SEMESTER 5

INDUSTRIAL ENGINEERING

SEMESTER S5

DATA ANALYTICS

Course Code	PCIET501	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	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 apply analytical tools and deduct valid inferences from data.
2. To equip students to develop decision making and analytical skills.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to data analysis:** Need for data analysis, collection of data, organization and presentation of data, primary types of measurement scales - nominal, ordinal, interval and ratio scales; Deciles, quartiles and percentiles. **Descriptive statistics:** Measures of central tendency, measures of variability, skewness and kurtosis, Chebyshev's theorem, the empirical rule. exploratory data analysis. Overview of discrete and continuous probability distributions.	11
2	**Sampling and sampling distributions:** Samples and population, sampling process, non- probability and probability sampling- different types, determination of sample size, introduction to sampling distributions, central limit theorem. **Estimators:** Properties, point estimates, interval estimates and confidence intervals.	11
3	**Hypothesis testing:** Formulation of hypothesis, type I and type II error, power of the test, One sample and two sample tests - z-test, t-test, Chi-square test, F-test. **Non-parametric methods:** K-S test, sign test for paired data, one sample Runs test, rank sum tests – Mann-Whitney U-test and Kruskal-Wallis test. **Analysis of variance:** Theory and computations of ANOVA, ANOVA table, two-way ANOVA, blocking designs, factorial design.	11

4	**Correlation and regression:** Correlation analysis-Pearson correlation, Spearman's rank correlation, significance of correlation, estimation using the regression line, multiple regression- k-variable multiple regression model, F-test of a multiple regression model. **Introduction to index numbers:** Overview of multivariate techniques - factor analysis, multidimensional scaling, cluster analysis, discriminant analysis and conjoint analysis.	**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 = 24 marks)**	• 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 subdivisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcomes		Bloom's Knowledge Level (KL)
CO1	Interpret data based on descriptive statistics.	**K2**
CO2	Apply statistical techniques for analysing samples from the fields of business and industry.	**K3**
CO3	Infer about the population on the basis of random samples from the population.	**K2**
CO4	Identify the relationships, patterns, correlations and trends between variables or datasets.	**K3**

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

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	2	2	3	1	-	-	-	2	-	2
CO2	2	2	3	2	3	2	-	-	-	2	-	2
CO3	2	2	3	2	3	2	-	-	-	2	-	2
CO4	2	2	3	2	3	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	Statistics for Management	Levin, I. R., Siddiqui, M. H., Rubin, D. S.	Pearson Education	8th Edition, 2017
2	Business Statistics	Sharma, J. K.	Pearson Education	5th Edition, 2019

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Complete Business Statistics	Aczel, A. D., Sounderpandian, J., Saravanan, P. and Joshi, R.	McGraw Hill	7th Edition, 2017
2	100 Statistical Tests	Kanji, K. G.	Sage Publication	3rd Edition, 2007
3	John E. Freund's Mathematical Statistics with Applications	Miller, I. and Miller, M.	Prentice Hall India	8th Edition, 2013
4	Probability and Statistics in Engineering	Hines, W. W., Montgomery, D. C., Goldsman, D. M., and Borror, C. M.	John Wiley& Sons	4th Edition, 2004
5	Research for Marketing Decisions	Green, P. E., Tull, D. S. and Albaum, G.	Prentice Hall	5th Edition, 2009

Video Links (NPTEL, SWAYAM…)	
Link ID	https://archive.nptel.ac.in/courses/110/107/110107114/
	https://archive.nptel.ac.in/courses/106/106/106106179/

SEMESTER S5

SUPPLY CHAIN AND LOGISTICS MANAGEMENT

Course Code	**PCIET502**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To enable for applying tools and techniques related to supply chain management.
2. To enable for applying models and tools related to logistics management.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to supply chains:** Definition, objectives, structures, decision phases, performance measures, drivers, metrics and strategic fit, design of distribution networks and models for facility location and layout decisions. Features of postponement, mass customisation and supply chain restructuring. Understanding of lean, agile, leagile, resilient, dual channel, humanitarian, and international supply chains, integration of block chain, cloud computing, internet of things (IoT), artificial intelligence (AI) and machine learning (ML) in supply chains.	11
2	**Forecasting and planning in supply chains:** Forecasting models for supply chains including seasonal models, de-seasonalization and forecast errors. Aggregate planning strategies, methods and models applied to example cases. Operations planning to respond predictable variability in production and manufacturing chains using sequencing, scheduling, and line balancing.	11
3	**Supply chain inventory models:** Application of cycle inventory models, discounting models, multi-item inventory models and production-consumption models related to supply chains including multi-echelon systems. Solutions for safety inventory models in continuous review and periodic review cases of single and multi-items with probabilistic demand included in multi-echelon chains. Apply techniques related to optimal level of product	11

