ACADEMIC CURRICULA

POSTGRADUATE DEGREE PROGRAMME
(REGULATIONS 2021)

MASTER OF SCIENCE

(M.Sc.- Atmospheric Science)

Two Years (Full-Time)

Learning Outcome based Curriculum Framework (LOCF)

Academic Year

2021 - 2022

SRM
INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY
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Contents

DEPARTMENT OF PHYSICS & NANOTECHNOLOGY

1. Department Vision Statement	
Stmt - 1	To be recognized nationally and internationally as an exemplary department of physics
Stmt - 2	To provide core instruction in pure and applied physics to train new generation of leading physicists
Stmt - 3	To emerge as a hub of world class research to disseminate our knowledge through interaction with industry, academia and society at large

2. Department Mission Statement	
Stmt - 1	To provide world class teaching and state of art research environment to highly talented young minds
Stmt - 2	To perform frontier research in pure and applied physics, and to serve the society through technological advances
Stmt - 3	To provide an outstanding educational and research experience for the students, researchers and technologists
Stmt - 4	To enable the students to have wide range of career choices through outstanding learning experience
Stmt - 5	To infuse best scientific methods in teaching theoretical and experimental concepts of physics

3. Program Education Objectives (PEO)	
PEO - 1	Post graduates gains sufficient knowledge on atmospheric sciences and its allied fields such as climate science and climate change.
PEO - 2	Post graduates acquires relevant analytical skills for handling the satellite and other remote sensing products related to weather and climate sciences
PEO - 3	Post graduates will get enough experience in taking the basic observations of atmospheric equipment such as rain gauge, wind vane, measurement of particulate matter etc.,
PEO - 4	Post graduates will be competent enough to qualify the national/international eligibility tests that pave the way for their higher education.
PEO - 5	Post graduates will acquire the basic knowledge in studying and exploring the strategies to mitigate climate related societal problems

4. Program Specific Outcomes (PSO)	
PSO-1	To develop the critical analysis and problem-solving skills required in the application of principles of Atmospheric Science.
PSO-2	To prepare the students with a working knowledge of experimental/computational techniques and instrumentation required to work independently in research or industrial environments.
PSO-3	To strengthen students' capability in organizing and presenting the acquired knowledge coherently both in oral and written discourse.

5. Consistency of PEO's with Mission of the Department

	Mission Stmt. - 1	Mission Stmt. - 2	Mission Stmt. - 3	Mission Stmt. - 4	Mission Stmt. - 5
PEO - 1	H	H	M	H	M
PEO - 2	H	M	H	H	H
PEO - 3	M	H	M	H	H
PEO - 4	H	H	H	L	M
PEO - 5	L	H	M	H	H

H – High Correlation, M – Medium Correlation, L – Low Correlation

6. Consistency of PEO's with Program Learning Outcomes (PLO)

	Program Learning Outcomes (PLO)														
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
PEO - 1	H	H	H	H	H	L	M	L	M	M	H	H	M	H	H
PEO - 2	H	H	H	H	H	L	M	L	M	H	M	M	H	H	M
PEO - 3	H	H	H	H	H	M	H	M	M	M	H	H	H	M	M
PEO - 4	H	M	M	H	H	H	M	H	H	H	H	L	M	M	H
PEO - 5	M	M	H	H	M	H	M	H	H	H	M	M	H	M	M

H – High Correlation, M – Medium Correlation, L – Low Correlation

7. PG Programme Structure (Total Credits:80)

1. Professional Core Courses (C)
(10 Courses)

Course Code	Course Title	Hours/ Week			
		L	T	P	C
PAS21101T	Mathematical Methods of Physics	3	1	0	4
PAS21102T	Atomic and Molecular Physics	3	1	0	4
PAS21103J	Atmospheric Thermodynamics	3	0	2	4
PAS21104T	Atmospheric Radiation	3	1	0	4
PAS21201T	Atmospheric Dynamics – 1	3	1	0	4
PAS21202T	Synoptic Meteorology	3	1	0	4
PAS21203T	Electrodynamics	3	1	0	4
PAS21204T	Middle Atmosphere	3	1	0	4
PAS21301J	Atmospheric Dynamics – 2	2	0	4	4
PAS21302T	Atmospheric Measurements	3	1	0	4
Total Learning Credits					**40**

2. Discipline Elective Courses (D)
(3 Courses)

Course Code	Course Title	Hours/ Week			
		L	T	P	C
PAS21D01T	Cloud Physics	3	1	0	4
PAS21D02T	Atmospheric Aerosols				
PAS21D03T	Boundary Layer Theory				
PAS21D04T	Land- Atmosphere Interactions	3	1	0	4
PAS21D05T	Ocean – Atmosphere Interactions				
PAS21D06T	Statistical Methods in Atmospheric Science				
PAS21D07T	Science of Climate change	3	1	0	4
PAS21D08T	Monsoon and Teleconnections				
PAS21D09T	Extreme Weather Events				
Total Learning Credits					**12**

3. Generic Elective Courses (G)
(Any 1 Course)

Course Code	Course Title	Hours/ Week			
		L	T	P	C
PMA21G01T	Mathematics for Artificial Intelligence	3	0	0	3
20CEC632T	Air Quality Modeling and Pollution Control	3	0	0	
PCY21G01T	Research Skills and Learning	3	0	0	
Total Learning Credits					**3**

4. Skill Enhancement Courses(S)
(3 Courses)

Course Code	Course Title	Hours/ Week			
		L	T	P	C
PAS21S01L	Computer programming for Atmospheric Science	0	0	6	3
PAS21S02L	Atmospheric Data Analysis Laboratory	0	0	6	3
PAS21S03L	Weather Monitoring Techniques	0	0	4	2
Total Learning Credits					**8**

5. Project Work, Internship In Industry / Higher Technical Institutions(P)

Course Code	Course Title	Hours/ Week			
		L	T	P	C
PAS21I01L	Massive Open Online Course	0	0	0	2
PAS21I02L	Internship				
PAS21P01L	Project Work	0	0	24	12
Total Learning Credits					14

6. Ability Enhancement Courses (AE)
(3 Courses)

Course Code	Course Title	Hours/ Week			
		L	T	P	C
PCD21AE1T	Professional skills and problem solving	1	0	0	**1**
PCD21AE2T	General aptitude for competitive examinations	1	0	0	**1**
PCD21AE3T	Employability skills	1	0	0	**1**
Total Learning Credits					**3**

Course Structure								
Semester	**Professional Core Courses (PCC)**	**Discipline Electives Courses (DEC)**	**Generic Electives Courses (GEC)**	**Skill Enhancement Courses (SEC)**	**Ability Enhancement Courses (AEC)**	**Project Work, Internship (P)**	**Total Credits**	**Total Hours**
Sem I	PCC-1(4) PCC-2 (4) PCC-3(4) PCC-4 (4)	DEC –1 (4)	--	SEC 1 (3)	AEC 1 (1)		**24**	**28**
Sem II	PCC-5 (4) PCC-6 (4) PCC-7 (4) PCC-8 (4)	DEC-2 (4)	--	SEC 2 (3)	AEC 2 (1)		**24**	**27**
Sem III	PCC-9 (4) PCC – 10 (4)	DEC –3 (4)	GEC – 1/2/3 (3)	SEC 3 (3)	AEC 3 (1)	MOOC/Internship(2)	**20**	**22**
Sem IV						P (12)	**12**	**24**
Total Credits	**40**	**12**	**3**	**8**	**3**	**14**	**80**	**101**

8. Implementation Plan

Semester – I					
Course Code	Course Title	Hours/ Week			C
		L	T	P	
PAS21101T	Mathematical Methods of Physics	3	1	0	4
PAS21102T	Atomic and Molecular Physics	3	1	0	4
PAS21103J	Atmospheric Thermodynamics	3	0	2	4
PAS21104T	Atmospheric Radiation	3	1	0	4
PAS21D01T	Cloud Physics	3	1	0	4
PAS21D02T	Atmospheric Aerosols				
PAS21D03T	Boundary Layer Theory				
PAS21S01L	Computer Programming for Atmospheric Science	0	0	6	3
PCD21AE1T	Professional Skills and Problem Solving	1	0	0	1
Total Learning Credits					24

Semester – II					
Course Code	Course Title	Hours/ Week			C
		L	T	P	
PAS21201T	Atmospheric Dynamics – 1	3	1	0	4
PAS21202T	Synoptic Meteorology	3	1	0	4
PAS21203T	Electrodynamics	3	1	0	4
PAS21204T	Middle Atmosphere	3	1	0	4
PAS21D04T	Land- Atmosphere Interactions	3	1	0	4
PAS21D05T	Ocean – Atmosphere Interactions				
PAS21D06T	Statistical Methods in Atmospheric Science				
PAS21S02L	Atmospheric Data Analysis Laboratory	0	0	6	3
PCD21AE2T	General Aptitude for Competitive examinations	1	0	0	1
Total Learning Credits					24

Semester – III					
Course Code	Course Title	Hours/ Week			C
		L	T	P	
PAS21301J	Atmospheric Dynamics – 2	2	0	4	4
PAS21302T	Atmospheric Measurements	3	1	0	4
PAS21D07T	Science of Climate Change	3	1	0	4
PAS21D08T	Monsoon and Teleconnections				
PAS21D09T	Extreme Weather Events				
PMA21G01T	Mathematics for Artificial Intelligence	3	0	0	3
20CEC632T	Air Quality Modeling and Pollution Control	3	0	0	
PCY21G01T	Research Skills and Learning	3	0	0	
PAS21S03L	Weather Monitoring Techniques	0	0	4	2
PAS21I01L	Massive Open Online Course	0	0	0	2
PAS21I02L	Internship				
PCD21AE3T	Employability Skills	1	0	0	1
Total Learning Credits					20

Semester – IV					
Course Code	Course Title	Hours/ Week			C
		L	T	P	
PAS21P01L	Project Work	0	0	24	12
Total Learning Credits					12

Total Learning Credits :80

9. Program Articulation Matrix

Course Code	Course Name	Programme Learning Outcomes														
		Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
PAS21101T	Mathematical Methods of Physics	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21102T	Atomic and Molecular Physics	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21103J	Atmospheric Thermodynamics	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21104T	Atmospheric Radiation	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21201T	Atmospheric Dynamics – 1	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21202T	Synoptic Meteorology	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21203T	Electrodynamics	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21204T	Middle Atmosphere	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21301J	Atmospheric Dynamics – 2	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21302T	Atmospheric Measurements	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21D01T	Cloud Physics	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21D02T	Atmospheric Aerosols	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21D03T	Boundary Layer Theory	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21D04T	Land- Atmosphere Interactions	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21D05T	Ocean – Atmospheric Interactions	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21D06T	Statistical methods in Atmospheric Science	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21D07T	Science of Climate change	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21D08T	Monsoons and Teleconnections:	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21D09T	Extreme Weather Events	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PMA21G01T	*Mathematics for Artificial Intelligence*	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
20CEC632T	*Air Quality Modeling and Pollution Control*	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PCY21G01T	*Research Skills and Learning*	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PCY21G01T	*Research Methodology*	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21S01L	*Computer programming for Atmospheric Science*	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21S02L	*Atmospheric* Data Analysis Laboratory	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21S03L	*Weather Monitoring Techniques*	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PAS21I01L	*MOOC/Internship*	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
PAS21P01L	*Project Work*	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
PCD21AE1T	*Professional skills and problem solving*	L	H	H	H	L	H	M	H	H	H	H	H	M	H	H
PCD21AE2T	*General aptitude for competitive Examinations*	L	H	H	H	L	H	M	H	H	H	H	H	M	H	H
PCD21AE3T	*Employability skills*	L	H	H	H	L	H	M	H	H	H	H	H	M	H	H
	Program Average	H	H	H	H	H	H	H	H	H	L	H	H	H	H	H

H – High Correlation, M – Medium Correlation, L – Low Correlation

SEMESTER – I

Course Code	PAS21101T	Course Name	Mathematical Methods of Physics	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*develop knowledge in mathematical physics and its applications.*
CLR-2:	*develop expertise in mathematical techniques required in physics.*
CLR-3:	*enhance problem solving skills*
CLR-4:	*enable students to formulate, interpret and draw inferences from mathematical solutions.*
CLR-5:	*develop expertise in mathematical techniques required in physics.*
CLR-6:	*enhance problem solving skills*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	*understand the linear algebra through matrices*	2	80	75
CLO-2:	*understand vector calculus and its application in physical fields*	2	80	70
CLO-3:	*understand the notions of probability and its various distribution*	2	75	70
CLO-4:	*understand and able to solve differential equation*	2	80	75
CLO-5:	*understand and develop the mathematics structure for periodic functions through integral transform*	2	80	70
CLO-6:	*understand and develop power to solve numerical problems and its use various parts of atmospheric sciences*	2	80	75

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Dimensional analysis	Matrix Multiplication	Definition of differential equation	Definition of Probability	Periodic function
	SLO-2	Vector algebra and vector calculus	Simultaneous linear equations	Degree and order	Axioms of probability theory	Odd and even functions
S-2	SLO-1	Gradient, divergence	Definition of matrix	Formation of differential equation	Random experiment	Square and triangular wave
	SLO-2	Curl of a Vector Field	Basic Matrix operations	Linear differential equation	Elementary events and Sample space	Euler formula for Fourier series
S-3	SLO-1	Transformation of vectors	Complex conjugation and transposition	Exact differential equation	Conditional probability	Euler coefficient
	SLO-2	Rotation of the coordinate axes	Classification of matrices	Condition for exactness	Bayes theorem	Fourier series with 2l period
S-4	SLO-1	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
S-5	SLO-1	Invariance of the scalar Product under rotations	Trace of a matrix and its properties	Leibnitz's differential equation	Binomial Distribution	Perseval's Identity
	SLO-2	Invariance of the vector Product under rotations	Determinant and its properties	General method of solution	Mean and Standard deviation of Binomial Distribution , Poisson distribution	Proof of Perseval's Identity
S-6	SLO-1	Vector analysis in curved coordinate	Definition of inverse matrix	Homogeneous second order differential equation	Mean and standard deviation of poisson distribution	Fourier integral theorem
	SLO-2	Special coordinate system	Algorithm to find inverse matrix	Complementary function	Gaussian distribution, Mean and standard deviation of poisson distribution	Proof of integral theorem
S-7	SLO-1	Spherical polar coordinates	Symmetric and skew-symmetric matrix	Particular integral [introduction]	Central limit theorem, Skewness and kurtosis	Motivation for fourier transform
	SLO-2	Cylindrical polar coordinates	Hermitian and skew-hermitian matrix	General method to find the particular integral	Covariance Correlation Coefficient	Definition of fourier transform

S-8	**SLO-1**	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
S-9	**SLO-1**	Introduction to tensor	Orthogonal matrix	Partial differential equations of theoretical physics	Basic topics in parametric statistics; estimation, confidence intervals	Properties of Fourier transform
	SLO-2	Einstein's summation notations	Unitary matrix	Series solutions-Fresenius method	Hypothesis testing	Linearity and shifting
S-10	**SLO-1**	Quotient rule	Eigenvalues and eigenvectors	Non-homogeneous differential equation Operator factorization method	analysis of variance, regression and correlation analysis	Fourier transforms of derivatives
	SLO-2	Pseudo tensors	Characteristic equation	Non-homogenous differential equation variable coefficient	goodness of fit tests; application in statistical quality control	Convolution theorem
S-11	**SLO-1**	Metric tensor	Cayley –hamilton theorem	Formation of pde	Demand forecasting	Inverse fourier transforms
	SLO-2	Non-Cartesian tensors	Diagonalization of matrix	Introduction to partial differential equation (PDE)	elementary design of experiments and data collection	Introduction to Laplace Transform
S-12	**SLO-1**	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving

Learning Resources

1. G. Arfken and H.J. Weber, *Mathematical Methods for Physicists*, 6th Ed., Academic Press, SanDiego, 2005.
2. P.K. Chattopadhyay, *Mathematical Physics*, Wiley Eastern, New Delhi, 2005.
3. C. Harper, *Introduction to Mathematical Physics*, Prentice Hall of India, New Delhi, 2004.
4. M.R. Spiegel, *Schaum's Outline of Advanced Mathematics for Engineers and Scientists*, 1st Ed., McGraw Hill, 2009. L.A. Pipes, *Applied Mathematics for Engineers and Physicists*, McGraw-Hill, 1958.
5. M.L. Boas, *Mathematical Methods in the Physical Sciences*, 3rd Ed., John Wiley, 2005.
6. M.R. Spiegel, Seymour Lipschutz, John J. Schiller, and Dennis Spellman, *Schaum's outline of Probability* , 2nd Ed., McGraw Hill, 2009.
7. B.D. Gupta, *Mathematical Physics*, 4th Ed., Vikas Publishing House, 2009.
8. S. Hassani, *Mathematical Physics: A Modern Introduction to Its Foundations*, 2nd Ed., Springer, 2013.
9. P.K. Chattopadhyay, *Mathematical Physics*, 1st Ed., New Age International, 2009.
10. Probability and Statistics, Murray R Spiegel, John Shiller & Alu Srinivasan, Mc Graw Hill, 2013

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	Prof. VS Subramanian, IIT Madras, manianvs@iitm.ac.in	Dr. Alok Kumar
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Course Code	PAS21102T	Course Name	Atomic and Molecular Physics	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*develop the skills to solve real physical problems using quantum mechanics.*
CLR-2:	*provide the accomplishments necessary for advanced courses such as optics, astrophysics, condensed matter physics and nuclear physics.*
CLR-3:	*emphasize the modern developments in experimental techniques especially spectroscopy*
CLR-4:	*realize the role and practical application of physics of atoms and molecules in the modern world.*
CLR-5:	*develop the skills to solve real physical problems using molecular spectroscopy*
CLR-6:	*explore the concept of Laser*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	*understand the concept of fine structure of hydrogen like atoms*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*know about the concept of ls-coupling and jj-coupling schemes*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*understand the idea of hartree-fock equations and thomas-reiche-kuhn sum rule*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*understand the basic concepts the rotation and vibration of diatomic molecules*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*know about the concept of frank-condon principle*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*understand the concepts of laser technology*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Fine structure of hydrogen like atoms	The idea of Hartree-Fock equations	Born-Oppenheimer separation for diatomic molecules	Rotation spectra (microwave) for diatomic molecules	Equation and saturation in 3-level system
	SLO-2	Mass correction	Properties of the Hartree-Fock potential and spin orbitals	The rotation and vibration of diatomic molecules	Vibration spectra (infrared) for diatomic molecules	Equation and saturation in 4-level system
S-2	SLO-1	Spin-orbit term	Helium spectra	Electronic structure of diatomic molecules	Vibration-rotation spectra for diatomic molecules	Significance of Rabi frequency
	SLO-2	Darwin term	Difference between hydrogen and helium spectra	Symmetry properties of H_2 , O_2 and N_2	Electronic spectra (UV-Vis) for diatomic molecules	Physical interpretation of Rabi Frequency
S-3	SLO-1	Intensity of fine structure lines	Two-electron atoms	Molecular orbital and valence bond methods for H_2^+	Pure Rotational Raman spectra for diatomic molecules	Laser pumping
	SLO-2	Fine structure splitting	Alkaline metal spectra	Molecular orbital and valence bond methods for H_2	Vibrational Raman spectra for diatomic molecules	Population inversion
S-4	SLO-1	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
S-5	SLO-1	The Zeeman effect	Thomas-Fermi model of atom	Centrifugal distortion	Principle of X-ray spectroscopy	He-Ne Laser
	SLO-2	Strong fields	Hartree-Fock equation	Morse potential	Application of X-ray spectroscopy	Solid state Laser
S-6	SLO-1	Weak fields	Many-electron atoms	Homonuclear diatomic molecules	Electronic Spin	Free-electron Laser
	SLO-2	The ground state of two-electron atoms	Alkaline earth-metal spectra	Pairing and valency	Electron Spin Resonance Spectroscopy	Non-linear phenomenon
S-7	SLO-1	Perturbation theory	Auger effect	Correlation diagrams for heteronuclear molecules	Nuclear Spin	Non-linear Lasers
	SLO-2	Harmonic oscillator	Stark effect	Lithium hydride	Nuclear Magnetic Resonance	Modes and harmonic generation
S-8	SLO-1	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
S-9	SLO-1	Variation method	Selection rules for electric multipole radiation	Hydrogen chloride (hcl)	Frank-condon principle	Laser accelerator
	SLO-2	*LS*-coupling schemes	Selection rules for magnetic multipole radiation	Sodium chloride (nacl)	Hund's cases and selection rules	Liquid Laser
S-10	SLO-1	*Jj*-coupling schemes	Absorption spectra	The structure of polyatomic molecules	Idea of symmetry for diatomic molecules	Gas laser
	SLO-2	Hund's rules	Emission Spectra	Electronic structure	Idea of symmetry for polyatomic molecules	Semiconductor Laser

