Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

(AUTONOMOUS)

Department of Statistics

Two Years Post Graduate Program

M.Sc. Data Science

Course Structure and Syllabus

Semester- I

Paper Code	Course Title	No. of Credits
PSDS111	Linear Algebra in Matlab	04
PSDS112	Probability Distributions	04
PSDS113	Optimization Techniques	04
PSDS114	Statistical Inference	04
PSDS115	Database Management System	04
PSDS116	Introduction to MATLAB and R	04

Semester- II

Paper Code	Course Title	No. of Credits
PSDS121	Design and Analysis of Experiments	04
PSDS122	Regression Analysis and Predictive Models	04
PSDS123	Statistical Quality Control	04
PSDS124	Computational Statistics	04
PSDS125	Bayesian Inference	04
PSDS126	Python and SQL Programming	04

Semester- III

Paper Code	Course Title	No. of Credits
PSDS231	Stochastic Models and Applications	04
PSDS232	Exploratory Multivariate Data Analysis	04
PSDS233	Time series analysis and Forecasting	04
PSDS234	Artificial Intelligence	04
PSDS235	Text Mining and Natural Language Processing	04
PSDS236	Data Visualization using Tableau	04

Semester- IV

Paper Code	Course Title	No. of Credits
PSDS241	Machine Learning	04
PSDS242	Discrete Data Analysis	04
PSDS243	Supply Chain & Logistics Analytics	04
PSDS244	Deep Learning	04
PSDS245	Thesis	08

Program Outcomes (POs) for M.Sc. Programme

PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the discipline that forms a part of a postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	**Social competence:** Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise way and help reach conclusions in group settings.
PO4	**Research-related skills and Scientific temper :** Infer scientific literature, build a sense of enquiry and able to formulate, test, analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	**Trans-disciplinary knowledge:** Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Perform independently and also collaboratively as a part of a team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

SYLLABUS (CBCS) FOR M.Sc. Data Science

(2022 Pattern)

(With effect from Academic Year 2022-2023)

Class : M. Sc. (Semester- IV)
Paper Code : PSDS241
Paper : I
Title of Paper : Machine Learning
Credit : 4 credits
No. of lectures : 60

Course Objectives:

1 Understanding the nature of problems solved with Machine Learning.

2 To study different supervised learning algorithms and unsupervised learning algorithms.

3 To understand the application development process using ML.

Course Outcomes:

By the end of the course, students will be able to:

CO1. have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.

CO2. compare the strengths and weaknesses of many popular machine learning approaches.

CO3. develop a solid understanding of the fundamental concepts of machine learning.

CO4. design and implement various machine learning algorithms in a range of real-world applications.

CO5. explore ethical considerations in machine learning, including issues related to bias, fairness, and transparency.

CO6. gain practical experience in implementing machine learning algorithms using programming languages such as Python.

CO7. effectively communicate the results of machine learning analyses in both written reports and oral presentations.

TOPICS/CONTENTS:

Unit 1

Introduction to Data and Machine Learning

Interpretability of Machine Learning Models - Why interpretability is necessary, Model agnostics methods of interpretability – Partial Dependence Plot (PDP), Individual

Conditional Expectation (ICE), Shapley values etc. Essentials of Data and its analysis, Framework of Data Analysis, History of Machine Learning, Machine Learning Vs Statistical Learning, Types of Machine Learning Algorithms, Supervised Learning, Unsupervised Learning, Reinforcement Learning. **(15L)**

Unit 2

Understanding Regression Analysis

Linear Regression, Multiple Regression, Logistic Regression

Classification Techniques

k-nearest neighbor, decision tree, Naïve Bayesian, Support vector machine ,artificial neural network, convoluted neural network (CNN),Classification based on logistic regression. **(15L)**

Unit 3 Clustering

K means clustering, Association Rule Mining, Apriori Algorithm

Model evaluation and selection methods:

Metrics for evaluating classifier performance (confusion matrix), holdout method and random sampling, cross validation, bootstrap, ROC curves, AIC, BIC, CIC, DIC (information criterion), bias variance tradeoff. **(15L)**

Unit 4

Techniques to improve classification accuracy

Bagging, boosting, Ada boosting, Random forest, gradiant boosting. Self-Organizing Map (SOM), EM algorithm, market basket analysis, text mining: sentiment analysis, word frequency analysis, N-grams and correlation, topic modeling. **(15L)**

References Books:

