BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani
Pilani Campus
AUGS/ AGSR Division

SECOND SEMESTER 2020-21
COURSE HANDOUT

Date: 11.03.2021

In addition to part I (General Handout for all courses appended to the Time table) this portion gives further specific details regarding the course.

Course No	**:**	**CE G516**
Course Title	**:**	Multi-Criteria Analysis in Engineering
Instructor-in-Charge	**:**	AJIT PRATAP SINGH
Instructor(s)	**:**	
Tutorial/Practical Instructors:		

1. Course Description:

Introduction, Conventional optimization, Multi-objective Optimization, Fuzzy logic and its extensions, in multi-objective optimization, Multicriterion Decision Making, Deterministic analysis, Stochastic analysis, Fuzzy analysis, Classification problems, Hybrid approaches in Decision Making, Genetic Algorithms, Artificial Intelligence, Artificial Neural networks, Practical applications in Engineering.

2. Scope and Objective of the Course:

Multi-criteria analysis (MCA) is a valuable and increasingly widely-used tool to aid decision making where there is a choice to be made between competing options. It is particularly useful as a tool for evaluating various options in context to infrastructure systems engineering and management where a complex and inter-connected range of environmental, social and economic issues must be taken into consideration and where objectives are often competing, making trade-offs unavoidable. It provides a robust and transparent decision-making structure, making explicit the key considerations and the values attributed to them, and providing opportunities for stakeholder and community participation. MCA can be applied at all levels of decision-making, from the consideration of project alternatives to broad-reaching policy decisions guiding a transition towards sustainability and the green economy. This course is an introduction to the field of multi-criterion decision making and allied fields so that student can learn where and how to search for the best solutions of real-life multi-criteria problems. Various advanced mathematical programming techniques (multi-objective optimization, artificial neural networks, fuzzy logic etc.) will also be covered along with practical applications and case studies. The unified approach will enable students to tackle the real-life problems in more comprehensive manner and provide a broader view on the subject.

3. Text Books:

T1. Saaty, T.L. and Luis G. Vargas Models, Methods, Concepts & Applications of the Analytic Hierarchy Process, Kluwer Academic, 2001.
T2. Rajasekharan S. and G. A. Vijaylakshmi Pai, Neural Networks, Fuzzy Logic, and Genetic Algorithms, Prentice-Hall of India, New Delhi, Eighth Edition 2007.

4. Reference Books:

R1. Kartalopoulos, S.V., Understanding Neural Networks and Fuzzy Logic, Prentice-Hall of India, New Delhi, 2002.
R2. Deb, K., Multi-Objective Optimization using Evolutionary Algorithms, John Wiley and Sons, Ltd, Singapore, 2001.
R3. Ross, T.J., Fuzzy Logic with Engineering Applications, John Wiley and Sons, Inc., New Delhi, 2005.

5. Course Plan:

Module No.	Lecture Session	Reference	Learning outcomes
1, 2	Conceptual framework and scope of the course in decision making process, Classification of MCDA Problems: Discrete and Continuous Cases.	CH-1(T-1) CH-1(T-3)	Introduction to Multi-criteria Decision Analysis: Its Role in Planning and Management
3, 4, 5	Introduction, Criteria, Social criteria, Economic criteria, environmental criteria, Constructing the Hierarchy of the Criteria	CH-1, 2 (T-1)	Study of hierarchy of the Criteria
6, 7, 8	Dominance method, Sequential Optimization(SO), Simple Additive Weighting (SAW), Distance Based Methods (DBM), Analytic Hierarchy Process (AHP), Case studies and Discussions	CH-2, 3 (T-1)	Study of solution techniques for Discrete MCDA Problems
9, 10, 11	Dominance Method, Sequential Optimization, Simple Additive Weighting, Distance Based Methods, Case Studies Discussions	CH-3, 6 (T-1), Supplementary Notes	Study of solution techniques for Continuous MCDA Problems
12, 13, 14, 15	Necessity of optimization, Linear Programming and other conventional methods, Numerical problems, Goal programming, Weighting and Constraint methods, Numerical problems	CH-2 (R2) CH-3(R2)	Study of Conventional optimization and Multi-Objective Optimization
16, 17, 18, 19	Multi-attribute utility theory and Outranking methods: PROMETHEE method, Compromise Programming, EXPROM	CH-3, 6 (T-1), Supplementary Notes	Study of solution techniques for Multi-Criterion Decision Making analysis under different environments
20, 21, 22, 23, 24	Introduction, Probabilistic methods, Certain equivalents, Fuzzy methods: Fuzzy arithmetic, Membership functions, Fuzzy relations, Fuzzy decision making Probabilistic-Fuzzy MCDA Models, Case studies, Long-Term watershed, management, Conservation or new water transfers	CH-4, 6, 12 (T-2), Supplementary Notes	Study of MCDA Problems Under Uncertainty: Fuzzy logic and Decision making
25, 26, 27, 28	Fuzzy Linear Programming: Single and multiple objective	CH-10, 11 (T-2), Supplementary Notes	Fuzzy multi-objective optimization