S-11	**SLO-1**	Many-electron atoms	Oscillator strengths	The water molecule (H_2O)	Principle of Mossbauer Spectroscopy	Diode Laser
	SLO-2	Lande interval rule	Thomas-Reiche-Kuhn sum rule	The methane, ethylene and acetylene molecules	Applications of Mossbauer Spectroscopy	Applications of different lasers
S-12	**SLO-1**	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving

Learning Resources	1. B.H. Bransden and C. J. Jochain, *Physics of Atoms and Molecules*, 2nd Ed., Pearson Education, 2003. 2. E.U. Condon and G. H. Shortley, *The Theory of Atomic Spectra*, Cambridge University Press, 1989. 3. C.J. Foot, *Atomic Physics*, Oxford Univ. Press, 2005. 4. C.N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw-Hill, 2008. 5. W. Demtroder, *Atoms, Molecules and Photons*, Springer, 2006.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. V Subramanian, CLRI, subbu@clri.res.in	Prof. S Balakumar, University of Madras, balakumar@unom.ac.in	Dr. Rohit Dhir

Course Code	PAS21103J	Course Name	Atmospheric Thermodynamics	Course Category	C	Professional Core Course	L	T	P	C
							3	0	2	4

Pre-requisite Courses	**Nil**	**Co-requisite Courses**	**Nil**	**Progressive Courses**	**Nil**
Course Offering Department	***Physics and Nanotechnology***	**Data Book / Codes/Standards**		***Nil***	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*understand the fundamentals of atmospheric thermodynamics*
CLR-2:	*acquire knowledge on the structure and dynamics of atmosphere*
CLR-3:	*create insights in to thermodynamics of gases*
CLR-4:	*understand the concept of atmospheric radiation*
CLR-5:	*acquire knowledge on the atmospheric motion*
CLR-6:	*gain the fundamental understanding on atmospheric waves*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	**Learning**			**Program Learning Outcomes (PLO)**															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	*understand the thermodynamic behaviour of atmosphere*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2:	*discern about the concept of thermodynamic laws and implications*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-3:	*know about the concept of hydrostatic equilibrium and stability*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-4:	*understand the formation and characteristics of cloud and aerosol*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5:	*study the motions of atmosphere*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6:	*analyse the characteristics of atmospheric waves*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		**15**	**15**	**15**	**15**	**15**
S-1	**SLO-1**	Introduction to the Atmosphere	Description of a Heterogeneous System	Hydrostatic Stability	Atmospheric Motion	Planetary Boundary Layer
	SLO-2	Mechanisms influencing atmospheric behaviour	Chemical equilibrium	Reaction to vertical displacement	Descriptions of atmospheric motion	Turbulence
S-2	**SLO-1**	Composition and Structure of atmosphere	Fundamental Relations for a Multicomponent System	Stability Categories	Kinematics of Fluid Motion	Reynolds Decomposition

	SLO-2	Stratification of Mass	Thermodynamic Degrees of Freedom	Implications for Vertical Motion	The Material Derivative	Turbulent Diffusion
S-3	SLO-1	Thermal and Dynamical Structure	Thermodynamic Characteristics of Water	Finite Displacements	Reynolds' Transport Theorem	The Ekman Layer
	SLO-2	Trace Constituents – various gases, molecules and compounds	Equilibrium Phase Transformations	Stabilizing and Destabilizing Influences	Conservation of Mass	The Surface Layer
S-4 to S-5	SLO-1	Point measurements of rainfall – Rain gauge	Calculation of integrated water vapor, actual and saturated vapor pressure using radiosonde data	Estimation of solar radiation and sun shine hours –comparison with Automatic Weather Station measurements	Synoptic weather charts	Analysis of surface and upper air data for western disturbances
	SLO-2					
S-6	SLO-1	Thermodynamics of Gases	Description of Moist Air – Gaseous Phase	Shortwave and Longwave Radiation	Atmospheric Equations of Motion	Atmospheric Waves
	SLO-2	Basic Concepts of Thermodynamics	Saturation Properties	Radiative Transfer	Curvilinear Coordinates	Wave Propagation
S-7	SLO-1	First Law of Thermodynamics	Distribution of Water Vapour	Absorption and Emission	Spherical Coordinates	Acoustic Waves
	SLO-2	Internal energy	State variables of the two-component system	Absorption characteristics of gases	The traditional approximation	Buoyancy waves
S-8	SLO-1	Heat capacity	Condensation and the release of latent heat	Radiative transfer in a plane parallel atmosphere	Special forms of motion	Lamb wave
	SLO-2	Adiabatic processes - potential temperature	The pseudo - adiabatic process	Thermal equilibrium	Motion-related stratification	Rossby waves
S-9 to S-10	SLO-1	Pressure –altitude relationships	Estimation of evapotranspiration from temperature-based methods	Wind measurements and plotting from Automatic Weather Station	Calculation of potential and virtual temperature from radiosonde data	Estimation of angstrom exponents from aerosol optical depth
	SLO-2					
S-11	SLO-1	Natural and Reversible Processes – Carnot Cycle	Equivalent Potential Temperature at the Surface	Morphology of Atmospheric Aerosol	Geostrophic Equilibrium	Atmospheric Energy
	SLO-2	Entropy	Liquid Water Content at the Freezing Level	Classification of Aerosol	The Helmholtz Theorem	Moist Static Energy
S-12	SLO-1	Second Law of Thermodynamics	Hydrostatic Equilibrium	Microphysics of Clouds	Vertical Shear of the Geostrophic Wind	Total and Available Potential Energy
	SLO-2	Restricted Forms of the Second Law	Effective Gravity	Macroscopic Characteristics of Clouds	Frictional Geostrophic Motion	Adiabatic Adjustment
S-13	SLO-1	Maxwell relations	Geopotential coordinates	Radiative transfer in aerosol and cloud	Curvilinear motion	Heat transfer in an axisymmetric circulation
	SLO-2	Noncompensated heat transfer	Hydrostatic balance	Scattering by molecules and particles	Types of curvilinear motion	Heat transfer in a laboratory analogue
S-14 to S-15	SLO-1	Use of hypsometric equation from pressure – humidity relations	Estimation of evapotranspiration from micro–meteorology methods	Air quality index using PM10 measurement	Analysis on daily weather report	Estimation of atmospheric boundary layer height from radiosonde data
	SLO-2					

Learning Resources

1. Fundamentals of Atmospheric Physics, Murry L. Salby (Academic Press, 1996).
2. Atmospheric Thermodynamics, J. V. Iribarne (Springer Netherlands, 2013)
3. An Introduction to Atmospheric Thermodynamics, Anastasios Tsonis, (Cambridge University Press, 2007)
4. Guide to Meteorological Instruments and Methods of Observation, WMO, (7th edition, 2007).
5. Meteorology Manual: The practical guide to the weather, Storm Dunlop, (Haynes Publishing, 2014)
6. Atmospheric Science an Introductory Survey, John M Wallace and Peter V Hobbs, (Academic Press, International Geophysics Series, 2005)

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %
	Understand										
Level 2	Apply	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %
	Analyze										
Level 3	Evaluate	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. N Vijayan, NPL, nvijayan @nplindia.org	Dr. K. Koteswara Rao, Azim Premji University, Bangalore, koti.meteo@gmail.com	Dr.R.M. Hariharan
Mr. R Seshadri, Titan Company Limited, seshadri@titan.co.in	Dr. Manoj Kumar Tahkur, Tribhuvan University, thakurmanoj2003@yahoo.com	Dr.T.V. Lakshmi Kumar

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Course Code	PAS21104T	Course Name	Atmospheric Radiation	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1:	*familiarize with the different frequency zone of electromagnetic spectrum*			
CLR-2:	*understand black body radiation and its use in the study atmospheric radiation*			
CLR-3:	*analyze the solar spectrum so that its atmospheric effect can be accounted for reliably*			
CLR-4:	*understand the scattering and absorption of radiation in the solar system*			
CLR-5:	*understand the role of radiative transfer in remote sensing*			
CLR-6:	*understand the basics of lasers*			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	*understand radiation as electromagnetic wave and the relation among various wave characteristics*	2	80	75
CLO-2:	*understand black radiation problem and its solution as Planck's radiation formula*	2	80	70
CLO-3:	*importance of Remote sensing with the help radiative transfer as practical methods*	2	75	70
CLO-4:	*understand the solar constant and its determination*	2	80	75
CLO-5:	*understand the Schrodinger equation and calculation Planck constant with black body radiation*	2	80	70
CLO-6:	*idea that the electromagnetic radiation is solution of Maxwell Equations*	2	80	75

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Electromagnetic Spectrum and its different range wavelength	Cross section diagram of the sun illustrating the solar interior and atmosphere	Rayleigh Scattering: Theoretically	Morphology of Atmospheric Particulates	Limb Extinction Technique
	SLO-2	Maxwell equations and electromagnetic radiation as its solutions	Solar Surface Activity: Sunspots	Phase function, scattering cross section, and polarizability	Lorenz–Mie Theory of Light Scattering by Spherical Particles	Remote Sensing Using Reflected Sunlight
S-2	SLO-1	Black Body Radiations and Planck formula	Orbital Geometry of solar system with 9 planets	Lorenz–mie scattering	Electromagnetic Wave Equation and Solution	Remote Sensing Using Emitted Infrared Radiation
	SLO-2	Determination of Planck constant from black body radiation	Solar insolation as a function of latitude and the time of year	Geometrical Optics: review	Formal Scattering Solution	Surface Temperature Determination
S-3	SLO-1	Stefan-boltzmann law	Definition of the solar constant	Anomalous diffraction theory	The far-field solution and extinction parameters	Remote sensing of temperature profiles
	SLO-2	Wien's law and Kirchhoff's law	Distribution of Solar Insolation	Fundamentals of Radiative Transfer	Scattering Phase Matrix for Spherical Particles	Radiation Budget of the Earth–Atmosphere System
S-4	SLO-1	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-5	SLO-1	Absorption line formation	Solar Spectrum	Single Scattering Approximation	Geometric Optics, Lorenz–Mie Theory, and Representative Results	Observational Considerations
	SLO-2	Bohr's model	Determination of the Solar Constant: Ground-Based Method	Diffusion Approximation	Light Scattering by No spherical Aerosols	Black and White sensors based on radiatiive equilibrium
S-6	SLO-1	Energy level diagram for a hydrogen atom	Hypothetical observed monochromatic solar irradiances curve	Atmospheric Solar Heating Rates	General Solution for Isotropic Scattering	Scanning radiometer and angular models
	SLO-2	Introduction to Schrodinger Wave Equation and its wave solutions	Satellite Measurements of the Solar Constant	The Thermal Infrared Spectrum and the Greenhouse Effect	Definitions of Scattering Parameters	Radiation Budget Viewed from Space
S-7	SLO-1	Wave function and its meaning	Composition and Structure of the Earth's Atmosphere	Absorption in the Thermal Infrared	Principles of Invariance for Semi-infinite Atmospheres	Cloud Radiative Forcing Derived from ERB Data
	SLO-2	Existence of wave functions by Davisson-Clinton experiments	Chemical Composition of Atmosphere	Vibrational transitions that produce the 15μm CO2 band-diagrams	Principles of Invariance for Finite Atmospheres	Radiative Heating/Cooling Rates of the Atmosphere
S-8	SLO-1	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-9	SLO-1	Rotational and Vibrational modes	Vibrational modes of diatomic and triatomic atmospheric molecules	Fundamentals of Thermal Infrared Radiative Transfer	Adding Method for Radiative Transfer	Radiation Budget at the Surface
	SLO-2	Transitions among rotational and vibrational modes of energy	Absorption cross section of ozone	Line-By-Line (LBL) Integration	Principle of remote sensing	Radiative and Convective Atmospheres
S-10	SLO-1	The Equation of Radiative Transfer	Absorption cross section of Nitrogen and Oxygen	Correlated K-Distribution Method for Infrared Radiative Transfer	Remote Sensing Using Transmitted Sunlight	Radiative and Convective Equilibrium

	SLO-2	Equation of Radiative Transfer for Plane-Parallel Atmospheres and Inhomogeneous Media	Photochemical Processes and the Formation of Ozone Layers	Band Models	Determination of Aerosol Optical Depth and Size Distribution	Radiation in One-Dimensional Climate Models
S-11	SLO-1	Beer–bouguer–lambert law	Catalytic destruction reactions of ozone	Infrared radiative transfer in cloudy atmospheres	Direct linear inversion	Ozone and other greenhouse gases
	SLO-2	Schwarzschild's Equation and Its Solution	Transfer of direct solar flux in the atmosphere	Exchange of Infrared Radiation between Cloud and Surface	Determination of Total Ozone Concentration	Radiation Feedback Consideration
S-12	SLO-1	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems

Learning Resources	1. Goody, R. M., and Yung, Y. L. (1989). *Atmospheric Radiation. Theoretical Basis*,OxfordUniversity Press, New York 2.Jastrow, R., and Thompson, M. H. (1984). *Astronomy: Fundamentals and Frontiers*,2nd ed.Wiley,NewYork 3. van de Hulst, H. C. (1957). *Light Scattering by Small Particles*. Wiley, New York	4. Liou, K. N. (1992). *Radiation and Cloud Processes in the Atmosphere. Theory, Observation, and Modeling* ed. Oxford University Press, New York *5.* Kerker, M. (1969). *The Scattering of Light and Other Electromagnetic Radiation.* Academic Press, New York 6. K. N. Liou, An Introduction to Atmospheric Radiation, Academic Press

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply / Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate / Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	*Dr. K. Koteswara Rao, Azim Premji University, Bangalore, koti.meteo@gmail.com*	Dr. Alok Kumar
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. Manoj Kumar Tahkur, Tribhuvan University, thakurmanoj2003@yahoo.com	Dr. Shadak Alee

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Course Code	PAS21D01T	Course Name	Cloud Physics	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	**Nil**	**Co-requisite Courses**	**Nil**	**Progressive Courses**	**Nil**
Course Offering Department	**Physics and Nanotechnology**	**Data Book / Codes/Standards**		**Nil**	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
CLR-1:	understand the fundamentals of dynamics of the clouds	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2:	acquire knowledge on the structure and dynamics of middle atmosphere			
CLR-3:	understand the concepts of cloud classification			
CLR-4:	familiarize the concepts of cloud condensation nuclei			
CLR-5:	acquire knowledge on the climatology of clouds			
CLR-6:	gain the fundamental understanding on various models of clouds			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	*understand the significance of the study of clouds*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*discern about the importance of low clouds*	2	80	70	H	M	M	H	M	H	H	H	M	H	M	H	M	H	M
CLO-3:	*know about the concept of cloud dynamics*	2	75	70	H	M	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	*apply the principles of cloud properties*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*identify various interactions of clouds with atmosphere*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*apply the principles hygroscopic nature and water vapor growth*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Atmospheric composition	Horizontal restoring forces	Droplet Growth by Condensation	Further growth by accretion	Mesoscale structure of rain
	SLO-2	Equation of state for dry air	Geostrophic wind and geostrophic wind shear	Diffusional growth of a droplet	The ice crystal process versus coalescence	Precipitation efficiency
S-2	SLO-1	The first law of thermodynamics	Slantwise displacement	The growth of droplet populations	Rain and Snow	Acidic precipitation
	SLO-2	Special processes	Symmetric instability	Some corrections to the diffusional growth theory	Drop-size distribution	Severe Storms and Hail
S-3	SLO-1	Entropy	Baroclinic instability	Initiation of Rain in Non-freezing Clouds	Drop breakup	Life cycle of the thunderstorm cell
	SLO-2	Meteorological thermodynamic charts	Geopotential	Setting the stage for coalescence	Distribution of snowflakes with size	Severe thunderstorms
S-4	SLO-1	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
S-5	SLO-1	Equation of state for water vapor	Mixing of air masses	Droplet growth by collision and coalescence	Aggregation and breakup of snowflakes	Precipitation
	SLO-2	Clausius-Clapeyron equation	Convective condensation level	The Bowen model	Precipitation rates	Precipitation production by thunderstorms
S-6	SLO-1	Moist air: its vapor content	Convection: elementary parcel theory	Statistical growth: the Telford model	Weather Radar	Hail growth
	SLO-2	Thermodynamics of unsaturated moist air	Modification of the elementary theory	Statistical growth: the stochastic coalescence equation	Principles of radar	Stimulation of rain
S-7	SLO-1	Pseudoadiabatic process	Sizes of clouds and cloud systems	Condensation plus stochastic coalescence	The radar equation	Stimulation of snow
	SLO-2	Reversible saturated adiabatic process	Microstructure of cumulus clouds	The effects of turbulence on collisions and coalescence	The weather radar equation	Hail suppression
S-8	SLO-1	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
S-9	SLO-1	Hydrostatic equilibrium	Cloud droplet spectra	Formation and Growth ofice Crystals	Relation of Z to precipitation rate	Numerical Cloud Models
	SLO-2	Buoyant force on a parcel of air	Likelihood of ice and precipitation in clouds	Nucleation of the ice phase	Relation of Z to precipitation rate	The governing equations
S-10	SLO-1	Stability criteria for dry air	Microstructure of large continental storm clouds	Experiments on heterogeneous ice nucleation	Precipitation Processes	One-dimensional models
	SLO-2	The pseudoadiabatic lapse rate	General aspects of cloud and precipitation formation	Atmospheric ice nuclei	Stratiform precipitation	Two-dimensional models
S-11	SLO-1	Stability criteria for moist air	Nucleation of liquid water in water vapor	The ice phase in clouds	Showers	Three-dimensional models
	SLO-2	Convective instability	Atmospheric condensation nuclei	Diffusional growth of ice crystals	Precipitation theories	Model evaluation
S-12	SLO-1	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving

Learning Resources	
1. A Short Course in Cloud Physics, R. R. Rogers, M. K. Yau, (Butterworth-Heinemann is an imprint of Elsevier, 1989).	3. Physics and Chemistry of Clouds, Dennis Lamb, Johannes Verlinde (Cambridge University Press, 2011)
2. Cloud Physics: A Popular Introduction to Applied Meteorology, Louis J. Battan, (Dover Publications, 2003)	4. B.J. Mason, "The Physics of Clouds", OUP Oxford, 2010.ISBN: 9780199588046, 019958804X

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, and Certifications etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	Dr. Sanjeev Dwivedi, IMD, Bhubanesar, sanjeev.esa@gmail.com	Dr. R.M. Hariharan
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. Manoj Kumar Tahkur, Tribhuvan University, thakurmanoj2003@yahoo.com	Dr. T.V. Lakshmi Kumar

