APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

(A State Government University)

B. Tech, 2024

Minor Degree in

INDUSTRIAL AND SYSTEMS ENGINEERING

Offered By: Industrial Engineering

CURRICULUM

Minor (INDUSTRIAL AND SYSTEMS ENGINEERING)											
Sl. No:	**Semester**	**Course Code**	**Course Title (Course Name)**	**Credit Structure**			**SS**	**Total Marks**		**Credits**	**Hrs./ Week**
				L	**T**	**P**		**CIA**	**ESE**		
1	3	MNIET309	Course*/MOOC[#] Production and Operations Management	3	1	0	5	40	60	4	4
2	4	MNIET409	Course*/MOOC[#] Data Analytics and Applications	3	1	0	5	40	60	4	4
3	5	MNIET509	Course/MOOC Optimisation and Heuristics	3	1	0	5	40	60	4	4
4	6	MNIET609	Course/MOOC System Dynamics and Simulation	3	0	0	4.5	40	60	3	3
Total							**20**			**15**	**15**

**Students must register for theory courses listed in the 3rd and 4th semesters of the Minor curriculum.*

[#]Students who fail a theory course listed in the Minor curriculum are permitted to register for an alternate MOOC course specified in the Minor curriculum.

SYLLABUS

SEMESTER 3

SEMESTER 3

PRODUCTION AND OPERATIONS MANAGEMENT

Course Code	MNIET309	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:1:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To equip students with the basics of production and operations management and production planning.
2. To familiarise concepts of facility location, layouts, and modern production systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction:** Definition, scope, and significance in both manufacturing and service sectors.Evolution and historical milestones in operations management.The role of operations strategy in achieving business success. **Demand Forecasting:** Causal and time series forecasting methods. Moving average, exponential smoothing, trend-cycle-seasonality analysis. Winter's complete model and error analysis. AI-driven forecasting and predictive analytics.	11
2	**Basic Inventory Models:** assumptions and performance measures. Inventory systems under risk, service levels, safety stock, joint determination of Q and R, time varying demands – Selective Inventory Control.	11

	Aggregate Planning: Definition, decision rules, and planning strategies. Methods of aggregate planning (Graphical, Linear Programming, Heuristic). Master Production Scheduling (MPS), Bill of Materials (BOM), structuring and disaggregation. Sustainable inventory management and digital transformation in planning.	
3	**Location Selection:** Factors affecting plant location. Factor rating method, Centre of Gravity method. Real-world case studies on global facility locations. **Plant Layout:** Types of layouts. Comparison and selection of layouts based on production needs. Systematic Layout Planning (SLP) and software tools for optimization. **Capacity Management:** Models for assembly line balancing. Capacity expansion and control strategies. Batch processing, continuous production, and flexible manufacturing systems.	**11**
4	**Job Shop and Production Activity Planning:** Scheduling methods (Gantt charts, Johnson's Rule, Theory of Constraints). Shop loading, sequencing, priority dispatching rules. **Lean Manufacturing and World-Class Manufacturing:** Just-In-Time (JIT), Toyota Production System (TPS). Kanban - Push vs. Pull production. Continuous improvement methodologies (Kaizen, Six Sigma, Total Quality Management - TQM). **ERP and Digital Integration in Operations Management:** Enterprise Resource Planning (ERP) systems in manufacturing. Role of AI, IoT, and Industry 4.0 in smart manufacturing. Supply Chain 4.0 and automation in production planning.	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the role and evolution of operations management and various demand forecasting techniques.	**K2**
CO2	Apply inventory management models, aggregate planning strategies, and sustainable inventory control techniques.	**K3**
CO3	Apply facility layout methodologies and capacity management strategies.	**K3**
CO4	Explain production planning and modern manufacturing systems	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**-**	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO2	**3**	**-**	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO3	**3**	**-**	**2**	**-**	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**2**
CO4	**2**	**-**	**2**	**-**	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**2**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Production and Operations Management	S.N. Chary	McGraw Hill	6th edition, 2019
2	Operations and Supply Chain Management	William J. Stevenson, Thomas J. Kull	McGraw Hill	Evergreen edition, 2025
3	Operations Management: Processes and Supply Chains	Lee J. Krajewski, Manoj K. Malhotra	Pearson	13th edition, 2021
4	Operations Management: Sustainability and Supply Chain Management	Jay Heizer, Barry Render, Chuck Munson	Pearson	14th edition, 2022

