungarian method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Assignment problem using Hungarian method | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Assignment problem using Hungarian method using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 12:** Interior point method in Linear Programming.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Interior point method in Linear Programming. | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Interior point method in Linear Programming. | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Interior point method in Linear Programming.using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 13:** Discrete Optimization using Cutting Plane method.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Discrete Optimization using Cutting Plane method. | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Discrete Optimization using Cutting Plane method. | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Discrete Optimization using Cutting Plane methodusing Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 14:** Discrete Optimization using Branch and Bound method.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Discrete Optimization using Branch and Bound method . | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Discrete Optimization using Branch and Bound method | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Discrete Optimization using Branch and Bound method using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Session 15:** Discrete Optimization using Additive algorithm.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 20 | Discrete Optimization using Additive algorithm . | 2 | Talk, PPT, Virtual Class room |  |
| 5 | CREATING A BREAKOUT ROOM | 1 | Chalk & Talk |  |
| 20 | Formulating and solving Discrete Optimization using Additive algorithm. | 3 | Talk, PPT, Virtual Class room |  |
| 40 | Solving the Discrete Optimization using Additive algorithm using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 10 | Problems Discussion | 1 | Talk, PPT, Virtual Class room |  |

**Lab Component:**

**Session 1:** Graphical Method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 15 | Formulating problem on Graphical Method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the graphical problem using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Class room |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Class room |  |

**Session 2:** Simplex Method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 15 | Formulating problem on Simplex Method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the simplex problem using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Class room |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Class room |  |

**Session 3:** Two Phase Simplex method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 15 | Formulating problem on Two Phase Simplex method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Two Phasesimplex problem using Python language | 3 | Talk, PPT, Virtual Class room |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Class room |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Class room |  |

**Session 4:** Duality in Linear Programming.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 15 | Formulating problem on Duality in Linear Programming. | 2 | Talk, PPT, Virtual Class room |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Duality in Linear Programming problem using Python language. | 3 | Talk, PPT, Virtual Class room |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Class room |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Class room |  |

**Session 5:** Transportation problem using NW method(Stepping stones).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 15 | Formulating problem on Transportation problem using NW method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Transportation problem using NW method using Python language. | 3 | Talk, PPT, Virtual Class room |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Class room |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Class room |  |

**Session 6:** Transportation problem using vogel method (U-V Method).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 15 | Formulating problem on Transportation problem using vogel method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Transportation problem using vogel method using Python language. | 3 | Talk, PPT, Virtual Class room |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Class room |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Class room |  |

**Session 7:** Transportation problem using NW method(U-V Method).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 15 | Formulating problem on Transportation problem using NW method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Transportation problem using NW method using Python language. | 3 | Talk, PPT, Virtual Class room |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Class room |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Class room |  |

**Session 8:** Transportation problem using Row Minimum method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap ;Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 15 | Formulating problem on Transportation problem using row minimum method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Transportation problem using row minimum method using Python language. | 3 | Talk, PPT, Virtual Class room |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Class room |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Class room |  |

**Session 9:** Transportation problem using Column Minimum method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap; Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 15 | Formulating problem on Transportation problem using column minimum method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Transportation problem using column minimum method using Python language. | 3 | Talk, PPT, Virtual Class room |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Class room |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Class room |  |

**Session 10:** Transportation problem using Modi method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap; Poll/Pop Question | 1 | Talk, Virtual Class room |  |
| 15 | Formulating problem on Transportation problem using modi method | 2 | Talk, PPT, Virtual Class room |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Transportation problem using modi method using Python language. | 3 | Talk, PPT, Virtual Class room |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Class room |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Class room |  |

**Session 11:** Assignment problem using Hungarian method

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap; Poll/Pop Question | 1 | Talk, Virtual Classroom |  |
| 15 | Formulating Assignment problem using Hungarian method | 2 | Talk, PPT, Virtual Classroom |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Assignment problem using Hungarian method using Python language. | 3 | Talk, PPT, Virtual Classroom |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Classroom |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Classroom |  |

