INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**OPERATIONS RESEARCH**				
Course Code	AME021				
Programme	B. Tech.				
Semester	VIII	ME			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. C. Labesh Kumar, Assistant Professor, ME				
Course Faculty	Mr. C. Labesh Kumar, Assistant Professor, ME Mrs. T. Vanaja Assistant Professor , ME				

I. COURSEOVERVIEW:

Operations research for short and it is a scientific approach to decision making which seeks to determine how best to design and operate a system under conditions requiring allocation of scarce resources. Operations research as a field, primarily has a set or collection of algorithms which act as tools for problems solving in chosen application areas. OR has extensive applications in engineering, business and public systems and is also used by manufacturing and service industries to solve their day to day problems. This course is titled in Fundamentals of Operations Research. This course facilitates to learn various models to optimize a problem.

II. COURSEPRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHS002	I	Linear Algebra and Calculus	4
UG	AHS011	II	Mathematical Transformation Techniques	4

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
OPERATIONS RESEARCH	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos
✔	Open Ended Experiments						

V. EVALUATIONMETHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question. The emphasis on the questions is broadly based on the following criteria:

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total Marks**
Type of Assessment	CIE Exam	Quiz/AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT)

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be Page | 3 answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES AREASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentation on real-world problems
PO 2	**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	2	Seminar
PO 3	**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.	2	Assignments
PO 6	**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.	1	Term Paper

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES AREASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	1	Seminar
PSO 2	**Problem Solving Skills:**An ability to adopt and integratecurrent technologies in the design and manufacturing domain to enhance the employability.	-	-
PSO 3	**Successful Career and Entrepreneurship:** To build the nation, by imparting technological inputs and managerial skills to become technocrats.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES:

The course should enable the students to:	
I	Formulate the mathematical model of real time problem for optimization.
II	Establish the problem formulation by using linear, dynamic programming, game theory and queuing models.
III	Apply stochastic models for discrete and continuous variables to control inventory.
IV	Visualize the computer based manufacturing simulation models.

IX. COURSE OUTCOMES(COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Formulate the mathematical model of real time problem for optimization, using Linear programming	CLO 1	Understand the characteristics, phases, types of operation research models and its applications.
		CLO 2	Visualize modeling principles scope, decision making, general methods for solving OR models.
		CLO 3	Understand linear programming concepts, problem formulation and graphical models.
		CLO 4	Understand simplex method and artificial variable techniques.
		CL05	Comprehend two-phase method and Big-M method of linear programming.
CO 2	Establish the problem formulation by using transportation, assignment models	CLO 6	Apply to build and solve transportation models of balanced.
		CLO 7	Understand the degeneracy model problem of transportation, unbalanced type-maximization.
		CLO 8	Apply to build assignment models for optimal solution.
		CLO 9	Understand variants of assignment model and travelling salesman model.

COs	Course Outcome	CLOs	Course Learning Outcome
CO 3	Apply sequencing for flow and replacement for maintenance of machines programming, game theory and queuing models.	CL10	Understand the flow shop sequencing model of 'n' jobs through two machines and three machines.
		CLO 11	Comprehend job shop sequencing of two jobs through 'm' machines.
		CLO 12	Understand the concept of replacement of items that deteriorate with time when money value is not counted .
		CLO 13	Understand the concept of replacement of items that deteriorate with time when money value is n counted .
		CLO 14	Visualize the replacement of items that fail completely and group replacement.
CO 4	Formulate game theory model and apply stochastic models for discrete and continuous variables to control inventory.	CLO 15	Understand minimax (maximini) criterion, optimal strategy , solution od games with saddle point
		CLO 16	Visualize dominance principle while solving game theory problem.
		CLO 17	Apply to solve m * 2 , 2 *n model of games and graphical method.
		CLO 18	Understand the concepts of deterministic inventory model and purchase inventory model with one price break and multiple price breaks.
		CLO 19	Visualize stochastic inventory models – demand may be discrete variable or continuous variable.
CO 5	Formulate queuing models and visualize dynamic programming and simulation models	CLO 20	Understand the concepts of waiting line model of single channel and multi server model.
		CLO 21	Visualize dynamic programming concepts and models
		CLO 22	Comprehend the simulation models, phases of simulation, application of simulation
		CLO 23	Visualize the application of simulation for inventory and queuing problems.