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Production and Operations Management	R. Panneerselvam	PHI Learning	3rd edition, 2012
2	Operations Management: Theory and Practice	B. Mahadevan	Pearson Education India	3rd edition, 2015
3	Operations Management: An Integrated Approach	R. Dan Reid, Nada R. Sanders	Wiley	7th edition, 2020
4	Production and Operations Management: Concepts, Models, and Behavior	Everett E. Adam Jr., Ronald J. Ebert	Prentice Hall	5th Edition, 1991

Video Links (NPTEL, SWAYAM…)	
Link ID	https://archive.nptel.ac.in/courses/112/107/112107238/
	https://archive.nptel.ac.in/courses/110/105/110105095/
	https://archive.nptel.ac.in/courses/112/107/112107238/

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B. TECH MINOR DEGREE EXAMINATION, MONTH AND YEAR

Course Code: MNIET309

Course Name: Production and Operations management

Max. Marks: 60 | Duration: 2 Hours 30 Minutes

PART A

		Answer all questions. Each question carries 3 marks	CO	Marks
1		List any four historical milestones in the evolution of operations management.	CO1	(3)
2		Mention the advantages of using AI in demand forecasting	CO1	(3)
3		Define service level and its importance in inventory systems under risk.	CO2	(3)
4		What is a Master Production Schedule (MPS)? Why is it important?	CO2	(3)
5		List four important factors affecting plant location decisions.	CO3	(3)
6		What is Systematic Layout Planning (SLP)? Mention one software used for layout planning.	CO3	(3)
7		Define Kanban. How is it different from push production systems?	CO4	(3)
8		Outline the concept of JIT.	CO4	(3)

PART B

Answer any one full question from each module. Each question carries 9 marks

Module 1

9	a)	Explain the scope and functions of operations management in both manufacturing and service sectors. Illustrate with suitable examples.	CO1	(4)
	b)	The nine-month demand data of a product is given below. Use this data to develop forecasts using three- and six-month moving averages	CO1	(5)
10	a)	Discuss the components of trend, cycle, and seasonality in demand forecasting. Explain how these elements influence decision-making in production planning.	CO1	(4)
	b)	Monthly demand at XYZ Electronics Centre for Smart TVs are as follows. Estimate demand for the next four weeks using a five-week moving average, as well as simple exponential smoothing with $\alpha = 0.2$. Evaluate the MAD, MAPE, MSE, bias, and TS errors in each case. Which one of the two methods do you prefer? Why?	CO1	(5)