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Course Code	PAS21D02T	Course Name	Atmospheric Aerosols	Course Category	D	Discipline Elective	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*familiarize with the concepts of atmospheric aerosols*
CLR-2:	*understand the concepts of* aerosol properties
CLR-3:	*identify the significance of aerosol loss processes*
CLR-4:	*create insights to the concepts of radiative forcing of aerosols*
CLR-5:	*understanding the impacts of aerosols*
CLR-6:	*understand the basics of lasers*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	*identify the problems of atmosphere interactions of aerosols*	2	80	75
CLO-2:	*understand the atmospheric transport processes*	2	80	70
CLO-3:	*apply the principles of transport and simulations*	2	75	70
CLO-4:	*utilize the concepts of radiative budget*	2	80	75
CLO-5:	*apply the principles of effects of aerosols*	2	80	70
CLO-6:	*apply the principles of carbon aerosols*	2	80	75

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Definition of aerosols	Nucleation, Accumulation, Course mode aerosols	Introduction of aerosol dynamics	Definition of radiometric quantities	Aerosol indirect effects
	SLO-2	Various aerosol sources	Processes affecting these modes	General Dynamic equation	Definition of radiometric quantities	Aerosol indirect effects
S-2	SLO-1	Formation processes and types of aerosols	Production and loss processes	General dynamic equation	Plank's law	Cloud condensation nuclei
	SLO-2	Formation processes and types of aerosols	Gas to particle conversion	New particle formation	Stephan's law and wien's law	Towmy effect
S-3	SLO-1	Background of marine aerosols	Coagulation	New particle formation	Concept of radiative transfer (rt) and rt equation	Aerosols impact on health effects due to indoor pollution
	SLO-2	Dust aerosols	Wind erosion	Growth by condensation	Concept of radiative transfer (rt) and rt equation	Aerosols impact on health effects due to indoor pollution
S-4	SLO-1	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*
	SLO-2	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*
S-5	SLO-1	Sulphate aerosols	Gravitational sedmentation	Growth by coagulation	Aerosol Scattering and absorption	Aerosols impact on health effects due to outdoor pollution
	SLO-2	Sulphur cycle	Wet removal process-condensation and evaporation	Growth by agglomeration	Aerosol Scattering and absorption	Aerosols impact on health effects due to outdoor pollution
S-6	SLO-1	Carbon aerosols	Size distributions	Deposition mechanisms	Definition of scattering and absorption parameters – rayleigh and mie scattering	Impacts of bioaerosols
	SLO-2	Urban aerosols	Power law, long normal distribution	Impact of cloudiness on solar radiation transfer	Definition of scattering and absorption parameters – rayleigh and mie scattering	Impact of bioaerosols
S-7	SLO-1	Volcanic erosols	Bimodal distribution	The distribution of aerosol in the cloudy atmosphere	Aerosol optical depth	Aerosol effects on agriculture
	SLO-2	High latitude atmospheric aerosols, global spatial and temporal variability of aerosols	Multi model distributions	The distribution of aerosol in the cloudy atmosphere	Angstrom exponent & turbidity co efficient	Aerosol effects on agriculture
S-8	SLO-1	*Assignment*	*Solving Problems*	*Assignment*	*Solving Problems*	*Solving Problems*
	SLO-2	*Assignment*	*Solving Problems*	*Assignment*	*Solving Problems*	*Solving Problems*
S-9	SLO-1	Interaction between aerosols and minor gas components	Introduction of aerosol transport	Numerical simulation of aerosol-cloud interactions	Single Scattering Albedo	Aerosol effects on water cycle and photosynthesis
	SLO-2	Photochemical processes with the participation of aerosols	African aerosols, asian aerosols	Numerical simulation of aerosol-cloud interactions	Assymetry factor	Aerosol effects on water cycle and photosynthesis
S-10	SLO-1	Tropospheric ozone variations in a highly polluted atmosphere	Processes of aerosol deposition	Aerosol remote sensing using ground based instruments	Radiative forcing of aerosols	Radioactive active aerosols and atmospheric processes
	SLO-2	Tropospheric ozone variations in a highly polluted atmosphere	*Sulfer cycle and its simulation*	Aerosol remote sensing using ground based instruments	Radiative forcing of aerosols	Radioactive active aerosols and atmospheric processes

S-11	**SLO-1**	Biomass burning and its impact on tropospheric ozone.	Numerical simulation of aerosol long range transport	Aerosol remote sensing using satellites	Radiative forcing of aerosols	*Impacts of aerosols in air pollution*
	SLO-2	Biomass burning and its impact on tropospheric ozone.	An expert system for the physics of atmospheric pollution	Aerosol remote sensing using satellites	Radiative forcing of aerosols	*Impacts of aerosols in air pollution*
S-12	**SLO-1**	Seminar	Seminar	Seminar	Seminar	Seminar
	SLO-2	Seminar	Seminar	Seminar	Seminar	Seminar

Learning Resources	1.Atmospheric aerosol properties, Kirill ya kondratyev et al, Praxiz Publishing Springer, 2006. 2.Aerosol Science : Technology and Applications, Ion Colbeck, Mihails Lazaridis, Wiley Publciations, 2014	*3.Atmospheric Aerosols, Regional Characteristics Chemistry and Physics, Hayder Abdul Razak, In Tech Open Publishers, 2012* 4. S Ramachandran, "Atmospheric Aerosols Characteristics and Radiative Effects" , CRC Press, 2018.ISBN: 9781351648455, 1351648454

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply / Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate / Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	Prof. Humberto Barbosa, UFAL, Brazil, barbosa33@gmail.com	Dr. T.V. Lakshmi Kumar
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. Sanjeev Dwivedi, IMD Bhubaneswar, sanjeev.esa@gmail.com	Dr.A. Naga Rajesh

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Course Code	PAS21D03T	Course Name	Boundary Layer Theory	Course Category	D	Discipline Elective Courses	L	T	P	C
							3	1	0	4

Pre-requisite Courses	**Nil**	**Co-requisite Courses**	**Nil**	**Progressive Courses**	**Nil**
Course Offering Department	**Physics and Nanotechnology**	**Data Book / Codes/Standards**		**Nil**	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	**Learning**		
		1	2	3
CLR-1:	*familiarize with the concepts of atmospheric boundary layer*			
CLR-2:	*understand the concepts of abl properties*			
CLR-3:	*identify the significance of abl processes*			
CLR-4:	*create insights to the concepts of abl*			
CLR-5:	*understanding the impacts of abl*			
CLR-6:	*familiarize with the concepts of atmospheric boundary layer*			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	*identify the problems of abl*	2	80	75
CLO-2:	*understand the abl processes*	2	80	70
CLO-3:	*apply the principles of convective boundary layer*	2	75	70
CLO-4:	*utilize the concepts of stable boundary layer*	2	80	75
CLO-5:	*apply the principles of effects of nocturnal boundary layer*	2	80	70
CLO-6:	*apply the principles of abl*	2	80	75

Program Learning Outcomes (PLO)

1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	**SLO-1**	Introduction of Atmospheric Boundary Layer (ABL)	Convective Boundary Layer : Introduction	Thermal structures	Stable Boundary Layer : Introduction	Low level jet
	SLO-2	Introduction of ABL	Convective Boundary Layer : Introduction	Thermal structures	Stable Boundary Layer : Introduction	Low level jet
S-2	**SLO-1**	A boundary layer definiiton	The unstable surface layer : Mean charactristics	Horizontal roll vortices and mesoscale cellular convection	Vertical profiles	Baroclinicity over slopping terrain
	SLO-2	A boundary layer definition	Plumes	Horizontal roll vortices and mesoscale cellular convection	Vertical profiles	Baroclinicity over slopping terrain

S-3	SLO-1	Wind and flow	Plumes	Dispersion	Bulk measures of SBL Depth and strength	Interaction of SBL processes
	SLO-2	Turbulent transport	Surface convergence bands	Dispersion	Bulk measures of sbl depth and strength	Interaction of sbl processes
S-4	SLO-1	Carrying out Assignments	Carrying out Assignments	Carrying out Assignments	Carrying out Assignments	Carrying out Assignments
	SLO-2	Carrying out Assignments	Carrying out Assignments	Carrying out Assignments	Carrying out Assignments	Carrying out Assignments
S-5	SLO-1	Taylor's hypotheiss	Dust devils	The entrainment zone : Characteristics	Idealized models for potential temperature profile	Boundary layer clouds : cloud entrainment mechanisms
	SLO-2	Taylor's hypotheiss	Dust devils	The entrainment zone : Characteristics	Idealized models for potential temperature profile	Boundary layer clouds : cloud entrainment mechanisms
S-6	SLO-1	Virtual potential temperature	Mixed boundary layer : Mean characteristics	Evolution and models	Processes : Radiation	Fair weather cumulus : cloud classification
	SLO-2	Virtual potential temperature	Mixed boundary layer : Mean characteristics	Evolution and models	Models	Fair weather cumulus : cloud classification
S-7	SLO-1	Boundary Layer Depth and Structure	Evolution	Overshooting and intermitatncy	Turbulence : Classification	Feedback from the clouds to the mixed layer
	SLO-2	Boundary Layer Depth and Structure	Evolution	KH waves	Length scales	Feedback from the clouds to the mixed layer
S-8	SLO-1	Assignment	Solving Problems	Assignment	Solving Problems	Solving Problems
	SLO-2	Assignment	Solving Problems	Assignment	Solving Problems	Solving Problems
S-9	SLO-1	Mixed layer	Continuity equation	Entrainment velocity and its parameterization : typical values	Continuous/contiguous turbulence	Cumulus onset time and cloud cover
	SLO-2	Residual layer	Continuity equation	Flux ratio method	Continuous/contiguous turbulence	Cumulus onset time and cloud cover
S-10	SLO-1	Stable boundary layer	Thermodynamic mixed layer growth	Energetics method	Discontinuous turbulence	Stratocumulus profiles and fluxes
	SLO-2	Stable boundary layer	Thermodynamic mixed layer growth	Energetics method	Subsidence and advection	Stratocumulus profiles and fluxes
S-11	SLO-1	Significance of the boundary layer	Models	Subsidence and advection	Bulk growth	Mixing processes
	SLO-2	Significance of the boundary layer	Models	Subsidence and divergence	Other depth models	Mixing processes
S-12	SLO-1	Seminar	Seminar	Seminar	Seminar	Seminar
	SLO-2	Seminar	Seminar	Seminar	Seminar	Seminar

Learning Resources	1. An introduction to Boundary Layer Meteorology, Ronald B Stull, Kluwer Academic Publishers, 2003 2. Atmospheric Boundary Layer for Engineers, Ram S Azad, Spinger Science, 1993	3. Atmospheric Boundary Layer Flows, J.C. Kaimal & J.J. Finnigan, Oxford University Press, 1994. 4. Hermann Schlichting (Deceased), Klaus Gersten , "Boundary-Layer Theory", Springer Berlin Heidelberg, 2016.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. Manoj Kumar Thakur, TU, thakurmanoj2003@yahoo.com	Dr. A. Naga Rajesh

Course Code	PAS21S01L	Course Name	Computer Programming for Atmospheric Science	Course Category	S	Skill Enhancement Course	L	T	P	C
							0	0	6	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	***Physics and Nanotechnology***	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
CLR-1:	*develop programming skill in python*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2:	*develop basic problem-solving skill through use of mathematics and statistics*			
CLR-3:	*understand programming structure of python language*			
CLR-4:	*enable the students to handle data related to physical experiments and theory*			
CLR-5:	*apply exploratory data analysis and generate basic statics for unfamiliar data sets.*			
CLR-6:	*enable the students to apply programming skill to solve problems in atmospheric science*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO – 1	PSO – 2	PSO – 3
CLO-1:	*demonstrate good programming skill*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*use basic programming constructs, including sequence, selection and iteration, the use of identifiers, variables and expressions, and a range of data types*	2	80	70	H	M	M	H	M	H	H	H	M	H	M	H	M	M	M
CLO-3:	*employ fundamental mathematical and statistical concepts to solve atmospheric science problems*	2	75	70	H	M	H	H	H	H	H	M	H	H	M	H	H	H	H
CLO-4:	*interpret experimental/observational results correctly*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLR-5:	*write code to analyse and present experimental/observational data*	2	80	70	H	H	H	H	H	M	H	H	M	H	M	H	H	H	H
CLR-6:	*analyse problems in a systematic manner and develop algorithms to solve them computationally*	2	80	75	H	H	H	M	H	M	H	H	M	H	M	H	H	M	H

DURATION (HOURS)		18	18	18	18	18
S1 to S6	SLO-1	Getting overview of the course and Setting up Python Environment Python Editors, Resources PythonIDE	Introduction to Python Environments and Distributions, CONDAS/ANACONDAS; EDITORS: Spyder, PyCharm, Visual Studio and Jupyter	Interpolation Curve Fitting - Fitting Exercises	Numerical Differentiation Simple Exercises	Data Manipulation and Analysis: Pandas Reading Data from Files Using Pandas Exercises
	SLO-2					
S7 to S12	SLO-1	Python Programming: Variables Numbers Strings String Built-in Functions Python Standard Library Packages and Modules Numy, Scipy, Matplotlib Plotting in Python	Mathematics in Python: Basic Math Functions, Statistics functions in Python, Trigonometric Functions, Polynomials Exercises	Models to Data Linear Regression Exercises	Numerical Integration, Simple Exercises	Data Structures: Series and Data Frame Getting Data from the Web Exercises
	SLO-2					
S13 to S18	SLO-1	Python Programming II: Loops, creating functions, Classes, file handling, Debugging	Linear Algebra: Vectors, Matrices, Linear Algebra (numpy.linalg) Matrix Addition/Subtraction/Multiplication/Transpose of a Matrix/Determinant/Inverse Matrix, Solving Linear Equations	Polynomial Regression Least Square Method Exercises	Discrete (Fast) Fourier Transforms Continuous and discrete Fourier transforms The SciPy FFT library	Extracting Information from a Data Frame Plotting with Pandas Grouping and Aggregation Exercises
	SLO-2					

Learning Resources	1. David J. Pine, Introduction to Python for Science & Engineering 2. Hans-Petter Halvorsen Python for Science and Engineering	3. Hans Fangohr, Introduction to Python for Computational Science and Engineering,

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	30 %	-	30 %	-	30 %	-	30 %	-	30 %
	Understand										
Level 2	Apply	-	40 %	-	40 %	-	40 %	-	40 %	-	40 %
	Analyze										
Level 3	Evaluate	-	30 %	-	30 %	-	30 %	-	30 %	-	30 %
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), dkaswal@nplindia.org	Dr. Sanjeev Dwivedi, IMD, sanjeev.esa@gmail.com	*Dr. Rohit Dhir*
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. K. Koteswara Rao, Azim Premji Univ, koti.meteo@gmail.com	Dr.R.M. Hariharan

Course Code	PCD21AE1T	Course Name	Professional Skills and Problem Solving	Course Category	AE	Ability Enhancement Course	L	T	P	C
							1	0	0	1

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Career Development Centre*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*utilise success habits to enhance professionalism*
CLR-2:	enable to solve problems and to crack competitive exams.
CLR-3:	understand and master the mathematical concepts to solve types of problem
CLR-4:	Identify a logically sound and well-reasoned argument
CLR-5:	*expertise in communication and problem-solving skills*
CLR-6:	*develop problem solving skills with appropriate strategies*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	*identify success habits and inculcate professional skills*	2	80	75
CLO-2:	*grasp the approaches and strategies to solve problems with speed and accuracy*	2	80	70
CLO-3:	*collectively solve problems in teams and groups*	2	75	70
CLO-4:	*construe and solve an argument through critical thinking*	2	80	75
CLO-5:	*acquire communication and problem- solving skills*	2	80	70
CLO-6:	*apply problem solving techniques and skills*	2	80	75

		Program Learning Outcomes (PLO)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:		H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:		H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:		H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:		H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:		H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:		H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		3	3	3	3	3
S-1	SLO-1	Personal profiling	Creative problem solving method	Case study analysis	Emotional Intelligence	Communication skills
	SLO-2	USP& Personal branding	Techniques	Case study analysis	Personal & social competence	Communication skills
S-2	SLO-1	Assumption and strengthening of an argument	Weakening and Inference of an argument	Conclusion and paradox of an argument	Main idea and structure of a passage	Tone and Style of a passage
	SLO-2	Assumption and strengthening of an argument	Weakening and Inference of an argument	Conclusion and paradox of an argument	Main idea and structure of a passage	Tone and Style of a passage
S-3	SLO-1	Arithmetic: Simple equations	Profit, Loss & Discount	Average	Percentage	Mixtures & alligation
	SLO-2	Equation 1 and equation 2	Interest calculation	Average	Percentage	Mixtures & alligation

Learning Resources	1.Arun Sharma-Quantitative aptitude for CAT, Tata McGraw Hill 2.Dinesh Khattar-The Pearson Guide to QUANTITATIVE APTITUDE for competitive examinations.	3.Manhatten Prep - GRE Reading Comprehension and Essays 4. Seven habits of highly effective people- Steven Covey 5. Manhattan Prep – Critical Reasoning Skills and Techniques

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Internal Experts	
1.Mr Ajay Zenne, Career Launcher, ajay.z@careerlauncher.com	Mr. P Priyanand, SRMIST	
	Mrs. Kavitha Srisarann, SRMIST	
2. Mr.Pratap Iyer, Study Abroad Mentors, Mumbai, pratap.iyer30@gmail.com	Mr. Harinarayana Rao, SRMIST	
	Dr. A Clement, SRMIST	

SEMESTER-II

Course Code	PAS21201T	Course Name	Atmospheric Dynamics-1	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1:	*familiarize with the concepts of synoptic systems*			
CLR-2:	*understand the concepts of* tropical cyclones			
CLR-3:	*identify the significance of development of systems*			
CLR-4:	*create insights to the concepts of meteorology*			
CLR-5:	*understanding the impacts of different stages of cyclones*			
CLR-6:	*understand the basics of lasers*			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3	
CLO-1:	*deep learning of basic dynamical processes*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	
CLO-2:	*understanding of the use of potential vorticity thinking to diagnose and interpret atmospheric flow and instabilities*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	
CLO-3:	*ability to develop ideas for analytical and (to some extent) numerical solutions to a problem*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H	
CLO-4:	*ability to formulate problems in a physical and mathematical framework*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	
CLO-5:	*ability to solve problems with respect to baroclinic flow*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	
CLO-6:	*basic knowledge enhancement on turbulent systems*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	

Duration (hour)		12	12	12	12	12
S-1	SLO-1	The laws of atmospheric motion- The equation of absolute motion	The material and the local description of flow- The description of Lagrange	The Helmholtz theorem- The three-dimensional Helmholtz theorem	Differential invariants	The baroclinic Weber transformation
	SLO-2	The equation of absolute motion	Lagrange's version of the continuity equation- Preliminaries	The three-dimensional Helmholtz theorem	Differential invariants	The baroclinic Weber transformation
S-2	SLO-1	The energy budget in the absolute reference system	The mass-conservation equation in the Lagrangian form	The two-dimensional Helmholtz theorem	The equation of motion for frictionless horizontal flow	The baroclinic Ertel–Rossby invariant
	SLO-2	The geographical coordinate system	An example of the use of Lagrangian coordinates- General remarks- The thermo-hydrodynamic equations	The two-dimensional Helmholtz theorem	The gradient wind relation	Circulation and vorticity theorems for frictionless Baroclinic flow- A general baroclinic vortex theorem
S-3	SLO-1	Operations involving the rotational velocity v-1.3.2 The centrifugal potential	Difference approximation- Initial values and boundary conditions	Kinematics of two-dimensional flow- Atmospheric flow fields	Boundary surfaces and boundary conditions- Introduction	Ertel's vortex theorem- Ertel's conservation theorem, potential vorticity
	SLO-2	The budget operator-The equation of relative motion	The numerical stability condition	Atmospheric flow fields	Differential operations at discontinuity surfaces	Circulation and vorticity theorems for frictionless Barotropic flow- The barotropic Ertel–Rossby invariant- Barotropic vortex theorems ofert el, Helmholtz, and Thomson
S-4	SLO-1	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-5	SLO-1	The energy budget of the general relative system	The local description of Euler	Two-dimensional streamlines and normals	Particle invariance at boundary surfaces, displacement Velocities	Turbulent systems- Simple averages and fluctuations
	SLO-2	The energy budget of the general relative system	The local description of Euler	Two-dimensional streamlines and normals	Particle invariance at boundary surfaces, displacement Velocities	Weighted averages and fluctuations
S-6	SLO-1	The decomposition of the equation of motion	Transformation from the Eulerian to the Lagrangian system	Streamlines in a drifting coordinate system	The kinematic boundary-surface condition	Averaging the individual time derivative and the budget operator
	SLO-2	The decomposition of the equation of motion	Atmospheric flow fields-The velocity dyadic	Streamlines in a drifting coordinate system	The kinematic boundary-surface condition- External boundary surfaces	Integral means
S-7	SLO-1	Scale analysis- An outline of the method	The deformation of the continuum	Natural coordinates- Introduction	Internal boundary surfaces- The generalized vertical velocity at boundary surfaces	Budget equations of the turbulent system
	SLO-2	Practical formulation of the dimensionless flow Numbers	The deformation of the continuum	Natural coordinates- Introduction	The dynamic boundary-surface condition	Budget equations of the turbulent system