**Session 12:** Interior point method in Linear Programming.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap; Poll/Pop Question | 1 | Talk, Virtual Classroom |  |
| 15 | Formulating Interior point method in Linear Programming. | 2 | Talk, PPT, Virtual Classroom |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Interior point method in Linear Programmingusing Python language. | 3 | Talk, PPT, Virtual Classroom |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Classroom |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Classroom |  |

**Session 13:** Discrete Optimization using Cutting Plane method.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap; Poll/Pop Question | 1 | Talk, Virtual Classroom |  |
| 15 | Formulating Discrete Optimization using Cutting Plane method in Linear Programming. | 2 | Talk, PPT, Virtual Classroom |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Discrete Optimization using Cutting Plane method using Python language. | 3 | Talk, PPT, Virtual Classroom |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Classroom |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Classroom |  |

**Session 14:** Discrete Optimization using Branch and Bound method.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap; Poll/Pop Question | 1 | Talk, Virtual Classroom |  |
| 15 | Formulating Discrete Optimization using Branch and Bound method in Linear Programming. | 2 | Talk, PPT, Virtual Classroom |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Discrete Optimization using Branch and Bound method using Python language. | 3 | Talk, PPT, Virtual Classroom |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Classroom |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Classroom |  |

**Session 15:** Discrete Optimization using Additive algorithm.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time(min)** | **Topic** | **BTL** | **Teaching – Learning Method** | **Active Learning Methods** |
| 5 | Attendance/Recap; Poll/Pop Question | 1 | Talk, Virtual Classroom |  |
| 15 | Formulating Discrete Optimization using Additive algorithm in Linear Programming. | 2 | Talk, PPT, Virtual Classroom |  |
| 5 | Split to sections | 1 | Chalk & Talk |  |
| 40 | Solving the Discrete Optimization using Additive algorithm using Python language. | 3 | Talk, PPT, Virtual Classroom |  |
| 15 | Assessment and Interaction | 1 | Talk, PPT, Virtual Classroom |  |
| 20 | Documenting Results Summary and result Explanation | 1 | Talk, PPT, Virtual Classroom |  |

**PJRC: Project with social responsibility:**

1. **Students 3 / 4 members must form a group in the first two weeks of commencement of the course.**
2. **Group need to identify the social problem and need to find the mathematical model for solving the problem.**
3. **Group must gather the required data for the problem.**
4. **Group must present their problem with the mathematical modelling in the fourth week**
5. **Group must present the mathematical solution and algorithm to write a python program for the problem in the twelfth week**
6. **Group must submit the report and present their work in the fifteenth week**

**Note: The project carries marks both in Internal and External assessments.**

**PRACTICAL COMPONENT**

List of Experiments supposed to finish in Open Lab Sessions: The student has to implement these programs in the Lab.

|  |  |  |
| --- | --- | --- |
| **Lab session no** | **List of Experiments** | **CO-Mapping** |
| 1 | Develop a python program to demonstrate the Graphical method in Linear Programming. | CO1 |
| 2 | Develop a python program to demonstrate the Simplex method in Linear Programming. | CO1 |
| 3 | Develop a python program to demonstrate Two Phase Simplex method in Linear Programming. | CO2 |
| 4 | Develop a python program to demonstrate the Duality in Linear Programming | CO2 |
| 5 | Develop a python program to demonstrate the Initial Basic Solution in Transportation problem using NW method in Linear Programming (Stepping stone). | CO3 |
| 6 | Develop a python program to demonstrate the Initial Basic Solution in Transportation problem using vogel method in Linear Programming (U-V method). | CO3 |
| 7 | Develop a python program to demonstrate the Initial Basic Solution in Transportation problem using NW method in Linear Programming (U-V method). | CO3 |
| 8 | Develop a python program to demonstrate the Initial Basic Solution in Transportation problem using Row Minimum method in Linear Programming. | CO3 |
| 9 | Develop a python program to demonstrate the Initial Basic Solution in Transportation problem using Column Minimum method in Linear Programming. | CO3 |
| 10 | Develop a python program to demonstrate the Transportation problem using Modi method (Initial solution can be of any method) in Linear Programming. | CO3 |
| 11 | Develop a python program to demonstrate the Assignment problem using Hungarian method. | CO3 |
| 12 | Develop a python program to demonstrate the Interior point method in Linear Programming. | CO4 |
| 13 | Develop a python program to demonstrate the Discrete Optimization using Cutting Plane method. | CO4 |
| 14 | Develop a python program to demonstrate the Discrete Optimization using Branch and Bound method. | CO4 |
| 15 | Develop a python program to demonstrate the Discrete Optimization using Additive algorithm. | CO4 |