Month	1	2	3	4	5	6	7	8	9
Demand	250	265	284	293	305	315	320	328	240

Month	1	2	3	4	5	6	7	8	9
Demand	600	665	654	683	705	695	720	728	740

<table>
<tr><th colspan="5">Module 2</th></tr>
<tr><td rowspan="2">11</td><td>a)</td><td>Explain the performance measures of basic inventory models. How do they help in effective inventory management?</td><td>CO2</td><td>(4)</td></tr>
<tr><td>b)</td><td>The company uses annually 48,000 units of raw materials costing Rs.2.25 / unit. Placing each order costs Rs. 50/- and the carrying cost is 15% of Unit cost. Suppose that the company follows the EOQ purchasing policy, it operates for 300 days an year, the procurement time is 12 days and the safety stock is 500 units. Determine the EOQ, ROP and Total annual inventory cost.</td><td>CO2</td><td>(5)</td></tr>
<tr><td rowspan="2">12</td><td>a)</td><td>Describe any two methods of aggregate planning. Compare their advantages and limitations using examples.</td><td>CO2</td><td>(4)</td></tr>
<tr><td>b)</td><td>The stores of a repair shop have 9 items whose details are shown in the following table. Apply ABC analysis to the stores and identify A Class, B Class, and C Class
<table>
<tr><td>Component code</td><td>C_1</td><td>C_2</td><td>C_3</td><td>C_4</td><td>C_5</td><td>C_6</td><td>C_7</td><td>C_8</td><td>C_9</td></tr>
<tr><td>Price/unit</td><td>60</td><td>300</td><td>125</td><td>80</td><td>410</td><td>700</td><td>300</td><td>100</td><td>300</td></tr>
<tr><td>Units/Year</td><td>125</td><td>40</td><td>310</td><td>720</td><td>425</td><td>525</td><td>900</td><td>90</td><td>510</td></tr>
</table></td><td>CO2</td><td>(5)</td></tr>
<tr><th colspan="5">Module 3</th></tr>
<tr><td rowspan="2">13</td><td>a)</td><td>Explain fixed position layout with applications</td><td>CO3</td><td>(4)</td></tr>
<tr><td>b)</td><td>Compare and contrast batch processing, continuous production, and flexible manufacturing systems. How does capacity management vary across these systems?</td><td>CO3</td><td>(5)</td></tr>
<tr><td rowspan="2">14</td><td>a)</td><td>Describe various models used for assembly line balancing. Why is balancing critical for operational efficiency?</td><td>CO3</td><td>(4)</td></tr>
<tr><td>b)</td><td>There are five existing facilities which are to be served by a single new facility. The details of the existing facilities are shown in the following table.
<table>
<tr><th rowspan="2">Existing facility (i)</th><th colspan="2">Coordinates</th><th rowspan="2">No. of trips of loads/year (w_i)</th></tr>
<tr><th>X</th><th>Y</th></tr>
<tr><td>1</td><td>5</td><td>10</td><td>100</td></tr>
<tr><td>2</td><td>14</td><td>8</td><td>210</td></tr>
<tr><td>3</td><td>12</td><td>19</td><td>220</td></tr>
<tr><td>4</td><td>25</td><td>23</td><td>280</td></tr>
<tr><td>5</td><td>24</td><td>9</td><td>150</td></tr>
</table>
Find the optimum location of the new facility based on gravity location method.</td><td>CO3</td><td>(5)</td></tr>
<tr><th colspan="5">Module 4</th></tr>
<tr><td rowspan="2">15</td><td>a)</td><td>Compare the key elements of Lean Manufacturing and World-Class Manufacturing (WCM). How do JIT and Kaizen contribute to continuous improvement?</td><td>CO4</td><td>(4)</td></tr>
<tr><td>b)</td><td>Product X is made of three units of Y and four units of Z. Y is made of two unit of A and three units of B. Z is made of three units of A and two units of C. Lead time for X is one week; Y is two weeks; Z is three weeks; A is</td><td>CO4</td><td>(5)</td></tr>
</table>

		two weeks; B is one week and C is three weeks. The beginning inventory for each item is zero. A) Show the bill-of-materials (product structure tree). B) If 1000 units of X are needed in week 10, develop a planning schedule showing when each item should be ordered and in what quantity.		
16	a)	Explain how ERP improves the performance of the firms.	CO4	(4)
	b)	Explain the impact of automation and Supply Chain 4.0 on production planning. Support your answer with relevant examples from industry.	CO4	(5)
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SEMESTER 4

SEMESTER 4

DATA ANALYTICS AND APPLICATIONS

Course Code	MNIET409	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:1:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To familiarise students with data management concepts and its applications in data analytics.
2. To equip students to apply Python's key data analytics libraries to manipulate, visualize, and analyse datasets.
3. To enable students to apply machine learning techniques in real-world scenario.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Data Management:** Basics of Statistics - measures of central tendency and dispersion, probability distributions. **Sampling and sampling plan:** Concept of population and sample, types of sampling- random, stratified, systematic, cluster, sampling distribution of sample mean and proportion. **Inferential statistics:** Confidence interval estimation, hypothesis testing, z-test, t-test, Chi-square test, ANOVA, Type I & Type II errors. **Design Data Architecture:** Manage the data for analysis - understand various sources of data like Sensors/Signals/GPS etc. Data management, data quality- noise, outliers, missing values, duplicate data and data processing.	11
2	**Advanced Python tools:** Data handling with pandas, data frames & series, data cleaning - handling missing data, duplicates, outliers, grouping, aggregation, and pivot tables. Data Visualization with Matplotlib & Seaborn - line plots, bar charts, histograms, scatter plots, pair plots, heatmaps, KDE plots for distribution analysis, customizing visualizations. **Statistical analysis using SciPy and Stats models**: Correlation and covariance, t-tests, ANOVA, regression analysis, non-parametric tests -Wilcoxon, Mann-Whitney, Kruskal-Wallis tests.	11