	availability, bullwhip effect and risk pooling.	
4	**Logistics management:** Understanding transportation networks, trade-offs, risk management, 3PL, 4PL and 5PL. Models for allocation, routing, scheduling and sequencing in transportation, solutions for vehicle routing problems and multi-stage transportation problems included with node capacities. Application logistics decision models including bin packing problems, fixed charge problems and knapsack problems, models and tools related to reverse, closed loop and green logistics in uncertain situations like pandemic and rescue scenarios.	**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 = 24 marks)**	• 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 subdivisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcomes		Bloom's Knowledge Level (KL)
CO1	Understand general and advanced supply chain networks.	**K2**
CO2	Apply tools on forecasting and planning decisions in supply chains.	**K3**
CO3	Apply inventory models on material flow decisions in supply chains.	**K3**
CO4	Apply tools and models for logistics decisions.	**K3**

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

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	-	-	-	-	-	-	-	-	1	-	2
CO2	2	-	3	-	3	-	-	-	-	1	-	2
CO3	2	-	3	-	3	-	-	-	-	1	-	2
CO4	2	-	3	-	3	-	-	-	-	1	-	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	Supply Chain Management: Strategy, Planning and Operation	Chopra, S., Meindl, P.	Pearson Education	6th Edition, 2016
2	Quantitative Models in Operations and Supply Chain Management	Srinivasan, G.	Prentice Hall India	2nd Edition, 2018

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Logistical Management: The Integrated Supply Chain Process	Bowersox, D. J., Closs, D. J.	McGraw Hill	1st Edition, 2017
2	Logistics and supply chain management	Christopher, M.	Pearson Education	4th Edition, 2011
3	Modelling and Supply Chain, Cengage Learning	Shapiro, J. F.	Cengage Learning	1st Edition, 2006
4	Manufacturing Operations and Supply Chain Management.	Taylor, D., Brunt, D.	Vikas Thomson Learning	1st Edition, 2009

Video Links (NPTEL, SWAYAM…)	
Link ID	https://archive.nptel.ac.in/courses/110/106/110106045/
	https://archive.nptel.ac.in/courses/110/105/110105095/

SEMESTER S5

QUALITY ENGINEERING

Course Code	**PCIET503**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To familiarise the fundamentals of Quality Engineering and its role in quality improvement.
2. To enable students to integrate the quality engineering principles into product development and manufacturing processes.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Concepts related to quality engineering:** Philosophies of Deming, Juran and Crosby. Basic concepts of quality- quality of design, quality of conformance, quality of performance. Quality objectives, quality policy, quality function, quality control, quality assurance, total quality management, cost of quality, loss functions, manufacturing tolerances.	9
2	**Statistical process control:** Process control- process variability, causes of variation, control charts for variables, control chart for attributes. State of control and process out of control identification in control charts, patterns in control charts. Other control charts - cumulative sum control chart for process mean and exponentially weighted moving average control chart. Specifications and process capability - process capability indices, process capability analysis, tolerances for assemblies and subassemblies.	9
3	**Acceptance sampling plans:** Single, double, multiple and sequential sampling plans. Operating characteristic curves for single and double sampling plans. Evaluating sampling plans. Standard sampling plans - MIL-STD 105E sampling method and its equivalents, Dodge - Romig tables, ABC standards, AOQL and LTPD plans.	9

4	**Quality improvement tools and techniques:** Fault tree analysis, event tree analysis, failure mode and effect analysis, quality function deployment, Six Sigma- introduction, definition, DMAIC method, roles and responsibilities, Taguchi's methods - robust design, control and noise factors, S/N ratios, Quality circles - concepts, objectives, organisational structure, KAIZEN - meaning - management practices, quality standards- ISO 9000 Series, ISO 14000 standards.	**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 philosophies and concepts related to quality engineering.	**K2**
CO2	Apply statistical quality control tools for process control.	**K3**
CO3	Apply the knowledge on acceptance sampling for sampling inspection.	**K3**
CO4	Explain the quality improvement tools and techniques and apply the same for process improvement.	**K3**

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

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	-	-	-	-	2	2	-	-	2
CO2	3	2	3	2	-	-	-	2	2	-	-	2
CO3	3	2	3	2	-	-	-	2	2	-	-	2
CO4	3	2	3	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	Fundamentals of Quality Control and Improvement	Mithra A.	Wiley	5th Edition, 2021
2	Statistical Quality Control	Mahajan M.	Dhanpat Rai & Co	4th Edition, 2018