1 Jiawei Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques, 3rd Edition.

2 Margaret H. Dunham, S. Sridhar, Data Mining - Introductory and Advanced Topics, Pearson Education

3 Tom Mitchell, Machine Learning‖, McGraw-Hill, 1997

4 R.O. Duda, P.E. Hart, D.G. Stork., Pattern Classification, Second edition. John Wiley and Sons, 2000.

5 Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer 2006

6 Ian H. Witten, Data Mining: Practical Machine Learning Tools and Techniques, Eibe Frank Elsevier /(Morgan Kauffman)

7 Bing Liu: Web Data Mining: Exploring Hyperlinks, Contents and Usage Data, Springer (2006).

8 Soumen Chakrabarti: Mining the Web: Discovering knowledge from hypertext data, Elsevier (2003).

9 Christopher D Manning, Prabhakar Raghavan and HinrichSchütze: An Introduction to Information Retrieval, Cambridge University Press (2009)

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)								
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	3				1			1	3
CO2	3	3			1			1	3
CO3	3				1			1	3
CO4	3			3	1			1	3
CO5	3		3		1		3	1	3
CO6	3				1	3		1	3
CO7	3				1			1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

All COs (Weightage: 3 - Strongly Related)

Justification: All outcomes contribute significantly to building disciplinary knowledge in the field of machine learning, covering fundamental issues, challenges, and practical applications.

PO2. Critical Thinking and Problem Solving

CO2. Compare the strengths and weaknesses of many popular machine learning approaches. (Weightage: 3 - Strongly Related)

Justification: Comparing the strengths and weaknesses involves critical thinking and problem-solving skills specific to machine learning approaches.

PO3. Social Competence

CO5. Explore ethical considerations in machine learning, including issues related to bias, fairness, and transparency. (Weightage: 3 - Strongly Related)

Justification: Exploring ethical considerations aligns with social competence, addressing societal implications and fairness in machine learning.

PO4. Research-related Skills and Scientific Temper

CO4. Design and implement various machine learning algorithms in a range of real-world applications. (Weightage: 3 - Strongly Related)

Justification: Designing and implementing machine learning algorithms is a direct application of research-related skills and scientific temper.

PO5. Trans-disciplinary Knowledge

All COs (Weightage: 1 - Partially Related)

Justification: While the outcomes are essential for machine learning expertise, there is limited direct connection to trans-disciplinary knowledge.

PO6. Personal and Professional Competence

CO6. Gain practical experience in implementing machine learning algorithms using programming languages such as Python. (Weightage: 3 - Strongly Related)

Justification: Gaining practical experience contributes directly to personal and professional competence in the field of machine learning.

PO7. Effective Citizenship and Ethics

CO5. Explore ethical considerations in machine learning, including issues related to bias, fairness, and transparency. (Weightage: 3 - Strongly Related)

Justification: Exploring ethical considerations aligns with effective citizenship and ethical considerations in the context of machine learning.

PO8. Environment and Sustainability

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more focused on machine learning techniques with less direct relevance to environmental or sustainability aspects.

PO9. Self-directed and Life-long Learning

All COs (Weightage: 3 - Strongly Related)

Justification: Continuous exploration of machine learning concepts and practical applications aligns with self-directed and life-long learning in this dynamic field.

Top of Form

SYLLABUS (CBCS) FOR M.Sc. Data Science
(2022 Pattern)
(With effect from Academic Year 2022-2023)

Class : M. Sc. (Semester- IV)
Paper Code : PSDS242
Paper : II
Title of Paper : Discrete Data Analysis
Credit : 4 credits
No. of lectures : 60

Course Objectives:

1. To familiarize students to learn about regression analysis and model building for discrete data.
2. To investigate possible diagnostics in various techniques for discrete data.
3. To acquaint students with validation of the generalized linear models using hypothesis testing and analysis of deviance.

Course Outcomes:

By the end of the course, students will be able to:

CO1. develop a solid understanding of the characteristics and challenges of discrete data.

CO2. develop the ability to critically appraise studies and research papers that utilize discrete data analysis methods.

CO3. learn and apply logistic regression for modelling and analysing the relationship between categorical outcomes and predictor variables.

CO4. gain practical experience using statistical software packages (e.g., R, Python) for discrete data analysis.

CO5. effectively communicate the results of discrete data analyses in written reports and oral presentations.

CO6. estimate the parameters and fit different models to discrete data.

CO7. validate the model such as Poisson regression and Logistic Regression using cross validation techniques.