S-8	**SLO-1**	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-9	**SLO-1**	Scale analysis of large-scale frictionless motion	Individual changes with time of geometric fluid Configurations	Differential definitions of the coordinate lines	The zeroth-order discontinuity surface	The energy budget of the turbulent system
	SLO-2	Scale analysis of large-scale frictionless motion	Individual changes with time of geometric fluid Configurations	Differential definitions of the coordinate lines	The zeroth-order discontinuity surface	The energy budget of the turbulent system
S-10	**SLO-1**	The geostrophic wind and the Euler wind	The Navier–Stokes stress tensor- The general stress tensor	Metric relationships	An example of a first-order discontinuity surface	Diagnostic and prognostic equations of turbulent systems
	SLO-2	The geostrophic wind and the Euler wind	The general stress tensor	Blaton's equation	An example of a first-order discontinuity surface	Diagnostic and prognostic equations of turbulent systems
S-11	**SLO-1**	The equation of motion on a tangential plane	Equilibrium conditions in the stress field	Individual and local time derivatives of the velocity	Circulation and vorticity theorems- Ertel's form of the continuity equation	Production of entropy in the microturbulent system
	SLO-2	The equation of motion on a tangential plane	Symmetry of the stress tensor- The frictional stress tensor and the deformation Dyadic	Individual and local time derivatives of the velocity	Circulation and vorticity theorems- Ertel's form of the continuity equation	Production of entropy in the microturbulent system
S-12	**SLO-1**	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems

Learning Resources	1. *Wilford Zdunkowski and Andreas Bott, Dynamics of Atmosphere: A Course in Theoretical Meteorology, Cambridge University Press, 2003* 2. *Richard A Lindzen, Dynamics in Atmospheric Physics, Cambridge University Press, 1990*	3. *Mankin Mak, Atmospheric Dynamics, Cambridge University Press, 2011.* 4. James R. Holton, "An Introduction to Dynamic Meteorology Volume 1", Elsevier Science, 2004.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	PAS21202T	Course Name	Synoptic Meteorology	Course Category	C	Professional Core Curse	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*familiarize with the concepts of synoptic systems*
CLR-2:	*understand the concepts of* tropical cyclones
CLR-3:	*identify the significance of development of systems*
CLR-4:	*create insights to the concepts of meteorology*
CLR-5:	*understanding the impacts of different stages of cyclones*
CLR-6:	*familiarize with the concepts of synoptic systems*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1:	*identify the problems of synoptic systems*	2	80	75
CLO-2:	*understand the tropical cyclones*	2	80	70
CLO-3:	*apply the principles concepts of meteorology*	2	75	70
CLO-4:	*utilize the concepts of tropical synoptic systems*	2	80	75
CLO-5:	*apply the principles of effects*	2	80	70
CLO-6:	*apply the principles of mesoscale systems*	2	80	75

Program Learning Outcomes (PLO)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	The global climate system	Early studies of extratropical systems	Mesoscale cyclones (mesocyclones, "polar lows"	Tropical cyclones : Distribution	Weather types
	SLO-2	Land surface	Early studies of extratropical systems	Mesoscale cyclones (mesocyclones, "polar lows"	Tropical cyclones : Distribution	Weather types
S-2	SLO-1	The hydrosphere	Climatology of cyclones and anticyclones	The Mesoscale Convective Complex	Tropical cyclones : Structure	Artificial neural networks and self-organizing maps
	SLO-2	The cryosphere. The biosphere	Climatology of cyclones and anticyclones	The Mesoscale Convective Complex	Tropical cyclones : Structure	Artificial neural networks and self-organizing maps
S-3	SLO-1	Time and space scales of weather and climate processes	Climatology of cyclones and anticyclones	The Mesoscale Convective Complex	Tropical cyclones : Cyclogenesis	Principal catalogs and their uses : The Lamb classification
	SLO-2	Time and space scales of weather and climate processes	Climatology of cyclones and anticyclones	The Mesoscale Convective Complex	Tropical cyclones : Cyclogenesis	Principal catalogs and their uses : The Lamb classification
S-4	SLO-1	*Carrying out Assignments*	*Development of cyclones : Historical background*	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*
	SLO-2	*Carrying out Assignments*	*Modern views*	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*
S-5	SLO-1	Synoptic meteorological data Surface report	*Modern views*	Tropical-extratropical cloud band connections	Scale interactions	Principal catalogs and their uses : The Lamb classification
	SLO-2	Upper-air reports	Cyclogenesis	Tropical-extratropical cloud band connections	Scale interactions	Principal catalogs and their uses : The Lamb classification
S-6	SLO-1	Climate variables and their statistical description	Cyclogenesis	Tropical-extratropical cloud band connections	Synoptic pattern classification	The Grosswetter classification
	SLO-2	Frequency distributions	Cyclogenesis	Tropical-extratropical cloud band connections	Synoptic pattern classification	The Grosswetter classification
S-7	SLO-1	Frequency distributions	Storm tracks : Climatology	The distribution of aerosol in the cloudy atmosphere	Subjective typing procedures	Hemispheric classifications
	SLO-2	Frequency distributions	Satellite-based climatologies of synoptic features	The distribution of aerosol in the cloudy atmosphere	Objective typing procedures	Hemispheric classifications
S-8	SLO-1	*Assignment*	*Solving Problems*	*Assignment*	*Solving Problems*	*Solving Problems*
	SLO-2	*Assignment*	*Solving Problems*	*Assignment*	*Solving Problems*	*Solving Problems*
S-9	SLO-1	Exploratory data analysis	Satellite-based climatologies of synoptic features	Synoptic-scale systems in the tropics	Objective typing procedures	Elementary circulation mechanisms
	SLO-2	Contingency analysis, Probability	Satellite-based climatologies of synoptic features	Synoptic-scale systems in the tropics	Assymetry Factor	Elementary circulation mechanisms
S-10	SLO-1	Normal distribution, Binomial distribution	Physical processes of satellite-viewed organized cloud fields	Global waves in the tropics	Correlation-based methods	Regional applications
	SLO-2	Poisson distribution, Gamma distribution, Weibul Distribution	*Synoptic-scale extratropical cloud vortices*	Global waves in the tropics	Correlation-based methods	Regional applications
S-11	SLO-1	*Synoptic maps*	*Synoptic-scale extratropical cloud vortices*	Characteristics of tropical waves	Classifications based on data reduction methods	*Analogs*
	SLO-2	*Synoptic maps*	Mesoscale cyclones (mesocyclones, "polar lows"	Characteristics of tropical waves	Classifications based on data reduction methods	*Seasonal structures*

S-12	**SLO-1**	*Seminar*	*Seminar*	*Seminar*	*Seminar*	*Seminar*
	SLO-2	*Seminar*	*Seminar*	*Seminar*	*Seminar*	*Seminar*

Learning Resources	1. Synoptic and Dynamic Climatology, Roger G Barry, Andrew M Carleton, Taylor & Francis, 2002 2. *Weather Analysis and Forecasting, Patrick Santurette and Christo, 2004*	3. Aulikki Lehkonen, "Synoptic Meteorology", Eumetrain, 2005. 4. Shawn Milrad, "Synoptic Analysis and Forecasting An Introductory Toolkit", Elsevier Science, 2017.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	Prof. Humberto Barbosa, UFAL, Brazil, barbosa33@gmail.com	Dr. T.V. Lakshmi Kumar
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. K. Koteswara Rao, Azim Premji Univ, koti.meteo@gmail.com	Dr. A. Naga Rajesh

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Course Code	PAS21203T	Course Name	Electrodynamics	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	**Nil**	**Co-requisite Courses**	**Nil**	**Progressive Courses**	**Nil**
Course Offering Department	**Physics and Nanotechnology**	**Data Book / Codes/Standards**		**Nil**	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	**Learning**		
		1	2	3
CLR-1:	*develop theoretical knowledge in electrodynamics.*			
CLR-2:	*develop skills on solving analytical problems in electrodynamics*			
CLR-3:	*bridge the gap between the fundamental principles taught in electromagnetism and its practical application*			
CLR-4:	*acquire advanced knowledge in current understanding of electrodynamics.*			
CLR-5:	*understand the electrodynamics of radiating and relativistic systems.*			
CLR-6:	*give basics of defining the complete electromagnetic response of complex systems.*			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	*be familiar with some elementary phenomena and concepts in electrodynamics*	2	80	75
CLO-2:	*master the technique of deriving and evaluating formulae for the electromagnetic fields from very general charge and current distributions*	2	80	70
CLO-3:	*apply mathematical tools to explain electromagnetic interactions.*	2	75	70
CLO-4:	*solve problems in electromagnetism that require analytical and numerical approach*	2	80	75
CLO-5:	*calculate the electromagnetic radiation from radiating systems*	2	80	70
CLO-6:	*formulate and solve electrodynamic problems in covariant form in four-dimensional space-time*	2	80	75

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	**SLO-1**	Electrodynamics before Maxwell	Poynting's theorem	Scalar and vector potentials	Electric dipole radiation	Special Theory of relativity
	SLO-2	Gauss law, Integral Differential Form	Poynting vector	Maxwell equations for V and A	Power radiated	General Concepts
S-2	**SLO-1**	Electric scalar potential	Electromagnetic waves in vacuum,	Gauge transformations	Magnetic dipole radiation	Lorentz transformations
	SLO-2	Generalization of concept	Transverse nature of electromagnetic waves	Non-unique A and V	Far field approximation and comparison with Electric dipole power	Lorentz transformation matrix

S-3	**SLO-1**	Laplace's equation	Energy and momentum in electromagnetic fields	Coulomb gauge	Radiation from an arbitrary source	covariant and contravariant vectors
	SLO-2	Poisson's equation	Radiation Pressure	Lorentz gauge	Total Power radiated and Larmor Formula as special case	Einstein's notation
S-4	**SLO-1**	Problem solving on Gauss Law, Vector calculus	Problem solving on Poynting Vectors	Problem solving on Potentials	Problem solving on Dipole radiations	Problem solving on relativity
	SLO-2	Problem solving Laplace Equation etc.	Problem solving on Energy and Momentum	Problem solving on Gauge Conditions	Problem solving on Power Radiated	Problem solving on Lorentz tranformations
S-5	**SLO-1**	Biot-Savart's law	Electromagnetic waves in matter,	Retarded potentials	Power radiated by a point charge:	Magnetism as a relativistic phenomenon
	SLO-2	Applications	Reflection and transmission at normal incidence	Derivation	Larmor formula	relativistic case of linear charge density
S-6	**SLO-1**	divergence and curl of magnetic field	Reflection and transmission at oblique incidence	Jefimenko's equations	Lienard's relativistic generalization	Electromagnetic field transformation
	SLO-2	Physical Significance	Fresnel's Equations	Physical Significance and meaning	Bremsstrahlung and Cyclotron Radiation (Qualitatively)	Various equations involved
S-7	**SLO-1**	magnetic vector potential,	Absorption and Dispersion	Lienard-Wiechert potentials	Radiation reaction	Field tensor
	SLO-2	Ampere's law	electromagnetic waves in conductor	Relation between V and A	Abraham-Lorentz formula	Asymmetry and components
S-8	**SLO-1**	Problem solving on Biot-Savart's law	Problem solving on Reflection, refraction	Problem solving on retarded potentials	Problem solving on relativistic charges in potentials	Problem solving on EM fields in Lorentz transformations
	SLO-2	Problem solving Vector Potential and Ampere's Law	Problem solving on Brewster's angle, Absorption and Dispersion	Problem solving on LW potentials	Problem solving on radiation reaction	Problem solving on Filed tensor Asymmetry
S-9	**SLO-1**	Faraday's law.	Propagation in conductors	Fields of moving point charge:	Acausal Preacceleration	Current density four-vector,
	SLO-2	Lorentz force,	Skin depth, Conductors and Dielectrics	Electric and Magnetic fields at retarded point	Modern Physics explanation based on Uncertainty principle	Continuity Equation in four vector
S-10	**SLO-1**	Electrodynamics after Maxwell:	Reflection at a conducting surface	Generalization of Coulomb field	Radiation Damping of a Charged Particle	Lorentz force law using tensor notation
	SLO-2	Maxwell's modification to Ampere's law	Boundary conditions	Velocity and acceleration Terms of Lorentz force	Damping factor and Frequency	Relativistic potentials.
S-11	**SLO-1**	Maxwell's equations in matter	Frequency dependence of permittivity	Fields of a moving charge	Physical basis of radiation reaction.	Maxwell's equations
	SLO-2	boundary conditions and continuity equation.	Cauchy's Formula	Constant Velocity case	Force of the charge on itself	In-homogenous and Homogenous four notations
S-12	**SLO-1**	Problem solving Maxwell Equations	Problem solving on conducting surface and dielectrics	Problem solving on retarded fields of moving charges	Problem solving on Damping	Problem solving on Maxwell Equations and field tensors
	SLO-2	Problem solving Boundary Conditions	Problem solving on Skin Depth, Wave Propagation	Problem solving on velocity and acceleration radiation force components	Problem solving on Radiation Reaction	Problem solving on relativistic Lagragian for ED

Learning Resources	1. D.J. Griffiths, Introduction to Electrodynamics, 4th Ed., Prentice-Hall India, 2013. 2. J.D. Jackson, Classical Electrodynamics, 3rd Ed., Wiley 1998. 3. E.C. Jordan, and K. G. Balmain, Electromagnetic Waves and Radiating Systems, Prentice Hall, 1995.	4. Schwinger et. al., Classical Electrodynamics, Persesus Books, 1998. 5. G.S. Smith, Classical Electromagnetic Radiation, Cambridge, 1997.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	*Prof. VS Subramanian, IIT Madras, manianvs@iitm.ac.in*	Dr. Rohit Dhir
Dr. V Subramanian, CLRI, subbu@clri.res.in	Prof. S Balakumar, University of Madras, balakumar@unom.ac.in	Dr. Shadak Alee

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Course Code	PAS21204T	Course Name	Middle Atmosphere	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	understand the fundamentals of dynamics of the middle atmosphere
CLR-2:	acquire knowledge on the structure and dynamics of middle atmosphere
CLR-3:	understand the concepts of circulation of waves in middle atmosphere
CLR-4:	familiarize the concept of the sudden warming
CLR-5:	acquire knowledge on the climatology of ozone layer
CLR-6:	gain the fundamental understanding on various models of lower stratosphere

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	understand the significance of the study of middle atmosphere dynamics	2	80	75
CLO-2:	discern about the importance of wind distributions	2	80	70
CLO-3:	know about the concept of linear wave theory	2	75	70
CLO-4:	apply the principles of equatorial circulations	2	80	75
CLO-5:	identify various tracer transport in the middle atmosphere	2	80	70
CLO-6:	apply the principles of general circulation modeling	2	80	75

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*The Static Structure of the Middle Atmosphere*	*Basics of Dynamics*	*Stationary Planetary Waves*	*The Winter Polar Stratosphere*	*Introduction to Ozone layer*
	SLO-2	*Zonal Mean temperature*	*The Beta-Plane Approximation and Quasi-Geostrophic Theory*	*Detailed Linear Models of Stationary Planetary Waves*	*Interpretation and Generalization*	*The Climatology of Ozone*
S-2	SLO-1	*Wind distributions*	*Eulerian-mean equations*	*Free traveling planetary waves*	*Equatorial circulations*	*Vertical distribution*
	SLO-2	*Composition of middle atmosphere*	*Linearized Disturbances to Zonal-Mean Flows*	*Detailed Linear Models of Free Traveling Planetary Waves*	*Theory of the Quasi-Biennial Oscillation*	*Elementary Aspects of Photochemical Modeling*
S-3	SLO-1	*Vertical Distribution of Eddy Amplitudes*	*The Generalized Eliassen-Palm Theorem*	*Barotropic Instability*	*Two-Dimensional Analog of the QBO*	*Photochemistry of Ozone: Catalytic Cycles*
	SLO-2	*Observational techniques*	*Charney-drazin Nonacceleration theorem*	*Baroclinic instability*	*Observed structure of the equatorial semiannual oscillations*	*Models of the natural and perturbed ozone layer*
S-4	SLO-1	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*
	SLO-2	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*
S-5	SLO-1	*Radiative processes And remote sounding*	*Lagrangian approach*	*Barotropic and baroclinic instability calculations*	*Dynamics of the equatorial semiannual oscillations*	*Models of the lower stratosphere*
	SLO-2	*Fundamentals of Radiative Process*	*The Zonal-Mean Equations in Isentropic Coordinates*	*Planetary-Wave Critical Layers*	*Inertial Instability in the Equatorial Zone*	*The GFDL SKYHI model*
S-6	SLO-1	*Gaseous absorption spectra*	*Introduction and classification of wave types*	*Stratospheric sudden warmings*	*Tracer transport in The middle atmosphere*	*The cold winter pole*
	SLO-2	*Molecular Energy Levels and Transitions*	*Wave Disturbances to a Resting Spherical Atmosphere*	*Observed Features of Sudden Warmings*	*Types of Tracers*	*Equatorial Waves*
S-7	SLO-1	*Transmission functions*	*Atmospheric thermal tides*	*Theoretical modeling of sudden warmings*	*Long-lived chemical tracers*	*Forecasting of sudden stratospheric warmings*
	SLO-2	*Band models*	*Free traveling planetary waves*	*Models and its conclusions*	*Transport in the meridional plane*	*Transport modeling*
S-8	SLO-1	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*
	SLO-2	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*
S-9	SLO-1	*Infrared Radiative Exchange and Radiative Damping*	*Forced Planetary Waves*	*The Extratropical Zonal-Mean Circulation*	*Mean Transport: The Brewer-Dobson Model*	*Interaction between the Middle Atmosphere and The Lower Atmosphere*
	SLO-2	*Departure from Local Thermodynamic Equilibrium*	*Gravity Waves and Equatorial Waves*	*Introduction to Zonal-Mean Circulation*	*Formulations of Eddy and Mean-Flow Transport*	*Introduction to Radiative and dynamical Processes*
S-10	SLO-1	*Absorption of Solar Radiation*	*Extratropical Planetary-Scale Circulations*	*Simple Zonally Averaged Models*	*Dispersive Wave Transport*	*Radiative Links: Deductions from Simple Models*
	SLO-2	*Radiative Equilibrium Temperature and Heating-Rate Distributions*	*Annual Cycle*	*Annually Varying Model with No Waves*	*Irreversible Mixing of Tracers*	*Radiative Links: Deductions from gcms*
S-11	SLO-1	*Remote sounding*	*The zonal-mean flow*	*Inclusion of wave-forcing effects*	*Troposphere-stratosphere exchange*	*Dynamical links: vertically propagating planetary waves*