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Statistical Quality Control	Grant, E., Leavenworth R.	McGraw Hill	7th Edition, 2017
2	Introduction to Statistical Quality Control	Montgomery D. C.	Wiley	8th Edition, 2020
3	Total Quality Management	Besterfield, D.H., Besterfield, C	Pearson Education	5th Edition, 2019
4	The Handbook for Quality Management	Pyzdek, T., Keller, P.A	McGraw Hill	2nd Edition, 2012

Video Links (NPTEL, SWAYAM…)	
Link ID	https://archive.nptel.ac.in/courses/110/104/110104080/

SEMESTER S5

OPTIMISATION TECHNIQUES

Course Code	**PBIET504**	**CIE Marks**	60
Teaching Hours/Week (L:T:P: R)	3:0:0:1	**ESE Marks**	40
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To enable students to solve large scale optimization problems with single as well as multiple objectives.
2. To enable students to apply advanced tools and techniques to handle linear, non - linear problems and network models.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Linear Programming:** Advanced solution techniques - Revised simplex method, dual simplex method, two phase method, interior point method, sensitivity analysis. **Integer programming**: Formulation and solution techniques - Introduction to dynamic programming and software tools for linear programming.	**11**
2	**Queuing theory**: Markovian queue models, single server & multiple server models. **Game theory**: Practical application of game theory, two–person, zero -sum games, solution with and without saddle point, rules of dominance, other solution methods.	**11**
3	**Nonlinear programming:** Definition, formulation of non-linear programming problems (NLPs), Convex and non-convex functions, solving NLPs with one variable (unconstrained maximization and minimization), unconstrained maximization and minimization with several variables, the method of steepest descent, Newton's method and quasi - Newton method, conjugate gradient and conjugate direction methods. **Constrained optimization methods:** Lagrange multipliers, Kuhn-Tucker condition, method of feasible directions, pareto optimality and trade-off curves.	**11**

4	**Network problems:** Introduction to graph theory and basic definitions. Minimum spanning tree problem - Prim's algorithm, Kruskal's algorithm, Shortest path problems - Dijkstra's algorithm, Floyd's algorithm, successive shortest path algorithm. Maximum flow problems, flow augmenting path, labelling algorithm, maximum flow and minimum cut, shortest augmenting path algorithm, minimum cost flow problem, network simplex method. **Travelling salesman problem (TSP)**: Branch and bound and heuristic algorithms for the TSP, Chinese postman problem. **Vehicle Routing Problems:** Optimal solutions, Little's algorithm and heuristic solutions, savings based algorithm, Holmes and Parker refinement.	**11**

Suggestion on Project Topics: Each student team can choose some simple close to real life projects from the areas discussed in the syllabus, such as

- Production Planning problem
- Cutting Stock Problem
- Fixed Charge Problem
- Resource allocation
- Scheduling
- Parameter optimization
- Analysis of practical problems using network models
- Portfolio optimization

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

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	**30**	**12.5**	**12.5**	**60**

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 2 marks **(8x2 =16 marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 subdivisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply advanced tools to solve linear and linear integer programming problems and analyse the sensitivity of solutions to dynamic situations.	**K4**
CO2	Apply queuing and game theory to develop solutions for industrial and allied areas.	**K3**
CO3	Solve the constrained and unrestricted nonlinear optimization problems using gradient non-gradient based techniques.	**K3**
CO4	Construct appropriate network models and build optimal solutions to industrial problems.	**K3**

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

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

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

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	Singaresu 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

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

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/112/106/112106131/

PBL Course Elements

L: Lecture (3 Hrs.)	**R: Project (1 Hr.), 2 Faculty Members**		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	**Evaluation for**	**Allotted Marks**
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. Project Planning and Proposal (5 Marks)

- Clarity and feasibility of the project plan
- Research and background understanding
- Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

    - Individual contribution to the presentation
    - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

    - Active participation and individual contribution
    - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

    - Adherence to the project timeline and milestones
    - Application of theoretical knowledge and problem-solving
    - Final Result

5. **Final Presentation (5 Marks)**

    - Quality and clarity of the overall presentation
    - Individual contribution to the presentation
    - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

    - Overall quality and technical excellence of the project
    - Innovation and originality in the project
    - Creativity in solutions and approaches