29, 30, 31	Social choice methods, Plurality voting, Borda count, Hare system (Successive Deletion), Dictatorship, Pairwise comparisons, Case studies, Forest Treatment problem, Ranking water resources Projects, Consensus on the Results, Discussions	CH-8, 12, 13 (T-1), **Supplementary Notes**	Study of Socio-economic Choice Methods
32, 33, 34, 35, 36	Basics of Artificial Neural Networks, genetic algorithms and their relationship to decision making	CH-2, 8 (T2 & R1)	Introduction to Artificial Neural Networks and Genetic Algorithms
37, 38, 39	Measures of association – Correlation, Chi-square distance, Jaccard index, Euclidean distance, Principal Components Analysis, Redundancy analysis etc.	**Supplementary Notes**	Analysis of more than one response variables through Multivariate techniques
40 to 42	Application to various aspects of civil engineering	Supplementary Notes and Journals of International Repute	Practical case studies

6. Evaluation Scheme:

Component	**Duration**	**Weightage (%)**	**Date & Time**	**Nature of component (Close Book/ Open Book)**
Mid-Semester Test	90 Min.	30	To be announced in the class from time to time.	OB
Comprehensive Examination	3 Hrs.	35	23/06 AN	CB
Project*/ Assignment		35	To be announced in the class from time to time. Two evaluative assignments will also be conducted).	

***Project/Assignment:** During the semester, each student will work in a team (of maximum two students) on a project dealing with a decision problem relevant to civil engineering and infrastructure systems planning and management. This project will be devoted to any the broad topics covered in the course such as analytic hierarchy process, analytic network process, fuzzy decision making, multi-objective optimization, artificial neural networks, genetic algorithms etc. Each group of students will work on the project related to his area of interest/work/research. This project may or may not involve software like MATLAB, expert choice and other software available on internet etc.

The projects typically may be of interdisciplinary in nature and may consider various aspects of civil engineering. There will be two presentations in a semester by each group to discuss the progress of their project work among all registered students and the I/C and submit a final project report.

The purposes of the project are:

1. To enable you to explore in-depth aspects of the subject of multi-criteria analysis.
2. To provide experience in the formulation, execution and presentation of an engineering investigation in the area of multi-criteria decision making methods.

3. To provide a teamwork experience dealing with the interdisciplinary nature of the project.

Steps in Carrying out the Project

The steps in carrying out the project are:

1. Prepare a proposal outline in MS Word and email it to the instructor specifying the objective of your project and outlining how you plan to go about executing it by **31 January 2021**.
2. Present an oral report in class on the date posted on the class assignment web page.
3. Send a written report (in MS Word) to the instructor on the date posted on the class assignment web page.

Before beginning your project, you need to prepare a project proposal and submit it to the instructor for approval and feedback. This proposal should be about one page in length. The instructor will review the proposals and provide comments for the student to revise the proposal for final submittal and approval. The proposal should contain:

- A minimum of 5 bibliographic citations relevant to your proposed project.
- Definition of the problem including relevant background.
- Discussion (preliminary) of the proposed methods of solution of the problem.
- Anticipated data needs.
- Anticipated problems in carrying out the project.
- Team members with ID. No. and Name
- Assignment of tasks to team members.

7. Chamber Consultation Hour: Tuesday 9th Hour at 2112

8. Notices: All notices concerning the course will be displayed on Civil Engineering Department Notice Board/Google Class Room.

9. Make-up Policy:

1. Make-up will be granted only on genuine reasons. However, prior permission is must.
2. For medical cases, a certificate from the concerned physician of the Medical Centre must be produced.
3. Please also refer item no. 6 on page 2 of Part I of course handout mentioned in the Timetable for **Second Semester 2020-21** for more details.

10. Note (if any): Academic honesty and academic integrity are to be maintained by all of the students throughout the Semester and no type of academic dishonesty is acceptable.

Instructor-in-charge
CE G516

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SECOND SEMESTER, 2020-2021
(Outline of the course: To be filled in consultation with the I/C)

Course No.: CE G516 **Course Title:** Multi-Criteria Analysis in Engineering

Date of Submission of Outline:

Name of the student: **ID No:**

Topic of the course work:

Aim and Scope of the Study:

Plan of Work:

References:

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Student's Signature Approved/Disapproved

_____

Date: **Signature of the instructor**

*The registered student must submit duly filled above outline after verification from the Instructor-in-charge of the course, Prof. A. P. Singh latest by 31.01.2021.