	Feature engineering and data preprocessing using Scikit-Learn: Handling categorical data (one-hot encoding, label encoding), feature scaling (standardization, normalization), imputation of missing values, train-test split and cross-validation.	
3	**Data Analytics:** Introduction to analytics, introduction to tools and environment, application of modelling in business, databases & Types of data and variables, data modelling techniques, missing imputations etc., need for business modelling. **Regression models for data analytics:** Simple and multiple linear regression, blue property assumptions, polynomial regression, ridge, lasso, and elastic net regression, practical applications in predictive modelling. Object Segmentation, regression Vs segmentation, analytics applications to various business domains. **Classification and clustering models for data analytics:** Logistic regression, decision trees, random forest, support vector machines (SVM), ROC curve, precision-recall, F1 score. Clustering techniques in data analytics - K-Means clustering, hierarchical clustering. **Advanced metrics and model evaluation:** Bias-Variance trade off, AUC-ROC, PR curves, Silhouette score.	**11**
4	**Case Study on Predicting House Prices:** Dataset - Kaggle housing prices. Pipeline - data cleaning, feature engineering, regression model. Evaluation metrics - RMSE, R^2. **Case Study on Customer Churn Prediction**: Dataset - telecom churn data. Pipeline - exploratory data analysis (EDA), classification model. Evaluation metrics - confusion matrix, precision, and recall. **Case Study on Clustering for Market Segmentation:** Dataset - mall customers dataset (Kaggle). Pipeline - K-Means clustering, PCA for dimensionality reduction. Visualization - cluster interpretation using scatter plots and heatmaps. **Case Study on Sentiment Analysis on Customer Reviews:** Dataset - Amazon or IMDB reviews. Pipeline- Text Preprocessing, TF-IDF Vectorization, Sentiment Classification. Model - Naïve Bayes.	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain data management concepts for analysing datasets to derive meaningful insights.	**K2**
CO2	Apply Python libraries like Pandas, Matplotlib, SciPy, and Scikit-Learn to preprocess, visualize, and perform statistical analysis on real-world datasets	**K3**
CO3	Utilize regression, classification, and clustering techniques to build predictive models.	**K3**
CO4	Develop a complete data analytics pipeline, from data acquisition to visualization, to extract actionable insights from complex datasets.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO2	**3**	**3**	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO3	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO4	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Practical Statistics for Data Scientists	Peter Bruce, Andrew Bruce, Peter Gedeck	O'Reilly	2nd edition, 2020
2	Data Science from Scratch: First Principles with Python	Joel Grus	Greyscale Indian Edition	2nd edition, 2019
3	Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow	Aurélien Géron	O'Reilly	3rd edition, 2022
4	Think Stats	Allen Downey	O'Reilly	2nd edition, 2014
5	Data Mining: Concepts and Applications	Jiawei Han, Micheline Kamber, Jian Pei	The Morgan Kaufmann Series in Data Management Systems	3rd Edition, 2012

Video Links (NPTEL, SWAYAM…)	
Link ID	https://onlinecourses.nptel.ac.in/noc25_cs17/

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER B. TECH MINOR DEGREE EXAMINATION, MONTH AND YEAR

Course Code: MNIET409

Course Name: Data Analytics and Applications

Max. Marks: 60 | Duration: 2 Hours 30 Minutes

PART A

		Answer all questions. Each question carries 3 marks	CO	Marks
1		A researcher conducts a two-tailed t-test at a 5% significance level and obtains a p-value of 0.03. Explain the interpretation of this result. What would be the conclusion if the significance level were changed to 1%? Justify.	CO1	(3)
2		Explain the key properties of a Normal Distribution. How is it different from a Poisson Distribution?	CO1	(3)
3		Write Python code to apply label encoding to a categorical column, fill missing values with the most frequent category, and scale the numerical features.	CO2	(3)
4		Write Python code using Pandas to Remove duplicate rows and Fill missing numerical values with the column mean.	CO2	(3)
5		Write the logistic function used in Logistic Regression. Explain how it models probability for binary classification.	CO3	(3)
6		What is the bias-variance trade-off?	CO3	(3)
7		Explain how text data is pre-processed before applying machine learning models for sentiment classification. Mention steps like tokenization, stop-word removal, and lowercasing.	CO4	(3)
8		Explain how missing data and outliers are handled in a real estate dataset like Kaggle Housing Prices using pandas.	CO4	(3)

PART B

Answer any one full question from each module. Each question carries 9 marks

Module 1

9	a)	A pharmaceutical company claims its new drug reduces blood pressure by an average of 10 mmHg. A clinical trial on 50 patients shows a mean reduction of	CO1	(5)