SEMESTER S5

ADVANCED MANUFACTURING PROCESSES

Course Code	PEIET521	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To provide students with a comprehensive understanding of advanced manufacturing methods and its processes parameters.
2. To enable students to apply the process capabilities of the modern manufacturing methods in industries.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Mechanical processes**: Ultrasonic machining- elements of process, effect of parameters, applications, limitations of the process, advantages and disadvantages. Abrasive jet machining (AJM) - variables in AJM, metal removal rate in AJM. Water jet machining- jet cutting equipment, process details, advantages and applications.	9
2	**Electrochemical processes:** Electrochemical machining (ECM) - elements of ECM process, tool work gap, chemistry of the process, metal removal rate, accuracy and surface finish, advantages, applications, limitations. Electrochemical grinding - material removal, surface finish, accuracy, advantages, applications.	9
3	**Thermal processes:** Electric discharge machining (EDM) or spark erosion machining processes, mechanism of metal removal, electrode feed control, dielectric fluids, selection of electrode material, surface finish, machining accuracy, applications, wire cut EDM. Laser beam machining (LBM)- apparatus, material removal, cutting speed and accuracy of cut, advantages and limitations.	9

4	**Plasma arc and Electron beam processes:** Plasma arc machining (PAM) - plasma, non-thermal generation of plasma, mechanism of metal removal, PAM parameters, safety precautions, other applications of plasma jets. Electron beam machining (EBM) - generation and control of electron beam, theory of electron beam machining, process capabilities and limitations. **High energy rate forming processes:** Explosive forming processes-principles, effect of process in material properties, types of explosives forming. Magnetic pulse forming processes - general principles, applications.	**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 = 24 marks)**	• 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 subdivisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcomes		Bloom's Knowledge Level (KL)
CO1	Apply the concepts of non conventional mechanical material removal processes.	**K3**
CO2	Identify the various electrochemical machining processes.	**K3**
CO3	Apply the principles and concepts of thermal material removal processes.	**K3**
CO4	Make use of the concepts of high energy rate forming, plasma arc and electron beam machining processes.	**K3**

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

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	-	3	-	-	-	-	-	-	2
CO2	3	1	2	-	3	-	-	-	-	-	-	2
CO3	3	1	2	-	3	-	-	-	-	-	-	2
CO4	3	1	2	-	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	Manufacturing Science	Amitabha Ghosh A. K., Mallik	East West Press	2nd Edition, 2010
2	Production Technology	HMT	McGraw Hill Education	1st Edition, 2017
3	Modern Machining Processes	P. C. Pandey, H. S. Shan	McGraw Hill Education	1st Edition, 2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Unconventional Machining Processes	M. Adithan	Atlantic	1st Edition, 2018
2	Advanced Methods of Machining	Mc Geongh J. A.	Chapman and Hall	1st Edition, 1988
3	Non-Traditional Machining Processes	Jagadeesha T.	I K International Publishing House	0th Edition, 2016

Video Links (NPTEL, SWAYAM…)	
Link ID	https://archive.nptel.ac.in/courses/112/103/112103202/

SEMESTER S5

MECHANICS OF METAL CUTTING

Course Code	PEIET522	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To provide students with a thorough understanding of the principles and mechanics underlying metal cutting processes.
2. To equip students with the skills to analyze and apply advanced machining techniques.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of metal cutting:** Definition and importance of metal cutting, types of metal cutting processes- turning, milling, drilling and grinding. Overview of cutting tools and their materials. Mechanics of cutting - chip formation and types of chips, orthogonal and oblique cutting. Forces in cutting - cutting force, thrust force, radial force. Cutting tool geometry - single-point and multi-point cutting tools, tool angles and their significance. Tool life and wear mechanisms. Cutting fluids- types and properties of cutting fluids, functions and applications of cutting fluids.	9
2	**Cutting tool materials and coatings:** High-speed steels, carbides, ceramics, and diamond tools, properties and applications of different tool materials. Tool coatings - types of coating - TiN, TiC and Al2O3, benefits of coatings in cutting performance. Tool material selection - criteria for selecting tool materials. Cost benefit analysis of different tool materials and coatings.	9
3	**Cutting parameters and surface integrity:** Cutting parameters - speed, feed, and depth of cut, influence of cutting parameters on cutting forces and tool life, optimization of cutting parameters for different materials. Surface integrity- surface roughness and its measurement, factors affecting surface	9

	finish in machining, impact of cutting conditions on surface integrity. Inspection methods for machined components, statistical process control in machining, tolerances and fits in metal cutting.	
4	**Advanced Machining Techniques and Future Trends:** Introduction to non-traditional machining processes - EDM, ECM, LBM, applications and advantages of non-traditional machining, high-speed and ultra-precision machining, principles of high-speed machining, equipment and techniques for ultra-precision machining, applications in aerospace, automotive, and electronics industries. Emerging technologies in machining- additive manufacturing, hybrid machining.	**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 =24 marks)**	• 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 fundamentals of metal cutting processes and cutting tool geometry.	**K2**
CO2	Identify cutting tool materials and coatings for their suitability in various machining applications.	**K3**
CO3	Apply cutting parameters to improve surface integrity and enhance the overall quality of machined components.	**K3**
CO4	Make use of advanced machining techniques and automation technologies to address the challenges in the industry.	**K3**