	SLO-2	*Sounding of Composition*	*Stationary Waves*	*The Upper Mesosphere*	*Transport Modeling*	*Interannual Variability in the Stratosphere*
S-12	**SLO-1**	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*
	SLO-2	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*

Learning Resources	1. Middle Atmosphere Dynamics, By David G. Andrews, Conway B. Leovy, James R. Holton, (ACADEMIC PRESS INC. 2016). 2. Transport Processes in the Middle Atmosphere, Guido Visconti and Rolando Garcia, (D. Reidel Publishing Company; 1986)	3. Aeronomy of the Middle Atmosphere Chemistry and Physics of the Stratosphere and Mesosphere, Guy P. Brasseur, Susan Solomon (.Springer Netherlands, 2005). 4. Guy P. Brasseur, Susan Solomon, "Aeronomy of the Middle Atmosphere Chemistry and Physics of the Stratosphere and Mesosphere" , Springer Netherlands, 2005.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	Prof. Humberto Barbosa, UFAL, koti.meteo@gmail.com	Dr.R.M. Hariharan
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr.K. Koteswara Rao, Azim Premji Univ, koti.meteo@gmail.com	Dr. T. Vijayakumar

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Course Code	PAS21D04T	Course Name	Land – Atmosphere Interactions	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	**Nil**	**Co-requisite Courses**	**Nil**	**Progressive Courses**	**Nil**
Course Offering Department	**Physics and Nanotechnology**	**Data Book / Codes/Standards**		**Nil**	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	**Learning**		
		1	2	3
CLR-1:	*familiarize with the concepts of* land surface processes and its influences on weather and climate			
CLR-2:	*understand the concepts of* atmospheric general circulation and climate			
CLR-3:	*identify the significance canopy air interactions*			
CLR-4:	*create insights to the concepts of vegetation dynamics and biosphere-atmosphere interactions*			
CLR-5:	*understanding the basics of* land use and land-cover change			
CLR-6:	*understand the basics of climate change*			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	*identify the problems of land –atmosphere interactions*	2	80	75
CLO-2:	*understand the atmospheric general circulation and climate*	2	80	70
CLO-3:	*apply the principles of general circulation models*	2	75	70
CLO-4:	*utilize the concepts of energy budget*	2	80	75
CLO-5:	*apply the principles of watershed hydrology*	2	80	70
CLO-6:	*utilizing the principles of land use and land-cover change*	2	80	75

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		**12**	**12**	**12**	**12**	**12**
S-1	**SLO-1**	*Introduction:* Water in the Earth system	Atmospheric General Circulation and Climate	Canopy-air interactions: Canopy Processes	Watershed Hydrology: Watersheds	Influence of land surfaces on weather and climate
	SLO-2	*Components of the Earth System – Basics*	General Circulation Models	Boundary layer exchange processes Canopy Resistances	Watershed Studies	The influence of existing land-atmosphere interactions
S-2	**SLO-1**	Water Vapor in the Atmosphere	Perturbations : Global Scale Influences on Hydrometeorology	Shelter factors	Runoff Processes	The influence of transient changes in land surfaces

	SLO-2	Measures of water vapor components	Perturbations : Global Scale Influences on Hydrometeorology - continuation	Stomatal resistance	Catchment Runoff	The influence of imposed persistent changes in land cover
S-3	**SLO-1**	Vertical Gradients in the Atmosphere	Nature and evolution of the ABL	Energy budget of a dry leaf	Riverflow	Terrestrial Ecosystems and Earth System Models: Hydrometeorological Models
	SLO-2	Vertical Gradients in the Atmosphere- continuation	Equations of Atmospheric Flow in the ABL	Energy budget of a dry canopy	Global Drainage Basins	Satellite Land Data Products
S-4	**SLO-1**	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*
	SLO-2	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*	*Carrying out Assignments*
S-5	**SLO-1**	Surface energy fluxes	Formation of clouds	Net photosynthesis	*Soil physics: introduction*	Land–atmosphere coupling experiments
	SLO-2	Energy balance	Formation of Precipitation	A Photosynthesis Model	*Soil Moisture*	Earth System Models
S-6	**SLO-1**	Evaporative fraction and Bowen ratio	Precipitation Measurement and Observation	Water-Use Efficiency	Soil Biogeochemistry	Anthropogenic Land Use and Land-Cover Change: Green Planets and Brown Planets
	SLO-2	Energy budget of open water	Precipitation Analysis in Time and Space	Stomata and Atmospheric CO2	Soil Profile and formation	Dryland Degradation
S-7	**SLO-1**	Terrestrial radiation	Climate variability	Leaf area index and radiative transfer	Basis and origin of land-surface sub-models	Tropical deforestation
	SLO-2	Longwave radiation	*Floods/Droughts*	Canopy Photosynthesis	Ongoing developments in land surface sub-models	Irrigation
S-8	**SLO-1**	*Solving problems*	*Solving problems*	Canopy conductance	*Solving problems*	*Solving problems*
	SLO-2	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*
S-9	**SLO-1**	Soil Temperature and Heat Flux	*Teleconnections*	Whole-canopy aerodynamics and canopy structure	Vegetation Dynamics	Land Use and Land-Cover Change as a Climate Forcing
	SLO-2	Thermal properties of soil	Modes of Variability	Wet canopies	Biosphere–Atmosphere Interactions	Integrated Biogeophysical and Biogeochemical Studies
S-10	**SLO-1**	Measuring surface heat fluxes	Climate change	Estimates of evaporation	Carbon cycle–climate feedbacks: present-day carbon cycle	Urbanization: urban morphology
	SLO-2	Comparison of evaporation measuring methods	Mechanisms of Climate Change	Reference crop evapotranspiration	Residual Terrestrial Sink	The Urban Heat Island and energy fluxes
S-11	**SLO-1**	Global Cycles: Hydrological cycle	Climate of the Twentieth Century	Canopy Models	Coupled Carbon Cycle–Climate Models	The Urban Canopy Layer
	SLO-2	Biogeochemical cycles	Climate of the twenty-first century	Environmental controls of canopy fluxes	The carbon cycle and global change	Urban energy balance models
S-12	**SLO-1**	*Seminar*	*Seminar*	*Seminar*	*Seminar*	*Seminar*
	SLO-2	*Seminar*	*Seminar*	*Seminar*	*Seminar*	*Seminar*

Learning Resources	1. Bonan, G., Ecological Climatology: Concepts and Applications, 2nd Edition, Cambridge, 2008 2. Shuttleworh, W. J., Terrestrial Hydrometeorology, 1st Edition, John Wiley & Sons.,2012	Wood, E.F., "Land Surface — Atmosphere Interactions for Climate Modeling",Springer, 1991. De Gruyter "Passive Microwave Remote Sensing of Land-Atmosphere Interactions", De Gruyter,2020.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	Dr. K. Koteswara Rao, Azim Premji Univ, koti.meteo@gmail.com	Dr. T.V. Lakshmi Kumar
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. Sanjeev Dwivedi, IMD, sanjeev.esa@gmail.com	Dr. A. Naga Rajesh

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Course Code	PAS21D05T	Course Name	Ocean – Atmosphere Interactions	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*familiarize with the concepts of state of the matter near the ocean-atmosphere interface*
CLR-2:	*analyze the principle of solar radiation*
CLR-3:	*identify the significance of surface and waves and turbulence transfer near the interface*
CLR-4:	*create insights to the concepts of planetary boundary layer*
CLR-5:	*understanding the basics of atmospherically forced perturbations in the oceans*
CLR-6:	*give basics of large-scale forcing by sea surface buoyancy fluxes*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	*identify the problems in ocean-atmosphere interface*	2	80	75
CLO-2:	*analyze the various types of solar radiation and waves*	2	80	70
CLO-3:	*apply the principles of turbulence transfer near the ocean-atmosphere interface*	2	75	70
CLO-4:	*utilize the concepts of planetary boundary layer in applications*	2	80	75
CLO-5:	*apply the principles of atmospherically forced perturbations at the interface*	2	80	70
CLO-6:	*utilizing the principles of deep convection in hurricanes and el nino and the southern oscillation*	2	80	75

Program Learning Outcomes (PLO)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	Slo-1	Conservation equations	Solar radiation: the net short-wave irradiance at the sea surface	The structure of the interface and adjacent layers: the profiles in the molecular sublayers	The ekman boundary layer	The effect of lateral boundaries on wind-forced perturbations: wind-forced upwelling and downwelling along a straight Coast
	Slo-2	Conservation of matter, momentum, energy	Reflection at the sea surface, absorption of solar radiation in the ocean	The matching of surface layers to molecular sublayers	The depth of the turbulent ekman layer; surface-waves effects	Coastal kelvin waves, shelf waves, storm surges
S-2	Slo-1	Turbulence	Terrestrial radiation: long-wave emission from the sea surface	Transition from smooth to rough flow	Coherent structures in the planetary boundary layer: observations of oceanic longitudinal rolls	Rossby or planetary waves: free planetary waves
	Slo-2	Turbulent transport	Radiative transfer in the lower atmosphere	The effect of stratification	Observations of atmospheric longitudinal rolls, energetics of longitudinal rolls	Forced planetary waves
S-3	Slo-1	Statistical description of fluctuating quantities: correlation functions and spectra	Empirical formulas for estimating the surface radiation budget: short-wave irradiance	Dynamic interactions between wind and sea surface	Parametric representation of pbl fluxes and profiles: diffuse models	Equatorial currents and perturbations: balanced equatorial currents
	Slo-2	Isotropic turbulence	Short-wave exitance, long-wave irradiance and exitance	Surface drift, wind-wave interactions	The transilient scheme, parametric representation of pbl profiles	Equatorial perturbations
S-4	Slo-1	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	Slo-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-5	Slo-1	The state of the matter near the interface: sea water, the equation of state	Basic dynamics of harmonic waves in fluids	Transport of trace gases across the interface	Mixed-layer models: the oceanic mixed layer	The predominant direction and variability of air-sea interactions
	Slo-2	Atmospheric gases in solution, molecular transport coefficients	Basic dynamics of harmonic waves in fluids	Application of the surface renewal model	The cloud-free atmospheric mixed layer, the cloud-topped convective marine boundary layer	Deep convection
S-6	Slo-1	Moist air, the equation of state	Small-amplitude waves at the air-sea interface	The stagnant water film model	Perturbations of a shallow, homogeneous ocean: the different types of atmospheric forcing	The general character and organization of deep Convection
	Slo-2	Isobaric mixing and fog formation, adiabaticand pseudo-adiabatic changes of state	Small-amplitude waves at the air-sea interface	Experimental methods and results	The forced shallow water equation, perturbations of different extent and duration	Laboratory experiments and dimensional analysis,
S-7	Slo-1	The liquid-gas interface, laminar sublayers	Second-order quantities and approximations	The sea surface temperature	The two-layer ocean model: the governing equations	Deep convection and bottom-water formation in the oceans
	Slo-2	Surface tension, contamination	Second-order quantities and approximations	The energy budget	Gravity waves at an internal density discontinuity	The tropical atmosphere
S-8	Slo-1	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	Slo-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems

S-9	Slo-1	Bubbles and spray, generation of bubbles and spray droplets	Sources and sinks of surface wave energy	Methods to observe the fluxes in the atmospheric surface layer: the eddy correlation method	The rigid-lid approximation	Deep convection in the presence of clouds and precipitation
	Slo-2	Equilibrium pressure in air bubbles and spray droplets	Transfer of energy between waves	The eddy accumulation method and the conditional sampling Method	Ekman pumping	The intertropical convergence zone and the hadley circulation
S-10	Slo-1	Terminal velocities of gas bubbles and spray droplets, the size and flux spectra of air bubbles in bubble clouds	Dissipation and breaking	The gradient method, the dissipation and inertial dissipation methods	Internal inertio-gravity waves: internal waves in a continuously stratified ocean	Hurricanes
	Slo-2	Sea surface bubble spectra and whitecap coverage as a function of wind speed	The generation of waves by the wind	Fluxes obtained with remote sensing techniques	Long waves; normal modes, atmospheric forcing of internal gravity waves	Some low-frequency ocean-atmosphere feedback processes: el nino and the southern oscillation (enso),
S-11	Slo-1	The size and flux spectra of spray droplets, environmental effects of bubbles and spray	The evolution of surface wave spectra	The ageostrophic transport or momentum budget method	The response of the open ocean to moving cyclonic storms: observations	The somali current and the indian monsoon
	Slo-2	Sea ice, formation and growth, physical properties of sea ice	The parameterization of surface wave spectra	Bulk parameterizations	The simulated short-term oceanic response to moving storms, the long-term oceanic response to moving storms	Interactions between the hydrological cycle and the Thermo-haline circulation
S-12	Slo-1	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	Slo-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems

Learning Resources	1. Atmosphere – Ocean Interactions by E.B. Kraus and J.A. Businger, Oxford University Press, 1994 2. Atmosphere and Ocean Our Fluid Environments by John G. Harvey; 1985.	3. Atmosphere – Ocean Dynamics, Adrian E. Gill, 1992. 4. Ocean – Atmosphere interaction and climate modeling, Beris A. Kagan, 1995

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	Dr. Manoj Thakur, TU, thakurmanoj2003@yahoo.com	Dr.T.Vijayakumar
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. K. Koteswara Rao, Azim Premji Univ, koti.meteo@gmail.com	Dr.R.M. Hariharan

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Course Code	PAS21D06T	Course Name	Statistical Methods in Atmospheric Science	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	**Nil**	**Co-requisite Courses**	**Nil**	**Progressive Courses**	**Nil**
Course Offering Department	**Physics and Nanotechnology**	**Data Book / Codes/Standards**		**Nil**	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*familiarize with the concepts of elements of probability*
CLR-2:	*analyze the principle of empirical distributions and exploratory data analysis*
CLR-3:	*identify the significance of parametric probability distributions*
CLR-4:	*create insights to the concepts of hypothesis testing*
CLR-5:	*understanding the basics of statistical forecasting*
CLR-6:	*give basics of forecast verification*

Learning		
1	2	3
Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																	
CLO-1:	*identify the problems in elements of probability in weather forecasting*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*analyze the various types of empirical distributions and data analysis*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*apply the principles of parametric probability distributions in forecasting*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*utilize the concepts of hypothesis testing in weather forecasting*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*apply the principles of statistical forecasting*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*utilizing the principles of forecast verification*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Review of Probability: The Elements of Probability	Graphical Summary Techniques: Other Boxplot Variants	Parametric Probability distributionsparametric vs. Empirical Distributions:	Parameter Fitting Using Maximum Likelihood: The Likelihood Function	Ensemble Forecasting: Probabilistic Field Forecasts
	SLO-2	Events, The Sample Space, The Axioms of Probability	Histograms	Parametric Distribution	The Newton-Raphson Method	Ensemble Average and Ensemble Dispersion
S-2	SLO-1	Meaning of Probability	Kernel Density Smoothing	Parameters vs. Statistics	The EM Algorithm	Graphical Display of Ensemble Forecast Information
	SLO-2	Frequency interpretation, bayesian interpretation	Cumulative frequency distributions	Discrete vs. Continuous distributions	Sampling distribution of maximum-likelihood estimates	Statistical post processing: ensemble mos
S-3	SLO-1	Properties of Probability: Domain, Subsets,	Reexpression:	Discrete Distributions: Binomial Distribution	Statistical Simulation: Uniform Random Number Generators	Subjective Probability Forecasts: The Subjective Distribution
	SLO-2	Complements, and Unions	Power Transformations		Non-uniform Random Number Generation by Inversion	Assessing Continuous Distributions
S-4	SLO-1	Solving problems	Solving problems	Geometric distribution	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-5	SLO-1	Demorgan's Laws	Standardized Anomalies	Solving Problems	Non-uniform Random Number Generation by Rejection	Forecast Verification: Purposes of Forecast Verification
	SLO-2	Conditional probability	Exploratory techniques for paired data: scatterplots	Negative binomial distribution	Box-muller method for gaussian random number generation, simulating from mixture distributions and kernel density estimates	Forecast skill
S-6	SLO-1	Independence	Pearson Correlation	Poisson Distribution	Hypothesis Testing: Background	Non probabilistic Forecasts of Discrete Predictands
	SLO-2	Law of Total Probability, Bayes' Theorem	Spearman Rank Correlation and Kendall's '□'		Some Parametric Tests, Goodness-of-Fit Tests	Conversion of Probabilistic to Non probabilistic Forecasts
S-7	SLO-1	Empirical Distributions and Exploratory Data Analysis	Serial Correlation	Statistical Expectations: Expected Value of a Random Variable	Nonparametric Tests, Permutation Tests	Nonprobabilistic Forecasts of Continuous Predictands
	SLO-2	Robustness and Resistance, Quantiles	Autocorrelation Function	Expected Value of a Function of a Random Variable	Field Significance and Multiplicity	Conditional Quantile Plots
S-8	SLO-1	Solving problems	Solving problems	Continuous distributions: distribution functions and expected values	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Gaussian distributions	Solving problems	Solving problems
S-9	SLO-1	Numerical summary measures	Exploratory techniques for higher-dimensional data: the star plot	Solving problems	Statistical forecasting: linear regression	Probability forecasts of discrete predictands
	SLO-2	Location, spread	The glyph scatterplot	Solving problems	Sampling distributions of the regression coefficients	The brier score, the roc diagram
S-10	SLO-1	Symmetry	The Rotating Scatterplot	Gamma Distributions	Nonlinear Regression: Logistic Regression	Probability Forecasts for Continuous Predictands: Central Credible Interval Forecasts
	SLO-2	Stem-and-Leaf Display	The Correlation Matrix	Beta Distributions	Poisson Regression	Non probabilistic Forecasts of Fields, Anomaly Correlation
S-11	SLO-1	Boxplots	The Scatterplot Matrix	Extreme-Value Distributions	Predictor Selection	Verification of Ensemble Forecasts: The Verification Rank Histogram
	SLO-2	Schematic plots	Correlation maps	Mixture distributions	Screening predictors	Verification based on economic value, sampling and inference for verification statistics
S-12	SLO-1	Solving problems	Solving problems	Qualitative assessments of the goodness of fit: superposition of a fitted parametric distribution and data histogram	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Quantile-quantile (q–q) plots	Solving problems	Solving problems

Learning Resources	1. Data analysis methods in Physical Oceanography by Wiliam J. Emery and Richard E. Thomson, 1997, Pergamon Press. 2. Statistical Methods in the Atmospheric Sciences, 1995, Daniel S. Wilks, Academic Press.	3.	Statistical analysis in climate research by Hans von Storch and Francis W. Zwier,2010, Cambridge University Press. 4. Climate Time Series Analysis: Classical Statistical and Bootstrap Methods, Manfred Mudelsee, Alfred Wegener, 2010, Springer.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	Dr. Humberto Barbosa, UFAL, barbosa33@gmail.com	Dr.T. Vijayakumar
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. K. Koteswara Rao, Azim Ppremji Univ, koti.meteo@gmail.com	Dr. A. Naga Rajesh

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Course Code	PAS21S02L	Course Name	Atmospheric Data Analysis Laboratory	Course Category	S	Skill Enhancement Course	L	T	P	C
							0	0	6	3

Pre-requisite Courses	*Nil*	**Co-requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Physics and Nanotechnology*	**Data Book / Codes/Standards**		*Nil*	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*familiarize with atmospheric data variables and their variability*
CLR-2:	*enriching knowledge in atmospheric data and its relationships*
CLR-3:	*knowledge on the methods of analysis of atmospheric/climate data*
CLR-4:	*interpretation of reanalysis and satellite data products*
CLR-5	*enable the students to analyze the different formats of atmospheric data*
CLR-6	*facilitate to interpret the stages of tropical cyclones using satellite data*

Course Learning Outcomes (CLO):	*at the end of this course, learners will be able to:*	**Learning**			**Program Learning Outcomes (PLO)**													
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	*generate the interest on atmospheric data methods*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*provide basic analytical techniques for atmospheric data*	2	80	70	H	M	M	H	M	H	H	H	M	H	M	H	M	H	M
CLO-3:	*enhance the basic knowledge of meteorological information from satellites*	2	75	70	H	M	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	*prepare the students with necessary atmospheric background*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5	*improving analytical skills of satellite data*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6	*enhancing the skills on statistical data analysis*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H

DURATION (HOURS)		**18**	**18**	**18**	**18**	
S1 to S6	**SLO-1**	To read and write data in the different format like Netcdf, Grib, HDF files using Matlab or Python?	Analyse data using Panoply, hdfviewer software tools for meteorological data? Plot RH data over Indian region and try to observe difference near coast and himalayas plain	Obtain the wavelet analysis of atmospheric data	Show the cyclone development using satellite wind and cloud data? Find Out the eye of the cyclone and mention components of cyclone structure.	Lomb Scargle Periodogram of climate data
	SLO-2					
S7 to S12	**SLO-1**	Find out the monsoon onset for earlier years using OLR Data, Rainfall data? Plot winds of NE and SW monsoon using reanalysis	Find out the Aerosol Optical Depth and Angstrom Exponent using satellite data	To calculate the probability distribution function analysis of any climate data	Obtain the interannual variability of rainfall of IMD for 30 years	Wavelet Coherence of climate data
	SLO-2					

		data.				
S13 to S18	**SLO-1** **SLO-2**	Find out the cloud cover using satellite data. Find out long-Wave and short - wave flux?	Derive any atmospheric variables and find the correlation and linear fit	Calculate daily, weekly,monthly, seasonally and yearly trend of Temperature using ERA5 data of 30 years? Determine the appropriate January mean and July mean, and annual temperature range for a place located at 20N, 80 E and 20S, 80E	Obtain the daily mean and standard error of atmospheric data from gridded data and plot them	*Simple harmonic analysis of atmospheric winds*

Learning Resources	1. Tim Vasquez, *Weather Analysis and Forecasting Handbook,* Weather Graphics Technology Publications 2. Jean Coiffier, *Fundamentals of Numerical weather prediction,* Cambridge University Press 3. Steven A. Ackerman, John A. Knox, *Meteorology,* Brooke/Cole Publications)	4. Atmospheric Science an Introductory Survey, John M Wallace and Peter V Hobbs, (Academic Press, International Geophysics Series, 2005) **5.** Handbook of Weather, Climate and Water, Thomas D Potter and Bradley R Colman, (Wiley Interscience, 2003).