X. COURSE LEARNING OUTCOMES(CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AME021.01	CLO 1	Understand the characteristics, phases, types of operation research models and its applications.	PO 1	3
AME021.02	CLO 2	Visualize modeling principles scope, decision making, general methods for solving OR models.	PO 2	2
AME021.03	CLO 3	Understand linear programming concepts, problem formulation and graphical models.	PO 1	3
AME021.04	CLO 4	Understand simplex method and artificial variable techniques.	PO 1	3
AME021.05	CLO 5	Comprehend two-phase method and Big-M method of linear programming.	PO 2	2
AME021.06	CLO 6	Apply to build and solve transportation models of balanced.	PO 2	2
AME021.07	CLO 7	Understand the degeneracy model problem of transportation, unbalanced type-maximization.	PO 1	3
AME021.08	CLO 8	Apply to build assignment models for optimal solution.	PO 2	2
AME021.09	CLO 9	Understand variants of assignment model and travelling salesman model.	PO 2	1
AME021.10	CLO 10	Understand the flow shop sequencing model of 'n' jobs through two machines and three machines.	PO 2	2

AME021.11	CLO 11	Comprehend job shop sequencing of two jobs through 'm' machines.	PO 2	2
AME021.12	CLO 12	Understand the concept of replacement of items that deteriorate with time when money value is not counted	PO1, PO2	3
AME021.13	CLO 13	Understand the concept of replacement of items that deteriorate with time when money value is n counted .	PO 1	3
AME021.14	CLO 14	Visualize the replacement of items that fail completely and group replacement.	PO 1	3
AME021.15	CLO 15	Understand minmax (maximini) criterion, optimal strategy , solution od games with saddle point	PO 1	3
AME021.16	CLO 16	Visualize dominance principle while solving game theory problem.	PO 1, PO 2	3
AME021.17	CLO 17	Apply to solve m * 2, 2 *n model of games and graphical method.	PO 1, PO 2	3
AME021.18	CLO 18	Understand the concepts of deterministic inventory model and purchase inventory model with one price break and multiple price breaks.	PO 1, PO 2	3
AME021.19	CLO 19	Visualize stochastic inventory models – demand may be discrete variable or continuous variable.	PO 1	3
AME021.20	CLO 20	Understand the concepts of waiting line model of single channel and multi-server model.	PO 2	2
AME021.21	CLO 21	Visualize dynamic programming concepts and models	PO 3, PO 6	2
AME021.22	CLO 22	Comprehend the simulation models, phases of simulation, application of simulation	PO 2,	2
AME021.23	CLO 23	Visualize the application of simulation for inventory and queuing problems.	PO1, PO 3,	2

3= High; 2 = Medium; 1 = Low

XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAMOUTCOMES

Course Outcomes (COs)	Program Outcomes and Program Specific Outcomes						
	PO 1	PO 2	PO 3	PO 6	PSO 1	PSO 2	PSO 3
CO 1	3	2			1		3
CO 2	2	2					
CO 3	3	2			1		
CO 4	3	3			1		
CO 5	2	2	2	2	1	2	

3= High; 2 = Medium; 1 = Low

XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFICOUTCOMES:

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												ProgramSpecific Outcomes(PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3														
CLO 2		2													
CLO 3	3														3
CLO 4	3												1		
CLO 5		2													
CLO 6		2													
CLO 7	3														
CLO 8		2													
CLO 9		1													
CLO 10		2													
CLO 11		2											1		
CLO 12	3	3											1		
CLO 13	3														
CLO 14	3														
CLO 15	3														
CLO 16	3	3											1		
CLO 17	3	3											1		
CLO 18	3	3											1		
CLO 19	3												1		
CLO 20		2											1		
CLO 21			2			2								2	
CLO 22		2											1		
CLO 23	2		2											2	

3 = High; 2 = Medium; 1 = Low

XIII. ASSESSMENT METHODOLOGIES –DIRECT

CIE Exams	PO1, PO2, PO6,PS01, PSO3	SEE Exams	PO1, PO2, PO6,PS01, PSO3	Assignments	-	Seminars	PO1, PO2, PO6,PS01, PSO3
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1, PO2, PO6,PS01, PSO3						

XIV. ASSESSMENT METHODOLOGIES -INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

Unit -I	**DEVELOPMENT OF O.R AND ALLOCATION**
Development, definition, characteristics and phases, types of operation research models, applications; Allocation: linear programming, problem formulation, graphical solution, simplex method, artificial variables techniques, two–phase method, big-M method.	
Unit -II	**TRANSPORTATION AND ASSIGNMENT PROBLEM**
Transportation problem: Formulation, optimal solution, unbalanced transportation problem, Degeneracy; Assignment problem, formulation, optimal solution, variants of assignment problem, traveling salesman problem.	
Unit-III	**SEQUENCING AND REPLACEMENT**
Sequencing: Introduction, flow, shop sequencing, n jobs through two machines, n jobs through three machines, job shop sequencing, two jobs through 'm' machines. Replacement: Introduction: Replacement of items that deteriorate with time, when money value is not counted and counted, replacement of items that fail completely, group replacement.	
Unit-IV	**THEORY OF GAMES AND INVENTORY**
Theory Of Games: Introduction, minimax (maximin) criterion and optimal strategy, solution of games with saddle points, rectangular games without saddle points, dominance principle, mx2 and 2xn games, graphical method; Inventory: Introduction, single item, deterministic models, purchase inventory models with one price break and multiple price breaks, shortages are not allowed, stochastic models, demand may be discrete variable or continuous variable, instantaneous production, instantaneous demand and continuous demand and no set up cost, single period model.	
Unit-V	**WAITING LINES, DYNAMIC PROGRAMMIMG AND SIMULATION**
Waiting Lines: Introduction, Terminology, Single Channel, Poisson arrivals and exponential service times with infinite population and finite population models, Multichannel, Poisson arrivals and exponential service times with infinite population. Dynamic Programming: Introduction, Terminology, Bellman‟s Principle of optimality, Applications of dynamic programming, shortest path problem, linear programming problem. Simulation: Introduction, Definition, types of simulation models, steps involved in the simulation process - Advantages and Disadvantages, Application of Simulation to queuing and inventory.	
Text Books:	
1. J. K. Sharma, "Operations Research", Macmillan, 5th Edition, 2012. 2. R. Pannerselvan, "Operations Research", 2nd Edition, PHI Publications, 2006.	