		8 mmHg with a standard deviation of 3 mmHg. Conduct a hypothesis test at α = 0.05 to verify the claim. Discuss the implications of Type I and Type II errors in this context.		
	b)	Define the Central Limit Theorem (CLT). A population has a mean of 50 and SD of 15. For samples of size 40, describe the sampling distribution of the mean. Calculate the probability that a sample mean exceeds 53.	CO1	(4)
10	a)	A disease affects 1% of a population. A test is 99% accurate for positives and 95% accurate for negatives. If a person tests positive, what is the probability they actually have the disease? Explain the practical implications of this result.	CO1	(5)
	b)	Explain the step-by-step procedure for conducting a two-tailed hypothesis test for a population mean when the population standard deviation is unknown. Include the rationale behind using the t-distribution instead of the z-distribution in this scenario.	CO1	(4)
Module 2				
11	a)	A researcher wants to compare the test scores of two independent student groups (Group A and Group B). Which statistical test from SciPy should be used? Justify your answer and write the code to perform it using NumPy arrays.	CO2	(5)
	b)	Given a dataset with continuous and categorical variables, write Python code using Seaborn and Matplotlib to: Plot a KDE for distribution of a continuous variable Create a bar chart comparing mean values across categories Customize the plot with title, labels, and legend	CO2	(4)
12	a)	You are working with a dataset for machine learning that includes: Missing numeric values, Categorical columns (Gender, City), A target column for prediction Write a Python pipeline using Scikit-Learn to: Impute missing values, encode categorical variables, standardize numeric columns, Split the data for training and testing	CO2	(5)
	b)	Explain the difference between group by () and pivot table () in Pandas with examples. Write a code snippet to show how both are used to compute the average sales per region from a Data Frame with columns: ['Region', 'Salesperson', 'Sales'].	CO2	(4)

Module 3				
13	a)	A classification model has a high accuracy but a low F1-score. (a) Explain how this situation can occur. (b) Discuss the importance of Precision, Recall, and F1-Score in evaluating classification models. (c) Use an example (confusion matrix) to support your explanation.	CO3	(5)
	b)	Explain the algorithmic or structural differences between K-Means Clustering and Hierarchical Clustering. How do their architectures or workflows differ?	CO3	(4)
14	a)	Explain with an example how polynomial regression differs from linear regression. What kind of problems is it suitable for?	CO3	(5)
	b)	Differentiate between Ridge Regression and Lasso Regression. What is the main advantage of Lasso in feature selection?	CO3	(4)
Module 4				
15	a)	What is the role of R^2 and RMSE in evaluating regression models?	CO4	(2)
	b)	Explain the complete pipeline for building a regression model for predicting house prices. Your answer should include steps such as data collection, exploratory data analysis (EDA), data cleaning, feature engineering, model building, evaluation metrics, and model interpretation.	CO4	(7)
16	a)	Why is TF-IDF preferred over simple word counts?	CO4	(2)
	b)	Describe the entire process of performing sentiment analysis on customer reviews using machine learning. Your answer should include steps like text preprocessing (cleaning, tokenization), feature extraction (TF-IDF), model selection (e.g., Naïve Bayes), and evaluation using classification metrics.	CO4	(7)
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SEMESTER 5

SEMESTER 5

OPTIMISATION AND HEURISTICS

Course Code	MNIET509	CIE Marks	40
Teaching Hours/Week (L: T:P)	3:1:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To enable students to formulate real-world industrial problems as mathematical models and solve them using appropriate optimization techniques.
2. To familiarise heuristic algorithms, highlighting their principles, advantages, limitations, and applications in industrial decision-making.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Linear Programming:** Concept, Formulation & Graphical and Simplex Solution **Assignment Models:** Concept, Flood's Technique/Hungarian Method, applications including restricted & multiple assignments. **Transportation Models:** Concept, Formulation, Problem types: Balanced, Unbalanced, Minimization, Maximization Basic initial solution using North West Corner, Least Cost & VAM, and Optimal Solution using MODI. Basic Engineering Applications.	11
2	**Queuing Theory**: Concept, Single Server queuing model (M/M/I,), **Decision Theory**: Concept, Decision under risk (EMV) & uncertainty, **Basic Game Theory**: Concept, 2 zero sum game with dominance, Pure & Mixed Strategy.	11
3	**Nonlinear Programming (NLP):** Basics, Unconstrained Optimization (Single & Multi-variable), Lagrange Multipliers (Constrained	11