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

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	2	-	1	-	-	-	-	-	-	2
CO2	3	-	2	-	2	-	-	-	-	-	-	2
CO3	3	-	2	-	2	-	-	-	-	-	-	2
CO4	3	-	2	-	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	Metal Cutting Principles	Milton C. Shaw	Oxford University Press	2nd Edition, 2005
2	Machining and Machine Tools	A. B. Chattopadhyay, P. C. Mishra	Wiley India	2nd Edition, 2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Elements of Workshop Technology	S. K. Hajra Choudhury	Media Promoters and Publishers	15th Edition, 2010
2	Fundamentals of Metal Cutting and Machine Tools	B. L. Juneja	New Age Publishers	2nd Edition 2017

Video Links (NPTEL, SWAYAM…)	
LINK ID	https://archive.nptel.ac.in/courses/112/105/112105233/

SEMESTER S5

ADVANCED METAL JOINING TECHNIQUES

Course Code	**PEIET523**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To equip students with fundamental knowledge of advanced welding processes.
2. To enable students to apply advanced welding processes for industrial applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Radiant energy welding:** Electron beam welding - guns, weld environment, welding in different degrees of vacuum, equipment and safety, joint design, applications. Laser beam welding - principle of operation, process parameters, applications and limitations. Explosive welding- process parameters, applications, advantages and limitations, joint design, materials and applications.	9
2	**Plasma arc welding:** Plasma arc welding- theory and principles, transferred arc and non-transferred arc techniques, equipment and tooling, advantages, disadvantages and applications. Laser TIG hybrid welding, double side arc welding, magnetic arc welding.	9
3	**Friction welding:** Basic principles, process variants, different stages of friction welding, process parameters, advantages, limitations and applications. Friction stir welding- process variables and applications. Diffusion welding- theory and principle of process, key variables	9
4	**Modeling of welding processes**: Wire arc additive manufacturing (WAAM), (concept only), modelling of welding processes, welding modelling software's and its applications, major welding defects and its detection. Heat Affected zone (HAZ) formation in different welding methods, welding distortions and residual stresses in different welding methods.	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 = 24 marks)**	• 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 subdivisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcomes		Bloom's Knowledge Level (KL)
CO1	Apply radiant energy welding processes in industries.	**K3**
CO2	Make use of plasma arc welding and other modern welding techniques in manufacturing.	**K3**
CO3	Identify the applications of friction and diffusion welding for various fabrication requirements.	**K3**
CO4	Analyse the performance of a welding process using modern tools.	**K4**

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

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	3	-	-	-	-	-	-	2
CO2	3	-	-	-	3	-	-	-	-	-	-	2
CO3	3	-	-	-	3	-	-	-	-	-	-	2
CO4	3	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	Welding Processes and Technology	R.S. Parmar	Khanna Publishers	3rd Edition, 1996
2	Advanced Welding Technology	B. R. Senthil Kumar	Notion Press	1st Edition, 2022

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	A Textbook of Welding Technology	G.D. Garg	S.K. Kataria & Sons	4th Edition, 2012
2	Welding and Welding Technology	Richard Little	McGraw Hill Education	2nd Edition, 2017
3	Advanced Welding Technology	S.P. Tewari	S.K. Kataria & Sons	1st Edition, 2011

Video Links (NPTEL, SWAYAM…)	
Link ID	https://archive.nptel.ac.in/courses/113/106/113106087/

SEMESTER S5

METAL FORMING AND TOOL DESIGN

Course Code	PEIET524	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To provide students with a comprehensive understanding of the principles, processes, and techniques involved in metal forming.
2. To equip students with the skills to design effective tools for various metal forming processes.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of metal forming:** Definition and classification of metal forming processes, advantages and limitations of metal forming, applications in various industries, stress and strain in metal forming. Concepts of stress and strain in deformable bodies, flow stress, true stress, and true strain, yield criteria for ductile materials (Von Mises and Tresca). Plastic deformation and work hardening, forming limit diagrams, influence of temperature on forming processes. Hot, warm, and cold working - strain rate sensitivity and its impact on material behavior.	9
2	**Bulk deformation processes:** Forging - types (open-die, closed-die, impression-die), equipment, and applications. Rolling - types (hot and cold rolling), rolling mills, and products. Extrusion - direct and indirect extrusion, equipment, and applications. Drawing - wire drawing, tube drawing, and deep drawing. **Sheet metal forming processes:** Bending- types of bending operations, bending allowances, and springback. Shearing - types of shearing operations, shearing force calculation. Deep drawing - mechanics of deep drawing. Stamping and punching - operations, tools and applications, defects of various metal forming processes and its remedies.	9

