CMR Institute of Technology, Bangalore		
Department(s): Mechanical Engineering		
Semester: 08	Section(s): A & B	
Subject: Operations Research	Sub-code: 17ME81	Lectures/week: 04
Course Instructor(s): Dr. Gopi.S		
Course duration: 19th April 2021 – 27th July 2021		
Course Site: https://sites.google.com/a/cmrit.ac.in/gopi-s/		

Course Objectives:

- To enable students to understand the scientific methods of providing various departments of an organization with a quantitative basis of decision making.
- To enable students to understand the importance of various tools and techniques in finding optimal solutions to problems involving limited resources in the form of Men, Materials and machinery

Pre-requisites:

- Higher elementary mathematics
- Probability and statistics

Lecture #	Book & Sections	Topics	Portions coverage	
			Teaching Aids	% of Syllabus Covered
1-8	TB2: Pg 1 To 8 1.1 To 1.6	**Module 1. Introduction** Evolution of OR, definition of OR, scope of OR, application areas of OR, steps (phases) in OR study, characteristics and limitations of OR, models used in OR, linear programming (LP) problem-formulation and solution by graphical method.	Chalk and Talk Video Lectures for some topics	20 %
Links to some useful online lectures: **https://www.youtube.com/watch?v=a2QgdDk4Xjw&list=PLjc8ejfjpgTf0LaDEHgLB3gCHZYcNtsoX** **https://www.youtube.com/watch?v=PSOW3_gX2OU** https://www.youtube.com/watch?v=dvsQr4dpa7g **https://www.youtube.com/watch?v=8IRrgDoV8Eo**				
9-21	RB2: Pg 9 To 70 2.1 To 2.7.2	**Module 2. Linear Programming Problems** The simplex method canonical and standard form of an LP problem, slack, surplus and artificial variables, big M method ,two phase simple method and concept of duality, dual simplex method.	Chalk and Talk Video Lectures for some topics	20 %
Links to some useful online lectures: **https://www.youtube.com/watch?v=PSOW3_gX2OU** **https://www.youtube.com/watch?v=M8POtpPtQZc** **https://www.youtube.com/watch?v=MZ843Vvia0A**				

22-33	RB2: Pg 71 To 126 3.1 To 3.5.2	**Module 3. Transportation Problem** Formulation of transportation problem, types, initial basic feasible solution using different methods, optimal solution by MODI method, degeneracy in transportation problems, application of transportation problem concept for maximization cases. Assignment Problem-formulation, types, application to maximization cases and travelling salesman problem Difference between assignment and TSP Finding best route using little's method Numerical problems.	Chalk and Talk Video Lectures for some topics	20 %
Links to some useful online lectures: https://www.youtube.com/watch?v=Q31jKiEXxdc https://www.youtube.com/watch?v=ItOuvM2KmD4 https://www.youtube.com/watch?v=-w2z3MVTcQA https://www.youtube.com/watch?v=r05tMndo7-8 https://www.youtube.com/watch?v=rrfFTdO2Z7I https://www.youtube.com/watch?v=_Qb9YWG5Mmo				
34-44	RB1: Pg 196 To 229 6.1 To 6.5	**Module 4. Network analysis** Introduction, network construction - rules, Fulkerson's rule for numbering the events, AON and AOA diagrams; Critical path method to find the expected completion time of a project, floats; PERT for finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project cost analysis of networks, crashing of networks Problems. **Queuing Theory** Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendal and Lee notations empirical queuing models – M/M/1 and M/M/C models.	Chalk and Talk Video Lectures for some topics	20 %
Links to some useful online lectures: https://www.youtube.com/watch?v=vUMGvpsb8dc https://www.youtube.com/watch?v=0Lo4zsB-bjE https://www.youtube.com/watch?v=6jHe01kYmlU https://www.youtube.com/watch?v=KG-SxYrMr4Y https://www.youtube.com/watch?v=xGkpXk-AnWU				
45-53	RB2: Pg 9 To 70 2.1 To 2.7.2	**Module 5. Game Theory** Definition pure strategy, mixed strategy saddle point Formulation of games, types, solution of 2X2 games with saddle point arithmetic solution , graphical method of solving mixed strategy games, dominance rule for solving mixed strategy games. **Sequencing** Basic assumptions, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's algorithm-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines.	Chalk and Talk Video Lectures for some topics	20 %

		Sequencing 2 jobs on 'm' machines using graphical method.		