	Optimization - Basic Cases Only). Applications in Engineering Optimization.	
4	**Heuristic Optimization:** Introduction to Heuristics, Real-world Applications of Heuristics, Greedy Algorithms, Local Search, Genetic Algorithms, Ant Colony Optimization, Particle Swarm Optimization, Simulated Annealing (Basic Concept & Working Mechanism). Multi-objective Optimization Heuristics (Basic concepts only) **Software Tools:** Introduction to solvers like LINGO, Gurobi, and Python-based tools.	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Formulate and solve linear programming, transportation and assignment problems.	**K3**
CO2	Apply queuing theory, game theory, and decision theory to solve industrial and allied problems.	**K3**
CO3	Solve constrained and unconstrained nonlinear optimization problems using Lagrange multipliers and heuristic methods.	**K3**
CO4	Explain the importance, features, advantages, limitations, and industrial applications of heuristic optimization algorithms.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO2	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO3	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO4	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Operations Research: Theory And Application	Sharma J. K	Laxmi Publications	6th Edition, 2017
2	Engineering Optimization: Theory and Practice	S. S. Rao	New Age International	3rd Edition, 2004
3	Operations Research	Srinivasan G.	Prentice Hall India	2nd Edition, 2010
4	Quantitative Methods in Management	Vohra N. D.	Tata McGrew Hill	5th Edition, 2017

5	Introduction to Management Science	Bernard W. Taylor	Pearson Education	11th Edition, 2013
6	Principles of Operations Research with Applications to Managerial Decisions	Harvey M. Wagner	Prentice Hall India	2nd Edition, 1975
7	Modern Heuristic Techniques for Combinatorial Problems	Colin R. Reeves	Orient Black Swan	1st Edition, 1993
8	Metaheuristics for Hard Optimization	Johann Dréo, Alain Pétrowski, Patrick Siarry, Eric Taillard	Springer-Verlag Berlin and Heidelberg Gmbh	1st Edition, 2010

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Operations Research	Frederick S. Hillier, Gerald J. Lieberman	Tata McGrew Hill	11th edition, 2020
2	Optimization in Operations Research	Ronald L. Rardin	Pearson Education	2nd edition, 2016
3	Introduction to Operations Research	Hamdy A. Taha	Pearson Education	10th edition, 2019
4	Operations Research: Applications and Algorithms	Wayne L. Winston	Duxbury Press	4th edition, 2003
5	Convex Optimization	Stephen Boyd, Lieven Vandenberghe	Cambridge University Press	1st edition, 2004
6	Convex Optimization Algorithms	Dimitri P Bertsekas	Athena Scientific	1st edition, 2015

7	Metaheuristic Search Concepts- A Tutorial with Applications to Production and Logistics	Günther Zipfel, Roland Braune, Michael Bögl	Springer-Verlag Berlin and Heidelberg GmbH	20th edition, 2014
8	Meta-Heuristics: Theory and Applications	Ibrahim H. Osman, James P. Kelly	Springer	1st edition, 1996
9	Meta-Heuristics: Advances and Trends in Local Search Paradigms for optimization	Stefan Voß, Silvano Martello, Ibrahim H. Osman, Cathérine Roucairol	Springer	1st edition, 1998
10	Genetic Algorithms + Data Structures = Evolution Programs	Z. Michalewicz	Springer-Verlag Berlin and Heidelberg Gmbh	2nd edition, 1994

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/noc/courses/noc21/SEM1/noc21-mg43/
2	https://archive.nptel.ac.in/noc/courses/noc17/SEM2/noc17-ma18/
3	https://archive.nptel.ac.in/courses/112/106/112106131/
4	https://archive.nptel.ac.in/courses/106/106/106106226/
	https://archive.nptel.ac.in/courses/110/106/110106134/

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH MINOR DEGREE EXAMINATION, MONTH AND YEAR