3	**Introduction to tool design**: Role of tool design in manufacturing, types of tools used in metal forming, material selection for tools and dies, design of forging dies, types of forging dies, design considerations and calculations for forging dies, lubrication and cooling of forging dies, die design for extrusion processes, tooling for tube and wire drawing, design of dies and punches for blanking and piercing, design of deep drawing dies and tooling for stamping operations.	**9**
4	**Advanced topics in metal forming and tool design**: Finite element analysis in metal forming, basics of finite element method (FEM) in metal forming, application of FEM in analyzing forming processes, role of automation in metal forming, CNC and robotic applications in forming processes, maintenance strategies for forming tools, additive manufacturing for tool design and repair.	**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 = 24 marks)**	● 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 and principles of metal forming processes, including stress, strain, and material behavior	**K2**
CO2	Apply various metal forming processes such as forging, rolling, extrusion, and sheet metal forming in industry.	**K3**
CO3	Identify tools for different metal forming processes, considering factors such as material selection, tool wear and maintenance.	**K3**
CO4	Apply finite element analysis (FEA) and other advanced techniques to optimize metal forming processes and tool design.	**K3**

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

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	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
CO4	3	-	2	-	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	Metal Forming: Mechanics and Metallurgy	William F. Hosford, Robert M. Caddell	Cambridge University Press	4th Edition, 2011
2	Fundamentals of Tool Design	Society of Manufacturing Engineers (SME)	SME	6th Edition, 2010

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Metal Forming Analysis	R. H. Wagoner, J. L. Chenot	Cambridge University Press	1st Edition, 2001
2	Tool Design	Cyril Donaldson, George H. LeCain, V. C. Goold	Tata McGraw-Hill Education	4thEdition, 2012
3	Sheet Metal Forming: Processes and Applications	Taylan Altan, A. Erman Tekkaya	ASM International	1st Edition, 2012

Video Links (NPTEL, SWAYAM…)	
Link ID	https://archive.nptel.ac.in/courses/112/107/112107250/

SEMESTER S5

ADDITIVE MANUFACTURING AND 3D PRINTING

Course Code	PEIET525	CIE Marks	40
Teaching Hours/Week (L:T:P:R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To enable students to familiarise the concepts and various software tools in Additive Manufacturing (AM).
2. To equip students with knowledge on applications of additive manufacturing in real world scenarios.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to additive manufacturing (AM):** Importance of additive manufacturing, basic principle of additive manufacturing, procedure of product development in additive manufacturing, classification of additive manufacturing processes, materials used in additive manufacturing, benefits and challenges in additive manufacturing.	9
2	**Design for additive manufacturing (DFAM):** Concepts and objectives of AM, unique capabilities - part consolidation topology. Optimization, generative design, CAD model preparation, AM file formats - STL, problems with STL, AMF Design for part quality improvement, part orientation, support structure, slicing, tool path generation, design rules for extrusion based AM. Introduction to slicing software - cura, creality print, modelling and converting CAD models into STL file, design and fabrication of parts by varying part orientation and support structures.	9
3	**Additive manufacturing processes**: Fused deposition modelling (FDM), Selective laser sintering (SLS), Selective laser melting (SLM), Electron beam melting (EBM), Stereolithography (SLA), Laser engineering net	9

	shaping (LENS), hands on sessions using FDM and resin 3D printers, design and fabrication of topology optimized parts.	
4	**Other additive manufacturing processes:** Laminated object manufacturing (LOM), binder Jetting, three-dimensional printing - materials, process, benefits, limitations, applications. Material jetting, multijet modeling - materials, process, benefits, limitations, applications. **Applications and case studies of additive manufacturing**: Biomedical, manufacturing, aerospace, automotive, food and electronics domains.	**9**

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

Continuous Internal Evaluation Marks (CIE):

Attendance	*Internal Examination*	*Analyse*	*Evaluate*	*Total*
5	**15**	**10**	**10**	**40**

Criteria for Assessment (Analyse and Evaluate): 20 marks

Phases	Assessment Criteria	Marks
Analyse	***Problem Definition*** *a. Clearly defines the real-world quality issue.* *b. Examine and identify relevant contextual factors.*	**5**
	Problem Analysis *a. Present a structured realistic solution methodology.* *b. Compare and justify the proposed solutions with evidence and logical reasoning*	**5**
Evaluate	***Validation of Results*** *a. Thoroughly evaluate the proposed solutions.* *b. Compares trade-offs, advantages, and disadvantages.* ***c.*** *Considers feasibility, scalability, and practical implications.*	**5**
	Conclusion and Report Writing *a. Summarizes procedure, findings and insights, limitation, and scope for future work.* *b. Preparation of Report with all components of project report.*	**5**