Links to some useful online lectures:

- https://www.youtube.com/watch?v=OKHiS0xDBb4&list=PLDlJ2nw7-dHb3oowMJfwgleor6dwWsVZ1
- https://www.youtube.com/watch?v=DK3alvfD9Rs&list=PLDlJ2nw7-dHb3oowMJfwgleor6dwWsVZ1&index=2
- https://www.youtube.com/watch?v=533dp83Er6E
- https://www.youtube.com/watch?v=Q8wGbBLVMn8

Book Type	Code	Author & Title	Publication information	
			Edition & Publisher	ISBN #
Text Book	TB1	Operations Research by P K Gupta and D S Hira	Chand Publications, New Delhi - 2007	
Text Book	TB2	Operations Research by Taha H A	Prentice hall	
Reference Book	RB1	Operations Research by A P Verma,	S K Kataria &Sons, 2008	9789350142400
Reference Book	RB2	Operations Research by Paneerselvam	Prentice hall of India 2nd edition	9788120329287
Reference Book	RB3	Operations Research by A M Natarajan, P Balasubramani	Pearson Education, 2012	9788131790526

Syllabus for Internal Assessment Tests (IAT*)

Sessional #	Syllabus
T1	Class # 01 – 21
T2	Class # 22 – 44
T3	Class # 45 – 53

*See calendar of events for IAT schedule

Course Outcomes
By the end of this course, students will be able to
1. Define and formulate linear programming problems and appreciate their limitations
2. Solve linear programming problems using graphical method, Simplex method, Big-M method, Two phase simplex method and Dual Simplex method.
3. Define and Formulate special linear programming problems and derive optimum solutions for transportation, Assignment and travelling salesman problems
4. Analyze probabilistic and deterministic networks by Computing critical path, floats & crashing of Networks.
5. Solve waiting line problems for M/M/1 and M/M/K queuing models
6. Solve game theory problems on pure and mixed strategy under competitive environment.
7. Select optimum processing sequences in manufacturing using graphical method and Johnson's algorithm.

**Based on table 01, 02, 03 in appendix, following are the Course outcomes.

CO-PO and CO-PSO Mapping

Course Outcomes	Modules covered	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4

CO1	Define and formulate linear programming problems and appreciate their limitations	**1**	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO2	Solve linear programming problems using graphical method, Simplex method, Big-M method, Two phase simplex method and Dual Simplex method.	**1,2**	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO3	Define and Formulate special linear programming problems and derive optimum solutions for transportation, Assignment and travelling salesman problems	**3**	3	2	-	-	-	-	-	-	-	-	3	-	-	-	2	-
CO4	Analyze probabilistic and deterministic networks by Computing critical path, floats & crashing of Networks.	**4**	3	2	-	-	-	-	-	-	-	3	3	-	-	-	2	-
CO5	Solve waiting line problems for M/M/1 and M/M/C queuing models	**4**	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO6	Solve game theory problems on pure and mixed strategy under competitive environment.	**5**	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO7	Select optimum processing sequences in manufacturing using graphical method and Johnson's algorithm.	**5**	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-

Note: Assignments, study material, Question bank and other course related content would be posted on site mentioned above.

Signature with date:	**Course Instructor**	**HOD**

Appendix

Table 01: Cognitive Levels

Cognitive Levels	
Cognitive level	**Revised Blooms Taxonomy Keywords**
L1	List, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.
L2	summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
L3	Apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover.
L4	Analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer.
L5	Assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize.

Table 02: Program Outcomes (PO) and Program Specific Outcomes (PSO)

Program Outcomes (PO), Program Specific Outcomes (PSO)	
PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** 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.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** 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.
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** 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.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
PSO1	Apply principles of physics, knowledge of material properties and strength, manufacturing methods, design codes and standards, and best practices to design, analyze and develop solutions in engineering and service sectors.
PSO2	Contribute to the project teams in the core and associated domains by applying knowledge of engineering graphics to read, interpret and create an engineering drawing, and by using modern tools for drafting, modeling, analyzing and simulating the product.
PSO3	Identify and articulate industrial problems and solve with the use of management tools for optimum solutions and realistic outcomes.
PSO4	Translate fundamental knowledge of thermal sciences and attempt solutions independently for real life situations.

Table 03: Correlation Levels

Correlation Levels	
0	No Correlation
1	Slight/Low
2	Moderate/ Medium
3	Substantial/ High