Reference Books:

1. A. M. Natarajan, P. Balasubramani, A. Tamilarasi, "Operations Research", Pearson Education, 2013.
2. Maurice Saseini, ArhurYaspan, Lawrence Friedman, "Operations Research: Methods & Problems", 1st Edition, 1959.
3. Hamdy A. Taha, "Introduction to O.R", PHI, 8th Edition, 2013.
1. Harvey M.Wagner, "Operations Research", PHI Publications, 2nd Edition, 1980.

Web References:

1. https://www.aicte-india.org/flipbook/p&ap/Vol.%20II%20UG/UG_2.html#p=8
2. https://www.britannica.com/topic/operations-research

XVI. COURSEPLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topic's to be covered	Course Learning Outcomes (CLOs)	Reference
1	Introduction– Definition– Characteristics and Phases – Types of operation Research models	CLO 1	T1: 1.1- 1.5
2	Modeling in operations research , principles and application	CLO 2	T1: 1.6 – 1.15
.15	Allocation : Linear Programming Problem formulation	CLO 3	T1: 2.7 – 2.86
5-6	Graphical solution	CLO 3	T1: 3.1- 3.4.2
6-7	Simplex method	CLO 4	T1: 4.1- 4.62
8-9	Artificial variables techniques	CLO 4	T1: 4.4.1
10-11	Two–phase method	CLO5	T1: 4.4.1
12-13	Big-M method	CLO5	T1: 14.1- 14.2
14-16	Transportation model Formulation-Optimal solution balanced model	CLO6	T1: 9.1 – 9.4
17-20	Formulation-Optimal solution balanced and unbalanced and transportation models	CLO6	T1: 9.5 – 9.6.1
21-23	Degeneracy type transportation model	CLO7	T1: 9.6.2 – 9.7
24-25	Assignment problem- Formulation – Optimal solution	CLO8	T1: 10.1 – 10.3.1
26-28	Variants of Assignment Problem, travelling salesman problem	CL09	T1:10.4 – 10.4.6
29-30	Introduction-Flow-Shop sequencing-n jobs through two machines-n jobs through three machines	CLO10	T1: 11..1-11.4
31-32	Job shop sequencing – two jobs through "m: machines	CLO11	T1: 11.5 – 11.8
33-34	Introduction , Replacement of items that deteriorate with time-when money value is not counted	CLO12	T1: 17.1 – 17.2
35-36	Replacement of items that deteriorate with time-when money value is counted	CLO13	T1: 17.3
37-39	Replacement of items that fail completely, group replacement. Group replacement	CLO14	T1: 17.4
40	Theory Games: Introduction, terminology , Solution of games with saddle points	CLO15	T1: 12.1 – 12.3
41	Rectangular games without saddle points-2 x 2 games conductivity gauges	CLO15	T1: 12.4 – 12.6
42-43	Dominance principle for solving Transportation problem	CLO16	T1: 12.5

44-45	m *2 & 2 * n games -graphical method	CLO17	T1: 12.6.4 – 2.6.5
46-47	Inventory: Introduction-Single item, Derive the formula for Inventory models	CLO18	T1: 14.1 – 14.7
48-49	Purchase inventory models with one price break and multiple price breaks	CLO18	T1: 14.10
50-51	Stochastic Models	CLO19	T1: 14.11 – 14.12.5
52-53	Demand may be discrete variable or continuous variable – Single period model and no setup cost	CLO19	T1:15.2 – 15.3
54-55	Waiting Lines: Introduction-Single Channel- Poisson arrivals	CLO20	T1: 16.1 – 16.6
55-56	Multichannel-Poisson arrivals	CLO20	T1: 16.7 – 16.9
57-59	Visualize dynamic programming concepts and models		
60	Simulation-Definition-Types of Simulation models-phases of simulation-applications of simulation	CLO21	T1: 19.1 – 19.4
61-62	Advantages and disadvantages-application of simulation to queuing and inventory.	CLO22	T1: 19.5 – 19.8

XVII. GAPS IN THE SYLLABUS-TO MEET INDUSTRY / PROFESSIONREQUIREMENTS:

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Advanced Simulation practices	Seminars and Laboratory Practice	PO2	PSO1
2	Advanced topics	Guest Lectures and Laboratory Practice	PO3	PSO2
3	Recommended practices in optimization processes	Seminars and Laboratory Practice	PO3	PSO2

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