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 = 24 marks)**	• 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 Outcomes		Bloom's Knowledge Level (KL)
CO1	Explain the principles and product development in Additive manufacturing technology.	**K2**
CO2	Apply the process of transforming a concept into the final product in AM technology.	**K3**
CO3	Identify the processes of additive manufacturing for various fabrication requirements.	**K3**
CO4	Apply the additive manufacturing techniques in real world scenarios.	**K3**

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

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	3	-	2	-	-	-	-	2
CO2	3	3	2	-	3	-	2	-	-	-	-	2
CO3	3	3	3	-	3	-	2	-	-	-	-	2
CO4	3	3	3	-	3	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	Additive manufacturing technologies	Ian Gibson, David Rosen, Brent Stucker, Mahyar Khorasani	Springer	3rd Edition, 2021
2	Rapid prototyping: Principles and applications	Chua C. K., Leong K. F., and Lim C. S.,	World Scientific Publishers	3rd Edition, 2010
3	3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping	Chee Kai Chua, Kah Fai Leong,	World Scientific Publishers	4th Edition, 2014
4	Additive Manufacturing	Amit Bandyopadhyay, Susmita Bose	CRC Press	1st Edition 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing	Andreas Gebhardt	Hanser Gardner Publication, Cincinnati., Ohio	3rd Edition, 2011
2	Laser Additive Manufacturing: Materials, Design, Technologies, and Applications	Milan Brandt	Woodhead Publishing., United Kingdom	2nd Edition, 2016
3	Rapid Prototyping: Theory and practice	Kamrani A. K., Nasr E. A.	Springer., United States	1st Edition, 2006
4	Rapid Prototyping and Engineering applications: A tool box for prototype development	Liou L. A. W., Liou F. W.	CRC Press., United States	3rd Edition, 2011

Video Links (NPTEL, SWAYAM…)	
Link ID	https://archive.nptel.ac.in/courses/112/103/112103306/

SEMESTER S5

QUALITY AND MATERIAL TESTING LAB

Course Code	**PCIEL507**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Lab

Course Objectives:

1. To enable the students gain practical knowledge and skills related with the theoretical studies of statistical quality control.
2. To develop skills to inspect and test materials and components for mechanical properties, defects and flaws.

Expt. No.	Experiments ((Minimum 8 experiments from Part A and 4 experiments from Part B should be completed)
	PART A: Quality Control Lab
1	Verification of central limit theorem using rectangular distribution.
2	Verification of central limit theorem using triangular distribution.
3	Verification of central limit theorem using Henry line.
4	Construction of variable control charts (X bar and R charts) using actual vernier measurements.
5	Construction of variable control charts (X bar and R charts) using actual micrometer measurements.
6	Construction of p - chart.
7	Construction of c- chart.
8	Construction of np - chart.
9	Construction of u - chart.
10	Construction of Demerit chart (D-chart).
11	Construction of Quality score chart (Q-chart).
12	Construction of CUSUM chart.
13	Construction of OC-curve.
14	Experiment on double sampling plan.

15	Experiment on multiple sampling plan.
16	Study and construction OC curve for p-chart.
17	Study on finished product inspection (visual) and certification procedures.
18	Performance test on finished products.
PART B: Material Testing Lab	
1	Study and experiment on Universal Testing Machine (UTM) to determine tensile characteristics of ferrous materials.
2	Study and experiment on Universal Testing Machine (UTM) to determine tensile characteristics of non- ferrous materials.
3	Study and experiment on Vickers Hardness Testing Machine to determine hardness of the given specimen.
4	Study and experiment on non-destructive examination using dye penetrant test.
5	Study and experiment on non-destructive evaluation (NDE) using yoke type magnetic crack detector.
6	Study and experiment on portable magnetic inspection unit (Model Radent - 2000).
7	Study and experiment on bench type wet horizontal magnetic particle machine (model Radent – B 2000) and black light.
8	Study and experiment on ultrasonic flaw detector (Model Einstein - II TFT).
9	Study and experiment on non-destructive evaluation (NDE) using radiographic film viewer.
10	Study and experiment on eddy current sorter.
11	Study and experiment on non-destructive evaluation using acoustic emission.
12	Study and experiment on non–destructive evaluation using thermal camera.