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)							
		CLA-1 (20%)		CLA-2 (20%)		CLA-3 (40%)		CLA-4 (20%)#	
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	30 %	-	30 %	-	30 %	-	30 %
	Understand								
Level 2	Apply	-	40 %	-	40 %	-	40 %	-	40 %
	Analyze								
Level 3	Evaluate	-	30 %	-	30 %	-	30 %	-	30 %
	Create								
	Total	100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. R Seshadri, Titan Company Limited, seshadri@titan.co.in	Dr. Manoj Thakur, TU, thakurmanoj2003@yahoo.com	Dr. TV Lakshmi Kumar
Dr. Ashok, ISRO, ashok@vssc.gov.in	Dr. Sanjeev Dwivedi, IMD, sanjeev.esa@gmail.com	Dr.A. Naga Rajesh

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Course Code	PCD21AE2T	Course Name	General Aptitude for Competitive Examinations	Course Category	AE	Ability Enhancement Course	L	T	P	C
							1	0	0	1

Pre-requisite Courses	*Nil*	**Co-requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	***Career Development Centre***	**Data Book / Codes/Standards**		*Nil*	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	**Learning**		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1:	recapitulate fundamental mathematical concepts and skills			
CLR-2:	provide context - based vocabulary enhancement			
CLR-3:	sharpen logical reasoning through skilful conceptualization			
CLR-4:	familiarize with basic grammatical and syntactical rules			
CLR-5:	enable to solve problems and to crack competitive exams			
CLR-6:	develop new strategies to enhance reading comprehension			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	*build a strong base in the fundamental mathematical concepts*	2	80	75
CLO-2:	*acquire strategies to build vocabulary*	2	80	70
CLO-3:	*apply the learn conditions towards solving problems analytically*	2	75	70
CLO-4:	*learn grammatical and syntactical rules*	2	80	75
CLO-5:	*grasp the approaches and strategies to solve problems with speed and accuracy*	2	80	70
CLO-6:	*improve reading comprehension strategies*	2	80	75

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		3	3	3	3	3
S-1	SLO-1	Logical Reasoning I	Vocabulary from inference to meaning	Numbers - I	Error Identification - I	Data Sufficiency
	SLO-2	Solving Problems	Vocabulary from inference to meaning	Numbers - I	Error Identification - I	Data sufficiency
S-2	SLO-1	Logical Reasoning - I	Cloze passage	Numbers - II	Error Identification - II	Data Interpretation
	SLO-2	Solving Problems	Cloze passage	Numbers - II	Error Identification - II	Data Interpretation
S-3	SLO-1	Logical Reasoning - I	Sentence Completion	Numbers - III	Sentence Correction - I	Sentence Correction - II
	SLO-2	Solving problems	Sentence Completion	Numbers - III	Sentence Correction - I	Sentence Correction - II

Learning Resources	2. Quantitative aptitude – r s agarwal 3. Quantitative aptitude – ARUN SARMA 4. ManhattanPrepGMAT Sentence Correction Guide–Avi Gutman	5. GRE Contextual.Vocabulary–Ken Springer

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers

Experts from Industry	Internal Experts	
1. Mr Nishith Sinha, dueNorth India Academics LLP, Dehradun,**nsinha.alexander@gmail.com**	*1. Dr.P.Madhusoodhanan SRMIST*	3. Dr. A Clement, SRMIST
2.Mr Ajay Zenner, Career Launcher, **ajay.z@careerlauncher.com**	2. Dr.M.Snehalatha SRMIST	4. Dr. J Jayapragash, SRMIST

SEMESTER-III

Course Code	PAS21301J	Course Name	Atmospheric Dynamics – 2	Course Category	C	Professional Core Course	L	T	P	C
							2	0	4	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	*Physics and Nanotechnology*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1:	*develop an understanding of atmospheric dynamics*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2:	*understanding the theory of internal gravity waves*																		
CLR-3:	*familiarize with the basics of numerical modelling*																		
CLR-4:	*enriching knowledge in weather prediction terms and their use*																		
CLR-5:	*knowledge on the methods of obtaining modeling data*																		
CLR-6:	*to obtain familiarity on votices*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1:	*gain in-depth understanding of barotropic model and instability*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2:	*familiarization of geostrophic wind field*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-3:	*understand the wind motion vectors*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-4:	*understand the relations between ssts and monsoon*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5:	*understand the basics of weather forecasting*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6:	*understand the concept of circulation*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		18	18	18	18	18
S-1	SLO-1	An excursion into spectral turbulence theory- Fourier Representation of the continuity equation and the equation of motion	Application of the Prandtl-layer theory in numerical Prognostic models	Wave motion in the atmosphere- The representation of waves	The barotropic model- The basic assumptions of the barotropic model- The unfiltered barotropic prediction model	Energy transport by Rossby waves- The influence of friction on the stationary Rossby wave
	SLO-2	The budget equation for the amplitude of the kinetic energy	Application of the Prandtl-layer theory in numerical Prognostic models	The group velocity	The unfiltered barotropic prediction model	Barotropic equatorial waves
S-2	SLO-1	Isotropic conditions, the transition to the continuous wavenumber space	The interface condition at the earth's surface	Perturbation theory	The filtered barotropic model- Barotropic instability	The principle of geostrophic adjustment
	SLO-2	Isotropic conditions, the transition to the continuous wavenumber space	The interface condition at the earth's surface	Perturbation theory	Barotropic instability	The principle of geostrophic adjustment
S-3 to S-6	SLO-1	Write a FORTRAN/MATLAB/R code to find ABL height using Richardson Number.	Satellite data assimilation in regional model like WRF.	Find out central and forward finite difference approximations over chennai region?	Plot synoptic features over India during different seasons using model output?	Subjective and objective analysis of geopotential height
	SLO-2					
S-7	SLO-1	The Heisenberg spectrum	The Ekman layer – the classical approach	Pure sound waves	The mechanism of barotropic development	Inertial and dynamic stability- Inertial motion in a horizontally homogeneous Pressure field
	SLO-2	Relations for the Heisenberg exchange coefficient	The Ekman layer – the classical approach	Pure sound waves	The mechanism of barotropic development	Inertial motion in a horizontally homogeneous Pressure field
S-8	SLO-1	A prognostic equation for the exchange coefficient	The composite Ekman layer	Sound waves and gravity waves	Rossby waves- One- and two-dimensional Rossby waves	Inertial motion in a homogeneous geostrophic wind field
	SLO-2	Concluding remarks on closure procedures	The composite Ekman layer	Sound waves and gravity waves	One- and two-dimensional Rossby waves	Inertial motion in a geostrophic shear wind field
S-9 to S-12	SLO-1	Find the forecast for the 3rd July 2021 based on different methods such as climatology, persistence and trends method using reanalysis data of past 30 years?	Perform sensitivity experiment on ABL, SST using WRF model different schemes.	Find the inverse of 3 x 3 matrix	Familiarization with Post-Processing and Visualization Software (grads, Ferret, NCAR Graphics..etc) for WRF Model.	Calculate vertical velocity using equation of continuity.
	SLO-2					
S-13	SLO-1	The atmospheric boundary layer- Introduction	Ekman pumping	Lamb waves- Lee waves	Three-dimensional Rossby waves	Derivation of the stability criteria in the geostrophic Wind field
	SLO-2	Prandtl-layer theory	Ekman pumping	Propagation of energy	Three-dimensional Rossby waves	Derivation of the stability criteria in the geostrophic Wind field
S-14	SLO-1	The Monin–Obukhov similarity theory of the neutral Prandtl layer	Problems	External gravity waves	Normal-mode considerations	Sectorial stability and instability

	SLO-2	The Monin–Obukhov similarity theory of the neutral Prandtl layer	Problems	Internal gravity waves- Nonlinear waves in the atmosphere	Normal-mode considerations	Sectorial stability for normal atmospheric conditions- Sectorial stability and instability with permanent Adaptation
S15-S18	**SLO-1**	*Handling of High Performance Computing cluster for parallel processing of large data. Basic ideas on multitasking and massively parallel processing.*	*Perform simpson and trapezoidal integration to calculate integrated Water vapour and compare*	*Plot walker circulation using u, v and w components of wind?*	*Parameterization of subgrid-scale processes like ABL, convection etc, Carry one parameter in WRF and notice the effect of different schemes?*	*Determine the relation between SST anamolies and surface pressure over Arabian sea during pre and post monsoon conditions.*
	SLO-2					

Learning Resources	1. *Wilford Zdunkowski and Andreas Bott, Dynamics of Atmosphere: A Course in Theoretical Meteorology, Cambridge University Press, 2003* 2. *Richard A Lindzen, Dynamics in Atmospheric Physics, Cambridge University Press, 1990*	3. *Mankin Mak, Atmospheric Dynamics, Cambridge University Press, 2011.* 4. James R. Holton, "An Introduction to Dynamic Meteorology Volume 1", Elsevier Science, 2004.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %
Level 2	Apply / Analyze	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %
Level 3	Evaluate / Create	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. R Seshadri, Titan Company Limited, seshadri@titan.co.in	Dr. Humberto Barbosa, UFAL, barbosa33@gmail.com	Dr. A. Naga Rajesh
Dr. Ashok, ISRO, ashok@vssc.gov.in	Dr. Sanjeev Dwivedi, IMD, sanjeev.esa@gmail.com	Dr. Alok Kumar

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Course Code	PAS21302T	Course Name	Atmospheric Measurements	Course Category	C	Professional Core Courses	L	T	P	C
							3	1	0	4

Pre-requisite Courses	**Nil**	**Co-requisite Courses**	**Nil**	**Progressive Courses**	**Nil**
Course Offering Department	**Physics and Nanotechnology**	**Data Book / Codes/Standards**		**Nil**	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	**Learning**		
		1	2	3
CLR-1:	*acquire knowledge and understanding of ground based atmospheric observations*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2:	*develop understanding of remote sensing in atmospheric variables estimation*			
CLR-3:	*learn to apply the scientific methods/ theories involved in atmospheric instrumentation and observation*			
CLR-4:	*develop skills in data analysis, evaluation, solving problems and drawing conclusions*			
CLR-5:	*develop an informed interest in the subject that may lead to further study*			
CLR-6:	*acquire knowledge and understanding of ground based atmospheric observations*			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:				**Program Learning Outcomes (PLO)**															
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
					Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3	
CLO-1:	explain the physical laws involved in atmospheric observations	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	
CLO-2:	analyze and interpret the atmospheric variables	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	
CLO-3:	understand the principles of radar and satellite observations and data estimation techniques	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H	
CLO-4:	utilize the data sets in understanding of atmospheric processes	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	
CLO-5:	give reasoned explanations for phenomena, patterns and relationships.	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	
CLO-6:	present and communicate atmospheric variables and its importance in a team or individually.	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	

Duration (hour)		**12**	**12**	**12**	**12**	**12**
S-1	**SLO-1**	Introduction and history of Atmospheric Observation tools	Radar meteorology, History and Technology	Overview of radar in meteorological applications	Introduction to satellite meteorology	Introduction of atmospheric variables estimation by satellites
	SLO-2	Atmospheric variables	Weather radar and its characteristics	Weather radar system and data	Meteorological satellite orbits	Temperature estimation (Sounding)
S-2	**SLO-1**	Principles of measurement and in-situ instrumentation	Radar accuracy	Rainfall estimation: vertical profile of reflectivity, Z-R relation	Keplerian orbit and perturbation	Trace gases estimation

	SLO-2	Temperature measurement techniques and sensors	Radar principle	Radar equation for precipitation target	Positioning and tracking	Wind estimation
S-3	SLO-1	Physical measures of Humidity and Working principle of Hygrometers	Radar principle	Gauge adjustment and Dual polarization technique	Satellite instrumentation	Ocean Surface wind
	SLO-2	Calibration and Comparison of hygrometers techniques	Phenomena observed by weather radar	Wind estimation: wind profiling and mapping	Satellite data	Doppler wind
S-4	SLO-1	Data analysis and Solving Problems	Solving Problems	Solving Problems	Solving Problems	Solving Problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-5	SLO-1	Atmospheric pressure and working of barometer	Signal and data processing	Convective wind features	EM spectra and radiative transfer equation	Clouds from sounder
	SLO-2	Types of barometers	Signal and data display techniques	Humidity estimation	Radiative transfer equation	Clouds from imager
S-6	SLO-1	Working of Liquid Barometer	Optimizing radar characteristics	Radar observation of tropical cyclone	General Spectral properties	Clouds from microwave radiometry
	SLO-2	Working of mercury Barometer and Hypsometer	Overcoming Doppler dilemma	Pattern, Doppler velocity, and wind	Absorption, scattering	Tropospheric Aerosol
S-7	SLO-1	Rainfall and Introduction of rain gauges	Radar observation of weather system	Rain band, eye, squall line	Image interpretation	Stratospheric Aerosol
	SLO-2	Working of Tilting siphon, Tipping bucket and Introduction of disdrometer	Radar observation of weather system	Track, intensity and distribution of rainfall	Geolocation and calibration	Precipitation estimation: (VIS technique)
S-8	SLO-1	Data analysis and Solving Problems	Solving Problems	Solving Problems	Solving Problems	Solving Problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-9	SLO-1	Wind measurement and anemometer	Operational weather radar	Introduction to 'clean air 'radar	Weather system observed in satellite imagery	VIS and IR technique
	SLO-2	Anemometer working, Solar Radiation, and its measurement	Doppler radar	Observation with 'clean air 'radar	Sounding theory	Passive microwave technique
S-10	SLO-1	Reference solar radiation/ Longwave instruments	Typical weather radar characteristics	Comparison and utility of 'clean air' radar and microwave radar	Retrieval methods	Passive microwave technique
	SLO-2	Radiosonde technology	Maintenance and calibration	Use of weather radar in aviation	Operational retrievals	active microwave and satellite
S-11	SLO-1	Uncertainty in radiosonde measurements	Radars installation	Use of weather radar in aviation	Pros /cons of satellite retrieved data sets	Earth radiation, solar constant
	SLO-2	Specialist radiosonde	Sources of error	New radar and the furure	Current and future meteorological satellites	Surface reflection and solar radiation
S-12	SLO-1	Data analysis and Solving Problems	Solving Problems	Solving Problems	Solving Problems	Solving Problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems

Learning Resources	*1.* R.G. Harrison,Meteorological Measurements and Instrumentation, R. Mets., WILEY, 1st Edition, 2015 *2.* S.Raghvan, Radar Meteorology, ATSL(27), springer,Dordrecht,	*3.* Stanley Q. Kidder, Thomas H. Vonder Haar, Satellite Meteorology – an ntroduction, Academic Press, 1995. *4.* R.R.Kelker, Satellite Meteorology, CRC press, 2nd Edition, 2017

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. R Seshadri, Titan Company Limited, seshadri@titan.co.in	Dr. K. Koteswara Rao, Azim Premji Univ, koti.meteo@gmail.com	Dr. T.V. Lakshmi Kumar
Dr. Ashok, ISRO, ashok@vssc.gov.in	Dr. Manoj, TU, thakurmanoj2003@yahoo.com	

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Course Code	PAS21D07T	Course Name	Science of Climate Change	Course Category	D	Discipline Elective Courses	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1:	*familiarize with the concepts of simple harmonic motion*			
CLR-2:	*analyse the principle of transverse and longitudinal wave-motion*			
CLR-3:	*identify the significance of propagation of light*			
CLR-4:	*create insights to the concepts of interference and diffraction*			
CLR-5:	*understanding the basics of geometrical optics*			
CLR-6:	*understand the basics of lasers*			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	*identify the problems regarding harmonic motion*	2	80	75
CLO-2:	*analyse the various types of wave motions*	2	80	70
CLO-3:	*apply the principles of propagation of light*	2	75	70
CLO-4:	*utilize the concepts of interference and diffraction in applications*	2	80	75
CLO-5:	*apply the principles of geometrical optics.*	2	80	70
CLO-6:	*utilizing the principles of laser in holography and microscopy*	2	80	75

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Overview of climate variability and climate science-Climate dynamics, climate change and climate prediction*	*Physical processes in the climate system- Conservation of momentum*	*El Niño mechanisms II: dynamics of transition phases-Equatorial jets and the Kelvin wave- The Kelvin wave speed*	*Parameterization of small-scale processes*	*Climate response time in transient climate change*
	SLO-2	*The chemical and physical climate system*	*Conservation of momentum*	*What sets the width of the Kelvin wave and equatorial jet?*	*Parameterization of small-scale processes*	*Climate response time in transient climate change*
S-2	SLO-1	*Climate models: a brief overview*	*Equation of state*	*Response of the ocean to a wind anomaly- The delayed oscillator model and the recharge oscillator model*	*The hierarchy of climate models*	*Climate model scenarios for global warming- Greenhouse gases, aerosols and other climate forcings*
	SLO-2	*Global change in recent history*	*Equation of state*	*ENSO transition mechanism in brief*	*The hierarchy of climate models*	*Climate model scenarios for global warming- Greenhouse gases, aerosols and other climate forcings*
S-3	SLO-1	*El Niño: an example of natural climate variability*	*Temperature equation*	*El Niño prediction*	*Climate simulations and climate drift*	*Global-average response to greenhouse warming scenarios*
	SLO-2	*El Niño: an example of natural climate variability*	*Temperature equation*	*El Niño prediction*	*Climate simulations and climate drift*	*Global-average response to greenhouse warming scenarios*
S-4	SLO-1	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*
	SLO-2	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*
S-5	SLO-1	*Paleoclimate variability*	*Continuity equation*	*El Niño remote impacts: teleconnections*	*Evaluation of climate model simulations for Present-day climate*	*Spatial patterns of warming for time-dependent scenarios*
	SLO-2	*Paleoclimate variability*	*Continuity equation*	*El Niño remote impacts: teleconnections*	*Evaluation of climate model simulations for Present-day climate*	*Spatial patterns of warming for time-dependent scenarios*
S-6	SLO-1	*Basics of global climate-Components and phenomena in the climate system*	*Conservation of mass applied to moisture*	*Other interannual climate phenomena*	*The greenhouse effect and climate feedbacks- The greenhouse effect in Earth's current climate*	*Ice, sea level, extreme events*
	SLO-2	*Basics of radiative forcing*	*Moist processes*	*Other interannual climate phenomena*	*The greenhouse effect and climate feedbacks- The greenhouse effect in Earth's current climate*	*Ice, sea level, extreme events*
S-7	SLO-1	*Globally averaged energy budget: first glance*	*Wave processes in the atmosphere and ocean*	*Climate models- Constructing a climate model- An atmospheric model*	*Global warming I: example in the global-average energy balance model*	*Summary: the best-estimate prognosis*
	SLO-2	*Gradients of radiative forcing and energy transports*	*Wave processes in the atmosphere and ocean*	*Treatment of sub-grid-scale processes*	*Global warming I: example in the global-average energy balance model*	*Summary: the best-estimate prognosis*
S-8	SLO-1	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*
	SLO-2	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*
S-9	SLO-1	*Atmospheric circulation*	*El Niño and year-to-year climate prediction- Recap of El Niño basics*	*Resolution and computational cost*	*Climate feedbacks*	*Climate change observed to date*

	SLO-2	*Ocean circulation*	*Tropical Pacific climatology*	*An ocean model and ocean–atmosphere coupling*	*Climate feedbacks*	*Climate change observed to date*
S-10	SLO-1	*Land surface processes*	*ENSO mechanisms I: extreme phases*	*Land surface, snow, ice and vegetation*	*The water vapor feedback*	*Emissions paths and their impacts*
	SLO-2	*Land surface processes*	*Pressure gradients in an idealized upper layer*	*Summary of principal climate model equations- Climate system modeling*	*Snow/ice feedback*	*Emissions paths and their impacts*
S-11	SLO-1	*The carbon cycle*	*Transition into the 1997–98 El Niño*	*Numerical representation of atmospheric and oceanic equations*	*Cloud feedbacks*	*The road ahead*
	SLO-2	*The carbon cycle*	*Transition into the 1997–98 El Niño*	*Numerical representation of atmospheric and oceanic equations*	*Other feedbacks in the physical climate system*	*The road ahead*
S-12	SLO-1	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*
	SLO-2	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*

Learning Resources	J. David Neelin, Climate Change and Climate Modeling, Cambridge University Press, 2011 Kendal McGuffie, Ann Henderson-Sellers, The Climate Modelling Primer, 4th Edition, Wiley-Blackwell,2014	Hugues Goosse, Climate System Dynamics and Modelling, Cambridge University Press, 2015 M. R. Islam, M. M. Khan, "The Science of Climate Change", Wiley, 2019.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	Dr. Humberto Barbosa, UFAL, barbosa33@gmail.com	Dr.A. Naga Rajesh
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. K.K.Rao, APU, koti.meteo@gmail.com	Dr.T.V.Lakshmi Kumar

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Course Code	PAS21D08T	Course Name	Monsoon and Teleconnections	Course Category	D	Discipline Elective Courses	L	T	P	C
							3	1	0	4

Pre-requisite Courses	**Nil**	**Co-requisite Courses**	**Nil**	**Progressive Courses**	**Nil**
Course Offering Department	**Physics and Nanotechnology**	**Data Book / Codes/Standards**		**Nil**	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1:	*familiarize with the concepts of* global monsoon systems			
CLR-2:	*understand the concepts of* indian summer and winter monsoon variability			
CLR-3:	*identify the significance indian monsoon system*			
CLR-4:	*create insights to the concepts of monsoon teleconnections*			
CLR-5:	*understanding the basics of* monsoon prediction			
CLR-6:	*understand the basics of lasers*			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	*identify the problems of intra-seasonal and interannual variability of monsoon rainfall*	2	80	75
CLO-2:	*understand the monsoon variability*	2	80	70
CLO-3:	*apply the principles of synoptic systems related to monsoons*	2	75	70
CLO-4:	*utilize the concepts of teleconnections*	2	80	75
CLO-5:	*apply the principles of large scale features*	2	80	70
CLO-6:	*utilizing the principles of monsoon predictability and enso*	2	80	75

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	Slo-1	*Introduction:* monsoons (global and regional distribution of monsoons)	Introduction: synoptic systems and weather	Interdecadal variability: introductions	*Effects of the tibetan plateau: introduction*	Seasonal prediction of indian summer monsoon : introduction
	Slo-2	Monsson domain	Major rainy seasons	Interdecadal variability of south asian summer monsoon	*Large scale features of the atmosphere near the tibetan plateau*	Weather and climate modelling of monsoon
S-2	Slo-1	Differential heating and the monsoon	Synoptic systems	Interdecadal variability of south asian winter monsoon	*Large scale features of the atmosphere near the tibetan plateau- continuation*	Monsoon forecast by using global models
	Slo-2	Key elements of the asian summer and winter monsoon	Monsoon lows and tropical cyclones	Mechanisms of interdecadal variability	*Heat sources on the tibetan plateau*	Monsoon forecast by using global models- continuation
S-3	Slo-1	Monsoon onset and withdrawal	Floods and droughts	Decadal changes in monsoon intraseasonal activity	*Heat sources on the tibetan plateau- continuation*	Multi model forecast
	Slo-2	Breaks in the indian monsoon	Cold waves and clod surges	Decadal changes in monsoon intraseasonal predictability	*Thermal influences*	Multi model forecast- continuation
S-4	Slo-1	*Carrying out assignments*	*Carrying out assignments*	*Carrying out assignments*	*Carrying out assignments*	*Carrying out assignments*
	Slo-2	*Carrying out assignments*	*Carrying out assignments*	*Carrying out assignments*	*Carrying out assignments*	*Carrying out assignments*
S-5	Slo-1	Active, break and withdrawal phases of indian monsoons .	Intra seasonal variability:	Large scale atmospheric dynamics: introduction	*Oscillations and teleconnections: introduction*	Dynamical seasonal prediction and limitations
	Slo-2	The somali jet	*General description :mjo,iso,isv,*	Equatorial waves	The north atlantic oscillation (nao)/ pacific decadal oscillation (pdo)	Prediction skill
S-6	Slo-1	Boundary layer dynamics of the somali jet	Synoptic organization and remote influences	Monsoon and subtropical anti cyclones	The madden–julian oscillation (mjo)	Multi model predictability
	Slo-2	Upwelling in the somali jet region	Low frequency variability	Monsoon and subtropical anti cyclones-continuation	The quasi-biennial oscillation (qbo)	Monsoons in the future: global aspects
S-7	Slo-1	Monsoon over southern asia	Theory and physical processes	Tibetan high and tropical easterly jet	Indian ocean dipole (iod)	Indian summer monsoon and onset
	Slo-2	Monsoon over eastern asia	*Prediction and predictability of monsoons*	Tibetan high and tropical easterly jet- continuation	Enso and related teleconnections	Enso monsoon relationship
S-8	Slo-1	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*
	Slo-2	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*	*Solving problems*
S-9	Slo-1	Meteorology of the maritime	*Intra annual variability: principal modes*	Cross equatorial flow and inertial instability	*Interaction between monsoon and enso: air –sea interations*	The asian monsoon and agriculture
	Slo-2	Monsoon over australia	Dominant impacting factors	Cisk and tropical intraseasonal oscillation	Precipitation anomalies	Variability of rice production in asia in relation to rainfall
S-10	Slo-1	Monsoon over africa	Tropospheric biennial oscillations	Variations of asian monsoon water budget: theoretical back ground	Enso related variability in the indian ocean basin	Facets of monsoon variability on indian region
	Slo-2	Monsoon over south america	Monsoon and global climate variability	Contribution of global hydrological cycle	Enso related variability in the indian ocean basin- continuion	Facets of monsoon variability on indian region - continuation
S-11	Slo-1	Monsoon over central america	Monsoon and global climate variability -continuation	Modulation of water vapour transport and rainfall	Impact of asian monsoon on enso	Role of the monsoon in rice cultivation in different states over india
	Slo-2	Extratropical monsoon over north america	Monsoon and global climate variability -continuation	Modulation of water vapour transport and rainfall- continuation	Impact of asian monsoon on enso-continuion	Role of the monsoon in rice cultivation in different states over india- continuation
S-12	Slo-1	*Seminar*	*Seminar*	*Seminar*	*Seminar*	*Seminar*
	Slo-2	*Seminar*	*Seminar*	*Seminar*	*Seminar*	*Seminar*

Learning Resources	
1. Saha, K., Tropical Circulation Systems and Monsoons, Springer, 2009 2. Wand, B., The Asian Monsoon, Springer,2006	3. Krishnamurti, T. N., L. Stefanova, and V. Mishra, Tropical Meteorology, 1st Edition, Springer, 2013 4. Howard A. Bridgman and John E. Oliver. The Global Climate System Patterns, Processes, and Teleconnections. Cambridge University Press,2006.

Learning Assessment												
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. K.K.Rao, APU, koti.meteo@gmail.com	Dr.A. Naga Rajesh

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Course Code	PAS21D09T	Course Name	Extreme Weather events	Course Category	D	Discipline Elective Courses	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1:	*familiarize with the concepts of turbulent atmosphere, temperature and humidity extremes*			
CLR-2:	*analyze the principle of condensation in the atmosphere, and clouds and its stability*			
CLR-3:	*identify the significance of precipitation extremes and atmospheric motions*			
CLR-4:	*create insights to the concepts of wind systems, and air masses and fronts*			
CLR-5:	*understanding the basics of thunderstorms and weather forecasting*			
CLR-6:	*give basics of the earth's changing climate and global warming*			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	*identify the concepts in turbulent atmosphere, temperature and humidity extremes*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*analyze the various types of clouds and the condensation in the atmosphere*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*understand the principles of precipitation extremes*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*utilize the concepts of wind systems, air masses and fronts*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*apply the principles of thunderstorms and weather forecasting*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*utilizing the principles of global warming and green house effect to preserve the earth's climate*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	The Earth's Atmosphere, Properties of the Atmosphere: Air Temperature	Extreme Relative Humidity in the Home, The Heat Index	Precipitation-Extreme Events, Aircraft Icing-A Hazard to Flying	Extreme Local Wind Systems, Average Wind Flow and Pressure Patterns Aloft	Weather Forecasting Tools, Weather Forecasting Methods
	SLO-2	Temperature Scales, Vertical Profile of Air Temperature, Air Pressure	Deadly Heat Waves, Beating the Heat-Dealing with Heat Waves, Measuring Humidity	The Influence of Mountains, Wet Regions, Dry Regions, and Precipitation Records	Monsoon Winds, Jet Streams	The Computer and Weather Forecasting: Numerical Weather Prediction, Types of Forecasts
S-2	SLO-1	Air Pressure and Barometers, Wind, Moisture	The Formation of Dew, Frost, and Haze	Too Much Rain -Floods and Flash Floods	Aircraft Turbulence, Sea and Land Breezes, Mountain and Valley Breezes	Accuracy and Skill in Forecasting, Predicting Short-Term Hazardous and Severe Weather Events
	SLO-2	Rising Air Produces Clouds, Relative Humidity and Dew Point	Fog, Foggy Weather	Doppler Radar and Precipitation, Drought and the Palmer Index	Windy Afternoons, Katabatic Winds, Chinook Winds, Santa Ana Winds, Extreme Winds	Forecasting Weather in the West, Forecasting Weather for the Great Plains, Forecasting Southern Storms
S-3	SLO-1	Hydrologic cycle	Fog turns to smog, clouds: identification from the surface, high clouds	Some notable droughts: african drought	Air masses, source regions, continental polar (cp) and continental arctic (ca) air masses	A forecast of south-eastern ice, weather forecast for the northeast, predicting long-term weather and climate patterns
	SLO-2	Extremes of Weather and Climate	Middle Clouds, Low Clouds, Clouds with Vertical Development	North American Drought	Extremely Cold Outbreaks, Extremely Cold Air Masses Produce a Record Cold Winter	El Niño, La Niña, and the Southern Oscillation, Pacific Decadal Oscillation, North Atlantic Oscillation, Arctic Oscillation
S-4	SLO-1	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-5	SLO-1	Energy and Heat Transfer: Latent Heat—The Hidden Warmth	Some Unusual Clouds	Horizontal Pressure Changes and Wind, Surface and Upper-Level Charts	Extremely Cold Air Masses Produce a Record Cold Winter, Maritime Polar (mp) Air Masses	Reconstructing Past Climates, Climate Throughout the Ages, Temperature Trends during the Past 1000 Years
	SLO-2	Conduction, convection	Clouds: observations from space	The surface map, isobaric (constant pressure) charts	Maritime tropical (mt) air masses, continental tropical (ct) air masses	The ocean's influence on rapid climate change, climate change caused by natural events
S-6	SLO-1	Comparing Energy in Storms, Radiation	Types of Atmospheric Stability, A Stable Atmosphere	Why the Wind Blows: Newton's Laws of Motion, Forces that Influence the Wind	Stationary Fronts, Cold Fronts, "Back Door" Cold Fronts, A Strong Cold Front , Warm Fronts	Climate Change: Feedback Mechanisms, Climate Change: Plate Tectonics and Mountain Building
	SLO-2	Energy Balancing Act—Absorption, Emission and	Stability and Subsidence Inversions, An Unstable	Pressure Gradient Force, Coriolis Force	The Dryline, Warm Fronts and Ice Storms, Occluded Fronts, Upper-	Climate Change: Variations in the Earth's Orbit, Climate Change:

		Equilibrium, Selective Absorbers and the Atmospheric Greenhouse Effect	Atmosphere		Level Fronts	Variations in Solar Output
S-7	SLO-1	Enhancement of the Greenhouse Effect, Shortwave Radiation Streaming from the Sun	A Conditionally Unstable Atmosphere, Causes of Instability	How the Wind Blows: Straight-Line Flow Aloft, Curved Winds Around Lows and Highs Aloft	Thunderstorm Development, Ordinary Cell Thunderstorms, Multicell Thunderstorms	Climate Change: Atmospheric Particles, Climate Change Caused by Human Activities
	SLO-2	The earth's annual energy balance	Cloud development, convection and clouds	Winds on upper-level charts, surface winds	The gust front, microbursts, heat bursts, squall-line thunderstorms	Climate change: aerosols injected into the lower atmosphere, climate change: increasing levels of greenhouse gases, climate change: land use changes
S-8	SLO-1	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-9	SLO-1	Seasons in the Northern Hemisphere	Topography and Clouds, Changing Cloud Forms	Measuring Winds, Locating the Center of Storms, The Influence of Extreme Winds	Mesoscale Convective Complexes, Supercell Thunderstorms, Thunderstorms and the Dryline	Global Warming, Radiative Forcing Agents, Climate Models and Recent Temperature Trends
	SLO-2	Seasons in the Southern Hemisphere	Lake-Effect Snowstorms and Atmospheric Stability	Strong Winds Blowing over Land, Extreme Winds and Water	Thunderstorms and Flooding, Distribution of Thunderstorms	Future Global Warming: Projections, Uncertainties about Greenhouse Gases
S-10	SLO-1	Daily temperatures: warm days, extreme heat, cold nights	Precipitation processes, collision and coalescence process	Winds, waves, and a seasick semester at sea	Lightning and thunder, electrification of clouds, the lightning stroke,	The ocean's impact, consequences of global warming: the possibilities
	SLO-2	Extreme cold, daily temperature variations	Ice-crystal process, cloud seeding and precipitation, precipitation in clouds	Windy places, extreme winds	The different forms of lightning, when lightning strikes	Global warming: possible impacts on extreme weather, temperature and humidity
S-11	SLO-1	Regional Temperature Variations, Weather Extremes and Human Discomfort, Wind and Cold,	Precipitation Types, Rain, Snow, The Effect of a Snowfall,	General Circulation of the Atmosphere, Single-Cell Model, Three-cell Model	Strange Lightning in the Upper Atmosphere	Precipitation-Drought and Floods, Lake-Effect Snowstorms, Thunderstorms, Tornadoes Hurricanes
	SLO-2	Cold, Damp Weather, High Dew Points, Dew-Point Extremes, Dry Air with a High Relative Humidity	Sleet, Freezing Rain, and Ice Storms, Hail	Average Surface Winds and Pressure: The Real World, The General Circulation and Precipitation Patterns	Lightning Detection and Suppression	Global Warming: Efforts to Curb
S-12	SLO-1	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems

Learning Resources	*1. Extreme Weather and Climate, C. Donald Ahrens, Perry Samson, Brooks Cole, 2011* *2. Attribution of Extreme Weather Events in the Context of Climate Change, coll., National Academies Press, 2016*	3. Christopher C. Burt, Mark Stroud, "Extreme Weather, A Guide & Record Book" W.W. Norton, 2007. 4. Philip John Sallis, "Extreme Weather", IntechOpen, 2018.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply / Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate / Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	Dr. Sanjeev Dwivedi, IMD, sanjeev.esa@gmail.com	Dr. T. Vijayakumar
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. Manoj, TU, Thakur.manoj2003@yahoo.com	Dr.A. Naga Rajesh

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Course Code	PMA21G01T	Course Name	Mathematics For Artificial Intelligence	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering	Mathematics	Data Book /		NIL	

Department		Codes/Standards	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

CLR-1 :	Understand the solution methods for solving system of linear equations
CLR-2 :	Acquaint knowledge on the concept of linear transformation
CLR-3 :	Understanding the concept of eigenvalues and eigenvectors
CLR-4 :	Understand the concept of probability and random variable
CLR-5 :	Acquire knowledge in Probability distribution
CLR-6 :	Familiarise in applying linear algebra and probability theory

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Apply formulation and solution procedure of system of linear equation	3	85	80	H	H	M	-	-	-	-	-	M	-	-	H	H	H	-
CLO-2 :	Gain familiarity with linear transformation	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	-	H
CLO-3 :	Gain knowledge in decomposition techniques of matrices	3	85	80	H	H	-		-	-	-	-	M	-	-	H	H	H	-
CLO-4 :	Understand about probability and random variables	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	H	-	-
CLO-5 :	Solve problems in probability distributions	3	85	80	M	H	M	-	-	-	-	-	M	-	-	H	H	H	-
CLO-6 :	Analyze and solve problems in linear algebra and probability theory	3	85	80	M	H	M	M	M	-	-	-	M	-	-	H	H	H	H