Course Code: MNIET509

Course Name: Optimisation And Heuristics

Max. Marks: 60		Duration: 2 hours 30 minutes

PART A

		Answer all questions. Each question carries 3 marks	CO	Marks
1		What are the components of a linear programming problem? What does the non-negativity restriction mean?	CO1	(3)
2		What is degeneracy? How does the problem of degeneracy arise in a transportation problem? How can we deal with this problem?	CO1	(3)
3		If the utilization parameter or traffic intensity is 0.75, what percent of time the system will be idle?	CO2	(3)
4		With an example illustrate how can entries in a regret table be derived from pay off table.	CO2	(3)
5		Find the stationary points of the following function and label them: $f(x) = x^4 - 10x^3 - 2x^2 + x + 10$	CO3	(3)
6		Describe KKT conditions as applied to constrained optimization problem with both equality and inequality constraints.	CO3	(3)
7		Write notes on pareto optimal set and pareto front.	CO4	(3)
8		Explain the characteristics of ACO.	CO4	(3)

PART B

Answer any one full question from each module. Each question carries 9 marks

Module 1

9		Using simplex method Maximize $Z = 6X + 4Y$ Subject to $-2X + Y \leq 2$ $X - 5 \leq 2$ $3X + 2Y \leq 9$ $X, Y \geq 0$	CO1	(9)
10		Five different machines can do five jobs with different profits resulting from each assignment as shown:	CO1	(9)

			A	B	C	D	E		
		1	30	37	40	28	40		
		2	40	24	27	21	36		
		3	40	32	33	30	35		
		4	25	38	40	36	36		
		5	29	62	41	34	39		
		Estimate the maximum profit possible through optimal assignment							
Module 2									
11		A typist receives, on an average, 22 letters per day for typing. He works for 8 hours a day and takes 20 minutes on average to finish a letter. The opportunity cost of a letter waiting to be mailed is Rs. 8/- per hour and the equipment operating cost and the salary of the typist will be Rs. 400/- per day. a) What is the utilization rate of the typist? b) What is the average number of letters waiting to be typed? c) What is the average waiting time needed to have a letter typed? What is the total cost of waiting letters to be mailed?						CO2	(9)
12		Following is the payoff matrix for player A & B.						CO2	(9)
		Player A→ Player B↓	I	II	III	IV	V		
		1	2	4	3	3	4		
		2	5	6	3	7	8		
		3	6	7	9	8	7		
		4	4	2	8	4	3		
		Using the dominance property obtain the optimal strategies for both the players and determine the value of the game.							
Module 3									
13		Maximize $8x_1^2 + 5x_1 + 6x_2^2$ Subject to $x_1 + 2x_2 \leq 9$ $x_1 + 3x_2 \leq 10$ $x_1, x_2 \geq 0$						CO3	(9)
14		Find the minimum of the following function using golden section search:						CO3	(9)

		$f(x) = (x + 10)^2 - 0.1x^3$ The interval of uncertainty is [-10, 0]. Do 6 iterations		
Module 4				
15	a)	Describe the ways by which the quality of a heuristic can be assessed.	CO4	(5)
	b)	Explain the main components of simulated annealing.	CO4	(4)
16	a)	Discuss the advantage of non-traditional optimization techniques	CO4	(5)
	b)	Explain important parameters in Particle Swarm Optimization.	CO4	(4)
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SEMESTER 6

SEMESTER 6

SYSTEM DYNAMICS AND SIMULATION

Course Code	MNIET609	CIE Marks	40
Teaching Hours/Week (L: T: P)	3:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To familiarise the fundamental principles of system modelling and simulation.
2. To enable students to simulate the behaviour of dynamic systems and to develop competency in model validation and optimization techniques.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of System Modelling:** Concept of systems, models and simulation. Classification of models: physical, mathematical and computational models. Continuous and discrete systems: characteristics and applications. Introduction to time-domain and frequency-domain analysis. Overview of system dynamics in engineering applications.	9
2	**Dynamic Systems and Simulation Techniques:** Introduction to dynamic modelling principles. Representation of physical systems: mechanical, electrical, hydraulic, pneumatic and thermal systems. System response: first-order and second-order systems. Transfer function representation and block diagram algebra. State-space representation of dynamic systems.	9
3	**Computational Tools for Simulation:** Introduction to simulation methodologies. Modelling and simulation using MATLAB and Simulink. Bond graph modelling approach and causality analysis. Application of simulation techniques for mechanical and electromechanical systems. Verification and validation of simulation models.	9
4	**Advanced System Analysis and Optimization:** Frequency response analysis: Bode plots and Nyquist plots. Stability analysis and performance measures of systems. System identification and parameter estimation techniques. Introduction to optimization in system modelling. Applications of Monte Carlo simulation in engineering problems.	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the fundamental concepts of system dynamics and simulation.	**K2**
CO2	Develop mathematical models for various dynamic systems.	**K3**
CO3	Apply simulation techniques using computational tools.	**K3**
CO4	Identify system performance through simulation models.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	3	-	-	-	-	-	-	-	-	-	2
CO2	-	3	3	2	-	-	-	-	-	-	-	2
CO3	-	3	3	2	3	-	-	-	-	-	-	2
CO4	-	3	3	2	3	3	-	-	-	-	-	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	System Dynamics: Modeling, Simulation, and Control	Dean C. Karnopp	John Wiley & Sons	5th edition, 2012
2	Introduction to Dynamic Systems: Modeling for Simulation	David G. Luenberger	Wiley	1st edition, 1979
3	System Dynamics and Control with Bond Graph Modeling	Amalendu Mukherjee	Springer	1st edition, 2006

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Dynamic Modeling and Simulation	Craig A. Kluever	Wiley	1st edition, 2015
2	Bond Graphs for Modelling, Control, and Fault Diagnosis	Wolfgang Borutzky	Springer	2nd edition, 2017
3	Simulation Modeling and Analysis	Averill M. Law	McGraw-Hill	5th edition, 2015
4	Engineering System Dynamics	Forbes T. Brown	CRC Press	2nd edition, 2006

Video Links (NPTEL, SWAYAM…)	
Link IDs	https://archive.nptel.ac.in/courses/112/107/112107220/
	https://archive.nptel.ac.in/courses/112/107/112107214/

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B. TECH MINOR DEGREE EXAMINATION, MONTH AND YEAR

Course Code: MNIET609

Course Name: System Dynamics and Simulation

Max. Marks: 60 | Duration: 2 hours 30 minutes

PART A

		Answer all questions. Each question carries 3 marks	CO	Marks
1		Differentiate between deterministic and stochastic systems with examples.	CO1	(3)
2		List and explain the properties of dynamic systems.	CO1	(3)
3		Derive the transfer function of a torsional system with multiple inertia and damping elements.	CO2	(3)
4		Discuss the significance of poles and zeros in the frequency response of dynamic systems.	CO2	(3)
5		Describe the process of causality assignment and its effect on simulation in bond graphs.	CO3	(3)
6		What are the challenges in validation of large-scale simulation models?	CO3	(3)
7		Explain how Bode plot asymptotes change with multiple pole-zero contributions.	CO4	(3)
8		Describe the methodology to perform optimization in a multi-variable nonlinear dynamic model.	CO4	(3)

PART B

Answer any one full question from each module. Each question carries 9 marks

Module 1

9	a)	Explain the components and classification of dynamic systems with suitable examples.	CO1	(5)
	b)	Discuss how simulation helps in analysing complex systems.	CO1	(4)
10	a)	With the help of a neat diagram, explain the working of a simple system.	CO1	(5)
	b)	Describe the steps involved in system modelling.	CO1	(4)

Module 2

11	a)	For a first-order system with transfer function G(s) = 1/(s+3), determine its step response.	CO2	(5)
	b)	Discuss the role of eigenvalues in analysing system stability.	CO2	(4)

12	a)	A second-order system has the transfer function G(s) = 25 / (s^2 + 6s + 25). Find its damping ratio and natural frequency.	CO2	(5)
	b)	Discuss modelling of electrical systems using differential equations.	CO2	(4)
Module 3				
13	a)	Model a robotic manipulator joint using bond graph and assign appropriate causality.	CO3	(5)
	b)	Discuss the complexities of simulating constrained systems in Simulink.	CO3	(4)
14	a)	Perform a detailed causality analysis and derive state equations for a multi-bond system.	CO3	(5)
	b)	How would you validate this model using hardware-in-the-loop simulation?	CO3	(4)
Module 4				
15	a)	Analyse a high-order system using Nyquist criterion and determine phase/gain margins.	CO4	(5)
	b)	Explain how model reduction techniques affect simulation accuracy.	CO4	(4)
16	a)	Apply Monte Carlo simulation to estimate system reliability under uncertain input distributions.	CO4	(5)
	b)	Outline a parameter optimization problem in system dynamics and solve using genetic algorithm basics.	CO4	(4)
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