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	**25**	**20**	**50**

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	**15**	**10**	**10**	**5**	**50**

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply SQC techniques / principles like central limit theorem, control charts, sampling plans and OC curve.	**K3**
CO2	Construct charts / graphs related to SQC techniques / principles and infer on the same.	**K3**
CO3	Experiment with various destructive testing techniques to determine mechanical properties of materials.	**K3**
CO4	Experiment with non-destructive evaluation on different test specimens using various NDT equipment.	**K3**

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

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

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

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	Statistical Quality Control	Grant E., Leavenworth R.	McGraw Hill	7th Edition, 2017
2	Mechanical Metallurgy	G. E. Dieter	McGraw Hill	3rd Edition, 2017
3	Practical Non-Destructive Testing	Balde, R., Jayakumar T., Thavasimuthu T.	Alpha Science	3rd Edition, 2007

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Statistical Quality Control	Gupta R. C.	Khanna Publishers	10thEdition, 2003
2	Fundamentals of Quality Control and Improvement	Mithra A.	Wiley	4th Edition, 2016
3	Introduction to Statistical Quality Control	Montgomery	John Wiley & Sons	8th Edition, 2019
4	Experimental Stress analysis	Dally J. W., Railey W. P.	Mcgraw Hill	3rd Edition, 1991
5	Non-Destructive Testing	Hull B., John V	Macmillan	1st Edition, 1998
6	Ultrasonic Testing of Materials	Krautkramer J., Krautkramer, H.	Springer-Verlag	4th Edition, 1990

Video Links (NPTEL, SWAYAM…)	
Link ID	https://nptel.ac.in/courses/112/107/112107259/

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. Viva Voce (5 Marks)

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S5

DATA ANALYTICS LAB

Course Code	PCIEL508	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	ESE Marks	50
Credits	2	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Lab

Course Objectives:

1. To enable students to apply data analysis for appropriate decision making in industrial and allied areas.
2. To equip students to develop skills in data management and data visualization.

Expt. No.	Experiments (Minimum 10 experiments should be completed)
1	Implement and Infer descriptive statistics in Excel.
2	Implement Parametric Tests in Excel.
3	Implement and Infer one-way and two-way ANOVA in Excel.
4	Conduct correlation and regression analysis in Excel.
5	Fitting Probability Distribution using EasyFit / StatFit.
6	Exploring data using SPSS / Minitab / Systat.
7	Hypothesis Testing using SPSS / Minitab / Systat.
8	Conduct Normality Test using SPSS / Minitab / Systat.
9	Conduct Parametric Tests in SPSS / Minitab / Systat.
10	Conduct Non-Parametric tests in SPSS / Minitab / Systat.
11	Conduct Correlation and Regression Analysis in SPSS / Minitab / Systst.
12	Multivariate Analysis in SPSS / Minitab / Systat.
13	Descriptive Analysis in R programming.
14	ANOVA Test in R programming.
15	Time Series Analysis in R programming.

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Classify, organize and summarize data sets.	**K2**
CO2	Apply concepts of data science to solve real world context problems.	**K3**
CO3	Apply inferential statistical analysis techniques to describe data sets.	**K3**
CO4	Examine data using exploratory statistical techniques to derive insightful analysis.	**K4**

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

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	3	2	-	1	-	-	-	2
CO2	2	2	2	2	3	2	-	1	-	-	-	2
CO3	2	2	2	2	3	2	-	1	-	-	-	2
CO4	2	2	2	2	3	2	-	1	-	-	-	2

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	Complete Business Statistics	Aczel A. D., Sounderpandian, J., Saravanan, P., Joshi, R.	McGraw Hill	7th Edition, 2017
2	Discovering Statistics using IBM SPSS Statistics	Andy Field	SAGE South Asia	4th Edition, 2019
3	The Book of R – A First Course in Programming and Statistics	Tilman M. Davies	No Starch Press	1st Edition, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	SPSS for Dummies	Keith McCormick, Jesus Salcedo, Aaron Poh	Wiley	3rd Edition, 2015
2	An Introduction to Secondary Data Analysis with IBM SPSS Statistics.	John MacInnes	SAGE	1st Edition, 2017
3	SPSS Survival Manual: A Step by Step Guide to Data Analysis using SPSS for Windows	Julie Pallant	Open University Press	4th Edition, 2010
4	Microsoft Excel 2019: Data Analysis and Business Modeling	Winston, Wayne L.	PHI Learning	6th Edition, 2019
5	R for Data Science: Import, Tidy, Transform, Visualize, and Model Data	Garrett Grolemund, Hadley Wickham	O'Reilly Media	1st Edition, 2017
6	R Programming – An Approach to Data Analytics	G. Sudhamathy, C. Jothi Venkateswaran	MJP Publishers	1st Edition, 2018

Video Links (NPTEL, SWAYAM…)	
Link ID	https://archive.nptel.ac.in/courses/110/106/110106072/
	https://archive.nptel.ac.in/courses/110/104/110104094/
	https://archive.nptel.ac.in/courses/110/107/110107092/
	https://archive.nptel.ac.in/courses/111/104/111104146/

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. Viva Voce (5 Marks)

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted