Course title: Applications of machine learning in alternate energy						
Course code: ENR 168	No. of credits: 3	L-T-P: 30-10-10	Learning hours: 50			
Pre-requisite course code and title (if any):						
Department: Department of Sustainable Engineering						
Course coordinator: Dr Sapan Thapar		Course instructor:				
Contact details: sapan.thapar@terisas.ac.in						
Course type: Elective		Course offered in: Semester 3				

### **Course Description**

The course aims to provide a broad introduction to machine learning (ML) techniques that have become essential technology solutions in the industry. The renewable energy industry is constantly looking for advanced technologies to analyze the past, optimize the present, and predict the future. The course starts with the introduction of ML methods and its applicability in renewable technologies with an introduction to basic computation using Python in module 1. In module 2, 3 and 4, both supervised and unsupervised learning methods are covered. Module 5 covers optimization techniques. The last module discusses the application of machine learning to solve problems in the renewable energy industry.

## **Course objectives**

The objective of the course is to prepare students with knowledge of machine learning techniques methods which may be applied to solve problems in the renewable energy field.

Module Topic	L	Т	Р	
1. Fundamentals of AI/ML				
Introduction to Machine Learning.	4	0	0	
Basic concepts of Python Programming.				
2. Supervised Learning - Regression				
Linear regression, Gradient descent, Weighted Least Squares,	4	2	2	
Logistic Regression.				
3. Supervised Learning - Classification				
k Nearest Neighbour (kNN), Discriminant function analysis,	6	2	2	
Bayesian decision theory, Decision Trees.				
4. Unsupervised Learning – Clustering				
The k-Means algorithm, Hierarchical clustering, Density-Based	C	2		
Spatial Clustering of Applications with Noise (DBSCAN),	0	2	2	
Gaussian Mixture Models (GMM).				
5. <b>Optimisation Techniques</b>				
Problem formulation: decision variables, objective function,	6	2	2	
maxima, minima, constraints. Solving optimization problems.				
6. Applications of ML in Alternate Energy	4 2			
Weather data forecasting, Estimation of energy generation from			2	
RE sources, Estimation of building energy demand, System fault	4	2	2	
detection and diagnostics.				
Total	30	10	10	
Evaluation criteria				
Minor Test 1: Written-test [at the end of teaching of modules 1 and 2] 20%				
Minor Test 2: Written-test [at the end of teaching of module 3 and 4] 20%				
Major Test: Written-test [at the end of the semester, full syllabus] 40%				

# Assignments – 20%

# Learning outcomes

Learning outcomes include:

- Understanding machine learning and its use for the alternate energy to address the challenges and mathematical complexities
- Understanding of supervised learning algorithms, preparation of data for analysis.
- Understanding issues in alternate energy with simple case studies.
- Understanding of classification and clustering algorithms.
- Enhancing ability to use ML algorithms and write small scripts in a programming language.

• Implementation and providing a complete solution to a problem given in project work with comprehensive knowledge about the fundamental principles, methodologies and industry practices.

## **Pedagogical approach**

Lectures, tutorials, labs, assessment, project.

# **Course Reading Materials**

- 1. T. Agami Reddy. 2011. Applied Data Analysis and Modeling for Energy Engineers and Scientists, Boston, MA: Springer US.
- 2. Richard O. Duda, Peter E. Hart, and Stork G. Devid. 2014. Pattern Classification, WILEY.
- 3. Bishop M. Christopher. 2006. Pattern Recognition and Machine Learning, Springer.
- 4. Andrew Ng. 2018. Machine Learning Yearning, deeplearning.ai.

# Additional information (if any)

## **Student responsibilities**

Attendance, discipline, feedback as per TERI SAS rules

### **Course reviewer**

Dr Vishal Garg, Professor, International Institute of Information Technology, Hyderabad Dr Amarjeet Singh, Assistant Professor, Indraprastha Institute of Information Technology, Delhi

Course tit	e: Independent Study					
Course co	de: ENR 120 No. of	credits: 4	L-T-P: 0-16-88 Learn	ning h	ours:	104
Pre-requis	ite course code and title (if any)	):				
Departmen	nt: Department of Sustainable En	gineering				
Course coo	ordinator: Naqui Anwer	Cours	se Instructor: Assigned	Facult	У	
Course typ	e: Core	Cours	e offered in: Semester 2	2		
Course de	scription					
	-					
The indepe	ndent study is a 4-credit course of	offered to the	e students registered for	the PO	G Dipl	oma
in Renewal	ole Energy and Management (PG	DREM). The	e student will conduct a	study		
independen	tly under the supervision of a fac	ulty member	. The supervisor can be a	ny fac	ulty	
member fro	m TERI School of Advanced St	udies. Studen	its are expected to get co	onsent	from	the
supervisor	before they register for the course.	. The course	will be conducted through	h subn 4th	1155101	n and
presentation	n of synopsis by August 2 <sup>nd</sup> week	, mid-term p	h succession by October 4	4 <sup>th</sup> we	ek and	1
Course ob	isotive	November 4	week.			
Course on	jecuve					
To en	able students carry out research s	studies indep	endently under supervise	ed self	-learn	ing
approa	ach					0
To hel	p students obtain advanced under	rstanding on	specific			
system	n/process/scenarios inrenewable e	nergy, energ	y systems, policy &			
regula	tion and allied areas.					
To ena	able students to study the contemp	orary develo	pments in the field of			
renew	able energy and allied areas.					
Module	Торіс			L	Т	Р
		. 1		0	0	10
	following:	ent and a pro	esentation having the	0	8	18
	Title of the study					
	• Pationala for the study of	nd Dagaarah	obiostivos Maximum			
	• Rationale for the study an	nu Kesearch	objectives (Maximum			
1	• Literature review					
	Methodology					
	Wrethodology					
	• Expected Outcome					
	• limeline					
	Keterences Work forward or the average	ad armana'-	loading to mid to	0	Λ	10
	work focused on the approv	ed synopsis	leading to mid-term	0	4	48
2	presentation of work compris	sing of the	progress made and			
	understanding developed by the	e student on	the specific topic. It			
	includes literature survey or exp	perimental w	ork to be conducted to			
	achieve the expected outcomes.					

	Completion of remaining work and preparation of Independent	0	4	22	
	Study Report containing the following and final presentation:				
	Abstract				
	Introduction				
	• Study Area				
3	• Aim and Objectives				
	Ann and Objectives     Methodology				
	Methodology     Begulte and Discussions				
	Results and Discussions				
	Conclusions and Limitations				
	Future Scope of Work				
	• References				
Discussion and presentation of research work before the faculty panel			16	00	
	Total	0	16	88	
Evaluation	criteria				
Test 1: Syn	opsis document and presentation: 15% (August 2 <sup>nd</sup> week)				
Test 2: Mic	1-term presentation: 15% (October 4 <sup>th</sup> week)				
Test 3: Fin	al evaluation (November 4 <sup>th</sup> week)				
Pr	esentation: 30%				
Ke Toot 4: Do	view peper				
10% (at the end of semester)					
• Sv	monsis will be evaluated by the supervisor and/or panel of faculty mer	nbers			
• M	id-term test will be evaluated by the supervisor and/or panel of faculty	mem	hers		
- Dr	example in the evaluated by the supervisor and/or panel of faculty members	mem	0015.		
Report su	ibmission at the end of the term evaluated by supervisor and/or panel of	of faci	ıltv		
members			,		
Learning of	outcomes				
After comp	leting the course, the students will be able to:				
• Pro	wide comprehensive knowledge about the topics of the study (Test 1)				
• Design and implement the concepts related to the study (Test 2 and 3)					
Test the systems (if any) with wholistic approach (Test 2 and 3)					
Pedagogical approach					
0.10.1	the state of the state of the state				
Self-learnin	ig; interaction with supervisor; literature review; interaction with expe	erts			
Materials					
Door review	red journal articles				
Peer-reviewed journal articles					
Reports rel:	ated to the specific				
project	and to the speenre				
Learning m	paterials provided by supervisor				
Additional information (if any)					
1. Th	e final report should be around 40 pages				
2. A g	2. A guideline along with important dates and format will be notified by thesupervisor or			or	
course/programme coordinator.					
3. Student needs to check plagiarism using software (e.g. Turnitin) and submit the report t			rt to		
sup	pervisor before final submission				
Student re	sponsibilities				
G 161					
Self learnin	g, attendance; Discipline; Research Ethics, etc.				
Regular discussion with supervisor and adhering to the timeline					

#### **Course Reviewers**

Dr. Milap Punia, Associate Professor, Jawaharlal Nehru University, New Delhi Dr. P.P. Pani, Assistant Professor, Jawaharlal Nehru University, New Delhi Dr. R.D. Garg, Associate Professor, Indian Institute of Technology, Roorkee Dr. T.P. Singh, Assistant Professor, Symbiosis Institute of Geoinformatics, Pune