TOPICS/CONTENTS:

Unit 1

Log linear model for two and three dimensional contingency tables: Interpretation of parameters, comparison with ANOVA and regression. ML estimation of parameters, likelihood ratio tests for various hypotheses including independence. Marginal and conditional independence, partial association, models with quantitative levels. **(15 L)**

Unit 2

Generalized linear models: concept of generalized linear model, Link function, ML estimation, large sample tests about parameters, goodness of fit, analysis of deviance, introduction to Poisson regression. **(15 L)**

Unit 3

Poisson regression: ML and Quasi-likelihood estimation of parameters, testing significance of coefficients, goodness of fit, power family of link functions, over dispersion: Types, causes and remedies. Negative Binomial regression: NB-2 model. **(15 L)**

Unit 4

Non-parametric regression and Interpolating and smoothing splines for simple regression. Use of cross-validation applications to logistic and Poisson regression. **(15 L)**

References Books:

1. Yvonne M. Bishop, Stephen E. Fienberg, Paul W. Holland Discrete (1975): Multivariate Analysis: Theory and Practice
2. Hosmer D.W. and Lemeshow S. (2000): Applied Logistic Regression, 2nd Ed. Wiley, New York.
3. Agesti A. (1990) : Categorical Data Analysis. Wiley, New York.
4. R. Christensen (1997): Log-Linear Models and Logistic Regression. 2nd Ed. Springer, New York.

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)								
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	3	3	1				1	1	3
CO2		3	1		2		1	1	3
CO3		3	1	3			1	1	3
CO4		3	1				1	1	3
CO5		3	1			3	1	1	3
CO6		3	1				1	1	3
CO7		3	1				1	1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1. Have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc. (Weightage: 3 - Strongly Related)

Justification: Developing a good understanding of fundamental issues and challenges in machine learning contributes significantly to building disciplinary knowledge.

PO2. Critical Thinking and Problem Solving

All COs (Weightage: 3 - Strongly Related)

Justification: All outcomes involve critical thinking and problem-solving skills, from understanding machine learning challenges to applying discrete data analysis methods.

PO3. Social Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more technical and focused on machine learning and discrete data analysis, with limited direct connections to social competence.

PO4. Research-related Skills and Scientific Temper

CO3. Develop the ability to critically appraise studies and research papers that utilize discrete data analysis methods. (Weightage: 3 - Strongly Related)

Justification: Critically appraising studies involving discrete data analysis aligns with research-related skills and scientific temper.

PO5. Trans-disciplinary Knowledge

CO2. Develop a solid understanding of the characteristics and challenges of discrete data. (Weightage: 2 - Moderately Related)

Justification: Understanding the characteristics and challenges of discrete data involves elements of trans-disciplinary knowledge, making this outcome moderately related.

PO6. Personal and Professional Competence

CO5. Gain practical experience using statistical software packages (e.g., R, Python) for discrete data analysis. (Weightage: 3 - Strongly Related)

Justification: Gaining practical experience in using statistical software contributes directly to personal and professional competence in discrete data analysis.

PO7. Effective Citizenship and Ethics

All COs (Weightage: 1 - Partially Related)

Justification: The content is more technical and less directly related to citizenship and ethics.

PO8. Environment and Sustainability

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more focused on machine learning and discrete data analysis techniques with less direct relevance to environmental or sustainability aspects.

PO9. Self-directed and Life-long Learning

All COs (Weightage: 3 - Strongly Related)

Justification: Continuous exploration of machine learning concepts and discrete data analysis aligns with self-directed and life-long learning in this dynamic field.

SYLLABUS (CBCS) FOR M.Sc. Data Science

(2022 Pattern)

(With effect from Academic Year 2022-2023)

Class : M. Sc. (Semester- IV)
Paper Code : PSDS243
Paper : III
Title of Paper : Supply Chain and Logistics
Credit : 4 credits
No. of lectures : 60

Course Objectives:

1. To develop an understanding of the various supply chain and logistics processes.
2. To develop knowledge on structures, decision phases, measures and tools of supply chains.
3. To develop understanding on the strategic, tactical and operational decision tools of supply chains.
4. To impart knowledge on logistics management and related advanced tools and techniques.
5. To develop and analyse the role of digital transformation of the supply chains and logistics.

Course Outcomes:

By the end of the course, students will be able to:

CO1. understand the various stages of a supply chain, from sourcing raw materials to delivering finished products to end customers.
CO2. understand the structures, decision phases, measures and tools of supply chains.
CO3. understand the strategic, tactical and operational decision tools of supply chains.
CO4. understand knowledge on logistics management and related advanced tools and techniques.
CO5. understand the role of distribution centers, warehouses, and transportation in the supply chain.
CO6. learn about collaborative approaches to planning, forecasting, and replenishing inventory.
CO7. apply supply chain and logistics concepts to real-world case studies.