**Note:**

1. Develop aExcel Solver to demonstrate the Sensitivity in Linear Programming.
2. Using TORA software verify the solution of the problems given in the tutorials.

**WEEKLY HOMEWORK ASSIGNMENTS/ PROBLEM SETS/OPEN ENDED PROBLEM-SOLVING EXERCISES etc.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Week** | **Assignment** | **Topic** | **Details** | **CO** |
| 3 | A01 | Solving Linear problems and Simplex method | Solve linear programing problems in engineering and business decision making problems. Solving Simplex Method using Big-M Method | CO1 |
| 7 | A02 | Dual Problem and Dual Simplex Method | Make use of Duality and Sensitivity Analysis in Linear Programming models. | CO2 |
| 10 | A03 | Transportation Problems and Assignment Problems | Solve network models and LPP using interior point methods. | CO3 |
| 13 | A04 | Integer programming problems,Gomory cutting plane method, branch and bound method, zero-one Programming | Apply Cutting plane and Branch and Bound methods to solve Discrete optimization problems. | CO4 |

**COURSE TIME TABLE**

**Course Conduct**

|  |  |  |
| --- | --- | --- |
| **Theory Lecture** | 24 Sections | 72 Students |Classroom | Course Coordinator | 2 Lectures per week |
|  |  |  |
| **Practical** | 24Sections | 72 Students each | 24 Batches | 1 Instructor | Individual laptops | 1 P per week | each 2 hrs.  90 minutes Experiment |  20 minutes Evaluation on submission |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Hour** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| **Day** | **Component** | **9:00-9:50** | **9:55-10:45** | **11:05-11:55** | **12:00-12:50** | **12:50-1:40** | **1:40-2:30** | **2:35-3:25** | **3:30-4:20** | **4:25-5:15** |
| **Mon** | Theory |  |  |  |  |  |  |  |  |  |
| Lab |  | |  | |  |  | |  | |
| **Tue** | Theory |  |  |  |  |  |  |  |  |  |
| Lab |  | |  | |  |  | |  | |
| **Wed** | Theory |  |  |  |  |  |  |  |  |  |
| Lab |  | |  |  |  |  | |  | |
| **Thu** | Theory |  |  |  |  |  |  |  |  |  |
| Lab |  | |  | |  |  | |  | |
| **Fri** | Theory |  |  |  |  |  |  |  |  |  |
| Lab |  | |  | |  |  | |  | |
| **Sat** | Theory |  |  |  |  |  |  |  |  |  |
| Lab |  | |  | |  |  | |  | |

