Machine Learning for Power Systems

a. Course Code: EPE-819

b. Title: Machine Learning for Power Systems

c. Credit Hours: 3

d. Objectives:

- To impart the understanding of machine learning concepts essential for power systems students.
- To comprehend the role of machine learning algorithms in smart power systems of developed countries.
- To apply machine learning algorithms for the prediction/forecasting and classification/clustering needs of developing countries using tools and platforms widely used.
- To discuss and understand the increasing role of machine learning in evolving power sector of Pakistan
- To demonstrate an insight into the advantages, limitations, and risks connected to AI's role in society from the energy sector perspective.

e. Outcomes

Preparation of graduates with a sound understanding of both power systems and machine learning so they are better equipped to manage the emerging smart grid.

f. Contents with suggested contact hours

	Topics	Text Book	Contact Hours
1	**Foundations of Machine Learning** Role of Machine Learning in Smart Grids Existing AI trends in the energy sector including companies and implications in their business.	TD RG	6

	Basic Concepts of Machine Learning Applications of Machine Learning Types of Machine Learning Supervised Learning Algorithm Unsupervised Learning Algorithm Semi-supervised Learning Algorithm Reinforcement Learning Algorithm Machine Learning Process Architecture Deep Learning vs Machine Learning Classification and Regression Model Selection and Feature Selection		
2	**Machine Learning Techniques** ARIMA, Linear Regression, and Multiple Regression for Wind/solar energy forecasting k-means Clustering for Identification of consumer type from smart meter data Decision Trees for Power Theft Detection Support Vector Machines for Anamoly Detection Artificial Neural Networks Fault Detection and Isolation	RA GD	15
3	**Predictive Analytics for Planning and Operations** Forecasting Wind and Solar resources Wind and Solar Forecasting Overview Data-driven Wind and Solar Forecasting Wind and Solar Forecasting Datasets Wind/Solar Short-term pattern Renewable forecasting performance evaluation metrics	RA AS	6
4	**ML to Compete and Cooperate in Electricity Markets**	RW	6

	Optimal bidding in centralized energy markets by Reactive Reinforcement Learning Q-Learning Negotiations in bilateral electricity trading by Evolutionary reinforcement learning Bayesian Learning		
5	**Modelling and Forecasting Electricity Loads and Prices** Stylized Facts of Loads and Prices Price Spikes Seasonality Seasonal Decomposition Mean Reversion Distribution of Electricity Prices Bottom-up and Top-down forecasting models Forecasting Electric Loads Factors Affecting Load Patterns, including statistics, behaviours, technology enhancements, etc. AI-based Methods Statistical Methods Forecasting Energy Prices Overview of Modeling Approaches Statistical Methods and Price Forecasting Quantitative Models and Derivatives Valuation	RW AS	6
6	**Other ML Applications in Power Systems** Partial Discharge Pattern Recognition in High Voltage Testing Energy Disaggregation or Nonintrusive Load Monitoring Informed Power System operation by Network Topology Detection	RA TD	6

	Machine learning enabled cyber security in smart grid Trustworthy Machine Learning for Power Systems Predictive vs Reactive Maintenance – AI behind equipment failure prediction Power System State Estimation Identification, Classification, Fault location and fault diagnosis, Hydro-thermal scheduling, Big Data Applications in Demand Response		
	Total		45

g. Details of lab work, and workshop practice (if applicable). N/A

h. Recommended Reading (including Textbooks and Reference books with dates).

S. No.	Title	Author(s)	Assigned Code	Remarks
1	Introduction to AI Techniques for Renewable Energy Systems (2021)	Editors: Tripathi and Dubey	TD	Textbook
2	Advanced Data Analytics for Power Systems (2021)	Ali Tajer, Samir M. Perlaza Publisher: Cambridge University Press	AS	Reference
3	Big Data Applications in Power Systems (2018)	Editors: Reza Arghandeh and Yuxun Zhou	RA	Reference
4	Handbook of Statistical Analysis and Data Mining Applications	Robert Nisbet, Gary Miner, Ken Yale	RG	Reference

5	An Introduction to Statistical Learning (2021)	Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani	GD	Reference
6	Modeling and Forecasting Electricity Loads and Prices (2006)	Rafal Weron	RW	Reference

i. Assessments

Mid-term, Final Exam and quizzes, assignment etc.