TOPICS/CONTENTS:
Unit 1

Introduction to Supply Chain: The basic Supply Chain model, Generalized Supply Chain Model, Value Chain and Value Chain Analysis, Supply Chain Effectiveness: Strategy,

Metrics, Technology, Supplier Performance, Integration and Collaboration, Risk Mitigation, Supply Chain Applications, Information Functionality – The Supply Chain. **[15L]**

Unit 2

Supply Chain Design and Planning: Supply Chain Configuration, Extent of Vertical Integration, Outsourcing and Off shoring, Location Decisions, Capacity Planning.

Planning Demand & Supply: Planning demand and supply in supply chains – Forecasting techniques for supply chains, Seasonal Forecasting Models, Measure of Forecast errors.

[15L]

Unit 3

Logistics in 21st Century, Definition and Concept of Logistics, Concept of Logistics, Logistics Value Proposition, Service Benefits, Cost Minimization, Logistics Value Generation, The Work of Logistics: Order Processing, Inventory, Transportation, Warehousing, Materials Handling, and Packaging, Facility Network Design, Logistical Operations: Inventory Flow, Physical Distribution, Manufacturing Support, Procurement ,Information Flow, Planning and Coordination Flows, Operational Requirements, Logistical Operating Arrangements : Echelon Structured Logistics, Direct Structured Logistics, Flexible Logistics System, Principles of Logistics Information. **[20L]**

Unit 4

Logistics Management: 3PL, 4PL, Design Options for Transportation Network. Routing, scheduling and Sequencing in Transportation, Vehicle Routing Problems. Quantitative Examples. Reverse Logistics: Reverse logistics and Closed Loop Supply Chains. Advanced Logistics Decision Models: Bin Packing Problems, Fixed Charge Problems, Knapsack Problems, Multi-stage transportation problems. **[10L]**

References Books:

1. Neha Tikoo LOGISTICS AND SUPPLY CHAINMANAGEMENT
2. Dr. Dawei Lu Fundamentals of Supply Chain Management
3. David Simchi – Levi & Philip Kaminsk, Designing and Managing the Supply Chain, McGraw-Hill Companies Inc.
4. David Taylor and David Brunt, Manufacturing Operations and Supply Chain Management, Vikas Thomson Learning, 2001.
5. Donald J. Bowersox & David J. Closs, Logistical Management, TMH.
6. Jeremy F. Shapiro, Modeling and Supply Chain,. Thomson Learning, 2001.

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	3		1	1		3
CO2		3	1	3	2	1	1		3
CO3		3	1	3		1	1		3
CO4		3	1	3		1	1		3
CO5		3	1	3		1	1		3
CO6		3	1	3		1	1	1	3
CO7		3	1	3		1	1		3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1. Have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc. (Weightage: 3 - Strongly Related)

Justification: Developing a good understanding of fundamental issues and challenges in machine learning contributes significantly to building disciplinary knowledge.

PO2. Critical Thinking and Problem Solving

All COs (Weightage: 3 - Strongly Related)

Justification: All outcomes involve critical thinking and problem-solving skills, from understanding machine learning challenges to comprehending various stages of a supply chain.

PO3. Social Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more technical and focused on machine learning, logistics, and supply chain concepts, with limited direct connections to social competence.

PO4. Research-related Skills and Scientific Temper

All COs (Weightage: 3 - Strongly Related)

Justification: The outcomes align closely with research-related skills and the development of a scientific temper in the context of machine learning, logistics, and supply chain concepts.

PO5. Trans-disciplinary Knowledge

CO2. Understand the various stages of a supply chain, from sourcing raw materials to delivering finished products to end customers. (Weightage: 2 - Moderately Related)

Justification: Understanding various stages of a supply chain involves elements of trans-disciplinary knowledge, making this outcome moderately related.

PO6. Personal and Professional Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes contribute more to technical competence in machine learning, logistics, and supply chain concepts, with limited direct connections to personal and professional aspects.

PO7. Effective Citizenship and Ethics

All COs (Weightage: 1 - Partially Related)

Justification: The content is more technical and less directly related to citizenship and ethics.

PO8. Environment and Sustainability

CO6. Understand the role of distribution centers, warehouses, and transportation in the supply chain. (Weightage: 1 - Partially Related)

Justification: The outcome is more focused on logistics and supply chain operations than on broader environmental or sustainability aspects.

PO9. Self-directed and Life-long Learning

All COs (Weightage: 3 - Strongly Related)

Justification: Continuous exploration of machine learning, logistics, and supply chain concepts aligns with self-directed and life-long learning in these dynamic fields.