**EVALUATION PLAN: Internal :60% External: 40%**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Evaluation** | **Evaluation Component** | **Weightage/Marks** | | **Assessment Dates** | **Duration (Hours)** | | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| **Type** |
| **Blooms Taxonomy Level** | | | | | | |  |  |  |  |  |
| **In-Semester** | **Sem-In Exam-I** | Weightage | 10 |  | 2 | | 5 | 5 |  |  |  |
| **Summative** | Max Marks | 50M | 25 | 25 |  |  |  |
| **In-Semester** | **Sem-In** | Weightage | 10 |  | 2 | |  |  | 5 | 5 |  |
| **Total =25%** | **Exam -II** | Max Marks | 50M |  |  | 25 | 25 |  |
|  | **Lab Sem-In Exam** | Weightage | 5 |  | 1 ½ | |  |  |  |  | 5 |
|  | Max Marks | 50M |  |  |  |  | 50 |
| **In-Semester Formative In-Semester Total =35 %** | **Moocs/ALMs** | Weightage | 7 | Continuous Evaluation | | | 1.75 | 1.75 | 1.75 | 1.75 |  |
| Max Marks | 100M | 25 | 25 | 25 | 25 |  |
|  | Weightage | 4 |  |  |  | 1 | 1 | 1 | 1 |  |
| **Tutorial** | Max Marks | 40 |  |  |  | 10 | 10 | 10 | 10 |  |
|  | Weightage | 2 |  |  |  |  |  |  |  | 2 |
| **LCE** | Max.Marks | 100 |  |  |  |  |  |  |  | 100 |
| **Home Assignment + Textbook** | Weightage | 2 | Continuous Evaluation | | | 0.5 | 0.5 | 0.5 | 0.5 |  |
| Max Marks | 40M | 10 | 10 | 10 | 10 |  |
| **Project Cont. Evaluation** | Review-1 | 7.5 | Continuous evaluation | | |  |  |  |  |  |
| 40 |  |  |  |  |  |
| Review-2 | 7.5 |  |  |  |  |  |
| 40 |  |  |  |  |  |
| Peer Review | 5 |  |  |  |  |  |
| 20 |  |  |  |  |  |
| Total Weightage | 20 |  |  |  |  |  |
| Max Marks | 100M |  |  |  |  |  |
| **Attendance** | Weightage |  | Continuous evaluation | | | | | | | |
| Max Marks | 5M |
|  | **Lab Sem-End Exam** | Weightage | 4 M | Continuous evaluation | | |  |  |  |  | 4 |
|  | Max Marks | 50 |  |  |  |  |  |  |  | 50 |
|  | **End Project Report (Exam Report)** | Weightage | 10M |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| **End-** | Report Max Marks | 50M | End Project Report | 1 ½ | |  |  |  |  |  |
| **Semester** | Weightage | 2M |
|  | Viva Max Marks | 25M |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | Total Weightage | 12 |  |  | 3 | 3 | 3 | 3 |  |
| **Summative** | Max Marks | 75M |  |  | | 18 | 19 | 19 | 19 |  |
| **Evaluation** |  |  |  |
| **Total = 40 %** | **Semester End Exam** | Weightage | 24 |  | **3 hrs** | | 6 | 6 | 6 | 6 |  |
|  | Max Marks | 100M | 25 | 25 | 25 | 25 |  |

**ATTENDANCE POLICY**

Every student is expected to be responsible for regularity of his/her attendance in class rooms and laboratories, to appear in scheduled tests and examinations and fulfill all other tasks assigned to him/her in every course. For Promotion, a Minimum of 40% of internal marks must be obtained. In every course, student has to maintain a minimum of 85% attendance to be eligible for appearing in Semester end examination of the course, for cases of medical issues and other unavoidable circumstances the students will be condoned if their attendance is between 75% to 85% in every course, subjected to submission of medical certificates, medical case file and other needful documental proof to the concerned departments.

**DETENTION POLICY**

In any course, a student has to maintain a minimum of 85% attendance and must secure a minimum of 50% marks in In-Semester Examinations to be eligible for appearing to the Semester End Examination, failing to fulfill these conditions will deem such student to have been detained in that course.

**PLAGIARISM POLICY**

Use of unfair means in any of the evaluation components will be dealt with strictly, and the case will be reported to the examination committee.

**GENERAL INSTRUCTIONS**

Students should come prepared for classes and carry the text book(s) or material(s) as prescribed by the Course Faculty to the class.

**NOTICES**

Most of the notices are available on the LMS platform.

All notices will be communicated through the institution email.

All notices concerning the course will be displayed on the respective Notice Boards.

**Signature of COURSE COORDINATOR: Signature of Head of CCRG:**

**Recommended by HEAD OF DEPARTMENT: Approved By: DEAN-ACADEMICS**

**(Sign with Office Seal)**