Top of Form

SYLLABUS (CBCS) FOR M.Sc. Data Science

(2022 Pattern)

(With effect from Academic Year 2022-2023)

Class : M. Sc. (Semester- IV)
Paper Code : PSDS244
Paper : IV
Title of Paper : Deep Learning
Credit : 4 credits
No. of lectures : 60

Course Objectives:

Deep learning eliminates some of data pre-processing that is typically involved with machine learning. These algorithms can ingest and process unstructured data, like text and images, and it automates feature extraction, removing some of the dependency on human experts.

Course Outcome:

CO1. Evaluate, in the context of a case study, the advantages and disadvantages of deep learning neural network architectures and other approaches.

CO2. Implement deep learning models in Python using the PyTorch library and train them with real-world datasets.

CO3. Design convolution networks for handwriting and object classification from images or video.

CO4. Design recurrent neural networks with attention mechanisms for natural language classification, generation, and translation.

CO5. Explore ethical challenges and considerations in the application of deep learning.

CO6. Evaluate the performance of different deep learning models (e.g., with respect to the bias-variance trade-off, over fitting and under fitting, estimation of test error).

CO7. Perform regularization, training optimization, and hyper parameter selection on deep models.

Unit 1:

Deep learning basics: Introduction, History, capabilities, the perceptron, Neural network learning: Back-Propagation, Practical network training o Autoencoders, Batch-normalization, why does it work? Over fitting and generalization. **[15 L]**

Unit 2:

Convolutional neural networks: Introduction to CNNs, Convolution, Correlation, Filtering. CNN architectures, Detection and Segmentation, Visualizing and Understanding, Advanced CNNs for computer vision. **[15L]**

Unit 3:

Advanced Deep architectures: Recurrent Neural networks (RNNs), Advanced RNN: LSTM, GRU, Generative Adversarial Networks (GANs), Advanced GANs, Advanced topics, Recent papers, Influential papers, Deep reinforcement learning, Deep Learning: Good -> Great, Visual Question Answering, Visual Dialog, Novel deep methods (Deep internal learning, Deep image prior). **[20 L]**

Unit 4:

Tools: Tensor flow, Pytorch, Practical sessions: Computer Vision, Sequence modeling, Natural / Biological signals **[10 L]**

References Books:

1. Deep Learning with Python by François Chollet, Manning Publications Co, ISBN: 9781617294433
2. Deep Learning - A Practical Approach by Rajiv Chopra, Khanna Publications, ISBN: 9789386173416
3. Deep Learning by Ian Good fellow and Yoshua Bengio and Aaron Courville Published by An MIT Press book.

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)								
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	3	3		3		1		1	3
CO2		3		3		1		1	3
CO3		3		3		1		1	3
CO4		3		3	2	1		1	3
CO5		3	3	3		1	3	1	3
CO6		3		3		1		1	3
CO7		3		3		1		1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1. Evaluate, in the context of a case study, the advantages and disadvantages of deep learning neural network architectures and other approaches. (Weightage: 3 - Strongly Related)

Justification: Evaluating advantages and disadvantages of deep learning models directly contributes to building disciplinary knowledge in the field.

PO2. Critical Thinking and Problem Solving

All COs (Weightage: 3 - Strongly Related)

Justification: All outcomes involve critical thinking and problem-solving skills, from implementing deep learning models to evaluating their performance and addressing ethical challenges.

PO3. Social Competence

CO5. Explore ethical challenges and considerations in the application of deep learning. (Weightage: 3 - Strongly Related)

Justification: Exploring ethical challenges in the application of deep learning aligns with developing social competence by considering broader societal impacts.

PO4. Research-related Skills and Scientific Temper

All COs (Weightage: 3 - Strongly Related)

Justification: The outcomes align closely with research-related skills and the development of a scientific temper in the context of deep learning research.

PO5. Trans-disciplinary Knowledge

CO4. Design recurrent neural networks with attention mechanisms for natural language classification, generation, and translation. (Weightage: 2 - Moderately Related)

Justification: Designing recurrent neural networks for natural language tasks involves elements of trans-disciplinary knowledge, making this outcome moderately related.

PO6. Personal and Professional Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes contribute more to technical competence in deep learning, with limited direct connections to personal and professional aspects.

PO7. Effective Citizenship and Ethics

CO5. Explore ethical challenges and considerations in the application of deep learning. (Weightage: 3 - Strongly Related)

Justification: Exploring ethical challenges aligns with effective citizenship and ethical considerations in the application of deep learning technologies.

PO8. Environment and Sustainability

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more technical and less directly related to environmental or sustainability aspects.

PO9. Self-directed and Life-long Learning

All COs (Weightage: 3 - Strongly Related)

Justification: Continuous exploration of deep learning models aligns with self-directed and life-long learning in this dynamic field.