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	System of linear equations	Linear transformation	Determinant and trace	Introduction to probability	Introduction to probability distributions
	SLO-2	System of linear equations	Matrix representation of linear transformation	Testing of matrix invertibility	Addition and multiplication theorems	Binomial distribution
S-2	SLO-1	Introduction to Matrices	Basis change	**Eigenvalues and eigenvectors**	Conditional probability	Binomial distribution
	SLO-2	Matrix addition and multiplication	Basis change	Properties of eigenvalues and eigenvectors	Theorem of probability	Poisson distribution
S-3	SLO-1	Matrix inverse and transpose	Image of Linear transformation	Geometric multiplicity	Bayes' theorem	Poisson distribution
	SLO-2	Representation of system of linear equation	Kernel of linear transformation	Spectral theorem	**Bayes' theorem**	Poisson distribution as limiting form of binomial distribution
S-4	SLO-1	Row reduced echelon form	Rank-nullity theorem	Eigenvalue decomposition	Random variable	Geometric distribution
	SLO-2	Inverse of a matrix by Gauss elimination method	Rank-nullity theorem	Eigenvalue decomposition	Discrete random variable	Geometric distribution
S-5	SLO-1	Problem solving using tutorial sheet 1	Problem solving using tutorial sheet 2	Problem solving using tutorial sheet 3	Problem solving using tutorial sheet 4	Problem solving using tutorial sheet 5
	SLO-2	Problem solving using tutorial sheet 1	Problem solving using tutorial sheet 2	Problem solving using tutorial sheet 3	Problem solving using tutorial sheet 4	Problem solving using tutorial sheet 5
S-6	SLO-1	Introduction to vector spaces	Affine space	Constrained optimization	Continuous random variable	Normal distribution
	SLO-2	Vector spaces	Affine mapping	Constrained optimization	Expectation	Normal distribution
S-7	SLO-1	Subspaces	Norms	Unconstrained optimization	Covariance	Normal distribution
	SLO-2	Linear dependence	Inner product space	Optimization using Gradient Descent	Variance	Normal distribution
S-8	SLO-1	Linear independence	Symmetric positive definite matrices	Optimization using Gradient Descent	Correlation coefficient	Exponential distribution
	SLO-2	Linear span	Lengths and distances	Optimization using Lagrange's Multiplier	Correlation coefficient	Exponential distribution
S-9	SLO-1	Basis	Angles and orthogonality	Optimization using Lagrange's Multiplier	Regression lines	Functions of several variables
	SLO-2	Rank of a matrix	Orthonormal basis	Convex optimization	Regression lines	Functions of several variables

Learning Resources	**1 Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong ,Mathematics for machine learning , Cambridge University press, 2020** **2. XIAN-DA ZHANG,A Matrix Algebra Approach to Artificial Intelligence , Springer 2020.** **3. Lipschutz. S and Schiller. J, "Schaum's outlines - Introduction to Probability and Statistics", McGraw-Hill, New Delhi, 1998**	**4. Hoffman and R. Kunze, Linear Algebra, 2nd Ed., Prentice Hall of India, 2005.** **5.S. Axler, Linear Algebra Done Right, 2nd Ed., Springer UTM, 1997** **6.T. Veerarajan, "Probability, Statistics and Random Processes", Tata McGraw - Hill Publishing Company Limited, New Delhi, 2004**

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	20CEC632T	Course Name	Air Quality Modelling and Pollution Control	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1	*Create insight into sources and classification of air pollutants*																		
CLR-2	*Address concepts related to meteorology and air pollution*																		
CLR-3	*Create insights into air quality Modelling and sampling procedures*																		
CLR-4	*Address concepts related to control of particulate matter*																		
CLR-5	*Address concepts related to control of gaseous pollutants*																		
CLR-6	*Practical application of the concepts in different Industries*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1	*Able to understand the sources and characteristics of air pollutants*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	-	*L*	*H*	-	-	-	-	*L*	*M*	-	-
CLO-2	*Gain knowledge in relation between meteorology and air pollution*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	-	-	*H*	-	-	-	-	-	*M*	-	-
CLO-3	*Gain knowledge in modelling and sample collection*	*2*	*80*	*75*	*H*	*H*	*M*	*M*	-	*L*	*H*	-	-	-	-	*L*	*M*	-	-
CLO-4	*Able to understand the equipment used to control particulate matter*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	-	-	*H*	-	-	-	-	-	*M*	-	-
CLO-5	*Able to understand the equipment used to control gaseous pollutant s*	*2*	*85*	*80*	*H*	*H*	*M*	*M*	*L*	*L*	*M*	-	-	-	-	*L*	*M*	-	-
CLO-6	*Gain knowledge in the practical application of control measures in different industries*	*2*	*80*	*75*	*H*	*H*	*M*	-	-	*L*	*M*	-	-	-	-	-	*M*	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Sources And Classification Of Air Pollutants. Introduction to air pollution	Air Quality Modelling And Sampling Procedures Modelling -Introduction	Control Of Particulates Particulate matter	Control Of Gaseous Pollutants Methods	Sources And Control Of Air Pollution In Industries Control Methods
	SLO-2	Sources and classification of Air Pollutants	Air quality modelling	Objectives	Absorption: principles	Processes based control mechanisms
S-2	SLO-1	Effects air pollutants on human health.	effluent dispersion theories	Gravitational settling chambers	description of equipment	Manufacturing Process and air pollution control measures in different industries
	SLO-2	Effect of air pollutants on vegetation, animals and structures.	Mathematical models	Design problem, Collection efficiency	packed and plate columns	industries -mineral products
S-3	SLO-1	Meteorology and air pollution	Box model-	Filters-theory	design and performance equations	asphaltic concrete manufacturing
	SLO-2	Measurement of meteorological parameters	problem	Types of filters, working	Adsorption: principles	cement plants
S-4	SLO-1	Atmospheric stability	Gaussian plume model	Filters- Principle , pressure drop and efficiency	equipment descriptions	Process flow chart of cement plant

	SLO-2	Types of inversions	problem	Cyclones-Principle	adsorption cycle	Control of particulates and gaseous pollutants
S-5	SLO-1	Plume behavior	Multiple cell model	Working, Types of cyclones	solvent recovery system	glass manufacturing plants
	SLO-2	Plume rise estimation	Computer Models	Collection efficiency and pressure drop	continuous rotary bed, fluidized bed	Thermal power plants
S-6	SLO-1	Mixing Height	Sampling procedure and selection of site	Wet collectors	Design and performance equations	Sources and control of air polluants
	SLO-2	Plume rise estimation-problems	particulate sampling	Scrubbers-principle	Condensation	Petroleum refining industry
S-7	SLO-1	Mixing Height-problems	equipment and methods	Working , efficiency of scrubbers	contact condensers-shell and tube condensers	Process flow chart and control of pollutants
	SLO-2	Stack height estimation	Gaseous Sampling	Design of scrubbers	design and performance equation	Fertilizer industry
S-8	SLO-1	Rules and Regulations to control air pollution	equipment and methods	Electrostatic presipitators(ESP)-principle	Incineration	Pharmaceutical industry
	SLO-2	Air quality standards	Stack sampling	Working , efficiency of ESP	hydrocarbon incineration kinetics	wood processing industry
S-9	SLO-1	Vehicular pollution control, Bharat stage emission standards	Ambient Sampling	Types of ESP, Design Procedure	equipment description	Field study
	SLO-2	Indoor Air quality	Isokinetic sampling	Recent Trends	design and performance equations	Case Study -presentation

Learning Resources	1. *Richard W.Boubel et al, "Fundamentals of Air Pollution", Academic Press, New York, 2004.* *2. Noel de Nevers, "Air Pollution control Engg." McGraw-Hill, New York,2005.* *3. M.N. Rao et al, "Air Pollution", Tata McGraw Hill, 2009.*	*4. C.S Rao, Air pollution Control Engineering* *5. Lawrence K. Wang, Norman C. Pareira, Yung Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*60%*	-	*60%*	-	*60%*	-	*60%*	-	*60%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	-	-	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), dkaswal@nplindia.org	*Dr. Sanjeev Dwivedi, IMD, sanjeev.esa@gmail.com*	Dr. Sija
Dr. V Subramanian, CLRI, subbu@clri.res.in	*Dr. Manoj, TU, Thakur.manoj2003@yahoo.com*	Dr. T.V. Lakshmi Kumar

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Course Code	PCY21G01T	Course Name	Research Skills and Learning	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	***Nil***	**Co-requisite Courses**	***Nil***	**Progressive Courses**	***Nil***
Course Offering Department	***Chemistry***	**Data Book / Codes/Standards**		***Nil***	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	**Learning**	**Program Learning Outcomes (PLO)**

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*To understand the concept of research and different types of research in the context of chemistry*																		
CLR-2 :	*To evaluate the different methods of scientific writing and reporting*																		
CLR-3 :	*To impart the knowledge about the statistical distribution and applications*																		
CLR-4 :	*To develop the skill of technical writing*																		
CLR-5 :	*To inculcate the knowledge of intellectual property and rights*																		
CLR-6 :	*To understand the concept of research and different types of research in the context of chemistry*																		
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Fundamental Knowledge	Application of Concepts	Link with Related Disciplines	Procedural Knowledge	Skills in Specialization	Ability to Utilize Knowledge	Skills in Modeling	Analyze, Interpret Data	Investigative Skills	Problem Solving Skills	Communication Skills	Analytical Skills	PSO -1	PSO -2	PSO-3

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																			
CLO-1 :	Understand the key areas of research	2	75	60	H	H	H	L	H	H	M	H	H	L	H	H	H	H	H
CLO-2 :	Develop scientific documentation skills	2	80	70	H	H	L	H	L	L	H	L	L	H	H	L	H	H	H
CLO-3 :	Develop competence on data collection and process of scientific documentation	2	70	65	H	H	H	M	L	L	H	L	L	H	H	L	H	H	H
CLO-4 :	Understand the research ethics	2	70	70	H	L	H	H	H	L	M	L	L	H	H	L	H	H	H
CLO-5 :	Submit proposals for funding agencies	2	80	70	L	H	L	M	L	H	H	L	L	H	H	L	H	H	H
CLO-6 :	Understand the key areas of research	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Objectives of research	Online databases	Analysis and Presentation of Data	Technical writing	Ethics in research
	SLO-2	Research methods and methodologies-Overview	E-journals, Journal acces	Descriptive statistics	Activity in Technical writing	authors Ackowledgement
S-2	SLO-1	types of research-Descriptive vs analytical	Citation index, Impact factor,	Choosing and using statistical tests	Technical presentation	Group discussion on ethics in research
	SLO-2	types of research -applied vs fundamental	H-index, E-consortium	Sample test – Student –t – test	Activity in Technical presentation	Outcome of group discussion
S-3	SLO-1	types of research-quantitative vs qualitative	UGC infonet, E-book	F- test	Creativity in research – Basic idea	Plagiarism
	SLO-2	types of research-conceptual vs empirical	Preprint servers	κ^2 test	Creativity in research - Activity	Tools to avoid plagiarism
S-4	SLO-1	Literature-review	Search engines, Scirus, Google Scholar	Chemometrics	Good practicals – Units, numbers	Presentations - Power-point presentation.
	SLO-2	Consolidation of Literature-review	ChemIndustry, Wiki-Databases	Analysis of variance (ANOVA),	Reproducibility	Poster presentation
S-5	SLO-1	Sources of information	ChemSpider, Science Direct	Correlation and regression	Scientific writing - Abbreviations	Elements of excellent presentation
	SLO-2	Primary, secondary, tertiary sources	SciFinder, Scopus	Curve fitting	nomenclature	Communication skills
S-6	SLO-1	Journal abbreviations, abstracts,	Internet resources for Science	fitting of linear equations,	justification for scientific contributions	Activity based on research presentation
	SLO-2	reviews, monographs, dictionaries	Library research,	analysis of residuals	description of methods	Activity based on research presentation
S-7	SLO-1	Introduction to Chemical Abstracts	field research	General polynomial fitting	conclusions	Proposal submission for funding agencies
	SLO-2	Author Index	Laboratory research	linearizing transformations	the need for illustration, style	Knowledge of funding agencies
S-8	SLO-1	Formula Index	Data Analysis – Making and Recording Measurements	exponential function fit,	Writing references	Intellectual property
	SLO-2	Subject Index	Continued.	r and its abuse	Research report writing	Intellectual property rights
S-9	SLO-1	Substance Index	Maintaining a laboratory record	Basic aspects of multiple linear regression analysis	Activity based on scientific writing	Copy rights
	SLO-2	other Indices with examples	Tabulation and generation of graphs	Basic aspects of multiple linear regression analysis	Activity based on scientific writing	Patent rights

Learning Resources	
	1. Dawson, C.. Practical research methods. UBS Publishers, New Delhi, 2002
	2. Walpole R.A., Myers R.H., Myers S.L.and Ye King: Probablity and statstics for engineers and scientist, Pearson Prentice Hall, Pearson Education, Inc. 2007
	3. 3. Kothari C.K., Research Methodology-Methods and Techniques(New Age International, New Delhi), 2004

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	50%	-	50%	-	50%	-	50%	-
Level 3	Evaluate Create	30%	-	20%	-	20%	-	20%	-	20%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	**Expert from Higher Technical Institutions**	**Internal Experts**
1. Dr. Sudarshan Mahapatra, Encube Ethicals Pvt. Ltd, sudarshan.m@encubeethicals.com	1. Prof. G. Sekar, IIT Madras, gsekar@iitm.ac.in	1. Dr. T. Pushpa Malini, SRMIST
2. Dr. Shanmukhaprasad Gopi, Dr. Reddy' s Laboratories, shanmukhaprasadg@drreddys.com	2. Prof. Vivek Polshettiwar, TIFR Mumbai, vivekpol@tifr.res.in	2. Dr.J.Arockia Selvi, SRMIST

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Course Code	PAS21S03L	Course Name	Weather Monitoring Techniques	Course Category	S	Skill Enhancement Course	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	***Physics and Nanotechnology***	**Data Book / Codes/Standards**	***Nil***		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*familiarize with weather data and analysing weather reports*
CLR-2:	*enriching knowledge in weather prediction*
CLR-3:	*knowledge on the methods of obtaining synoptic data*
CLR-4:	*interpretation of weather disturbances*
CLR-5	*enable the students in identifying the climate of a region*
CLR-6	*familiarize to interpret the changes in atmospheric conditions*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	**Learning**			**Program Learning Outcomes (PLO)**														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	*provides basic understanding of weather prediction*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*enriches the computation skills on weather events*	2	80	70	H	M	M	H	M	H	H	H	M	H	M	H	M	H	M
CLO-3:	*enhance fundamental knowledge on synoptic computations*	2	75	70	H	M	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	*analyse the monsoon activities qualitatively*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5	*improving technical skills in using observations data*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6	*enhancing the skills on current weather comparison*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H

DURATION (HOURS)		**12**	**12**	**12**	**12**	**12**
S1 to S4	**SLO-1**	Plotting Isobars on weather charts-Using Synoptic weather Data	Understanding the cyclone tracks from IMD Atlas	Understanding different stages of cyclone and assigning the Dwarak Number	Analysing the daily weather reports	Monitoring the tracks of southwest monsoon
	SLO-2					
S5 to S9	**SLO-1**	Identifying the climate of a region using temperature and rainfall data	Understanding the monsoon activity and monsoon disturbances	Calculation of Climate anomalies and understanding the deficit/excess rainfall years	Understanding the daily weather from satellite data	Monitoring the tracks of northeast monsoon
	SLO-2					
S9 to S12	**SLO-1**	Computations of Atmospheric moisture conditions	Cloud types identification through visual perception	Identification of Sea Breeze using the wind data	Understanding the daily weather from radar data	Monitoring the rainfall over different seasons
	SLO-2					

Learning Resources	1. Weather analysis and forecasting – Vol.1 & 2 by B. Patterson 2. Monsoon meteorology by C.S. Ramage	3. Meteorology for Pilots by Mike Wickson 4. Manual of meteorology, part 2. Aviation meteorology / Bureau of Meteorology, Department of Science

Learning Assessment									
	Bloom's Level of Thinking	**Continuous Learning Assessment (100% weightage)**							
		CLA-1 (20%)		**CLA-2 (20%)**		**CLA-3 (40%)**		**CLA-4 (20%)#**	
		Theory	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**
Level 1	Remember	-	30 %	-	30 %	-	30 %	-	30 %
	Understand								
Level 2	Apply	-	40 %	-	40 %	-	40 %	-	40 %
	Analyze								
Level 3	Evaluate	-	30 %	-	30 %	-	30 %	-	30 %
	Create								
	Total	100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), dkaswal@nplindia.org	*Dr. Sanjeev Dwivedi, IMD, sanjeev.esa@gmail.com*	Dr. TV Lakshmi Kumar, SRMIST
Dr. V Subramanian, CLRI, subbu@clri.res.in	*Dr. Manoj, TU, Thakur.manoj2003@yahoo.com*	Dr. A. Naga Rajesh, SRMIST

Course Code	PAS21I01L	Course Name	Massive Open Online Course	Course Category	I	Internship in Industry/higher technical institutions	L	T	P	C
							0	0	0	2

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Physics and Nanotechnology*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*encourage initiative by Govt. of India to achieve the three cardinal principles of access, equity and quality in different learning communities.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1:	*demonstrate the knowledge and skill gained through learning of professional/elective courses taken on SWAYAM portal*
CLO-2:	*able to develop the professional skill on the subject areas beyond his curriculum*
CLO-3:	*experience unique and independent learning opportunity*
CLO-4:	*expand his/her knowledge of a particular area(s) of interest to enhance employability*

Learning Assessment	*Student shall be allowed to choose one Swayam course on the recommendation of faculty advisor and appropriate credits will be transferred as per regulations 2021*
MOOCS	

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Course Code	PAS21I02L	Course Name	Internship	Course Category	I	Internship in Industry/higher technical institutions	L	T	P	C
							0	0	0	2

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Physics and Nanotechnology*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*assist the student's professional skill development useful to employer such as teamwork, communications and work ethics & details*
CLR-2:	*provide unique learning opportunities by exposing the student to the environment and expectations of professional performance*
CLR-3:	*expand the student's knowledge of a particular area(s) of interest to enhance employability*
CLR-4:	*help students to explore career alternatives/opportunities prior to their graduation*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1:	*demonstrate the skill gained through work experience with mentors or successful professionals to support the early stages of their career*

	Continuous Learning Assessment (50% weightage)		Final Evaluation (50% weightage)	
	Review – 1	Review – 2	Project Report	Viva-Voce
Internship	20%	30 %	30 %	20 %

Course Code	PCD21AE3T	Course Name	Employability Skills	Course Category	AE	Ability Enhancement Course	L	T	P	C
							1	0	0	1

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Career Development Centre*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*develop contextual approach to acquire new vocabulary*
CLR-2:	*establish clear relationship between words*
CLR-3:	*identify problems*
CLR-4:	*learn the fundamental skills to solve problems*
CLR-5:	*acquire experience of attending group discussion and personal interview*
CLR-6:	*equipping students with necessary employability skills*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:

Learning	1	2	3
	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3

CLO-1:	*determine the accurate meanings of words*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*recognise parallel relationship between words*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*learn to solve problems*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*understand and applies problem solving skills learned.*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*inculcate professional communication through Interviews & Group Discussions*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*acquirenecessary skills for successful career*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		**3**	**3**	**3**	**3**	**3**
S-1	**SLO-1**	Time & work	Time, speed, distance	Permutation and combination	Probability	Geometry and Mensuration
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-2	**SLO-1**	Perspective on Issues	Critical Reasoning	Synonyms	Antonyms	Word Analogy
	SLO-2	Perspective on Issues	Critical Reasoning	Synonyms	Antonyms	Word Analogy
S-3	**SLO-1**	Resume preparation	Group Discussion	Mock GD	Interview Techniques	Mock PI
	SLO-2	Resume preparation	Group Discussion	Mock GD	Interview Techniques	Mock PI

Learning Resources	6. Quantitative aptitude by Dinesh Khattar 7. Ramachandran and Karthik, From Campus to Corporate, India, PEARSON Publication, 2016.	8. Verbal Advantage – Ten Easy Steps to a Powerful Vocabulary – Charles Harrington Elster 9. Barron's GRE

Learning Assessment

	Bloom's Level of Thinking	**Continuous Learning Assessment (50% weightage)**								**Final Examination (50% weightage)**	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers

Experts from Industry	Internal Experts	
1.Mr. Ajay Zenne, Career Launcher,**ajay.z@careerlauncher.com**	*1.* Dr.P.Madhusoodhanan, SRMIST	2. Dr. A Clement, SRMIST
	3. Dr.M.Snehalatha, SRMIST	4. Dr.Jayapragash J, SRMIST
2.Mr.Pratap Iyer, Study Abroad Mentors, Mumbai,**pratap.iyer30@gmail.com**	5. Mr. Harinarayana Rao, SRMIST	6. Mr. P Priyanand, SRMIST
	7. Mrs. Kavitha Srisarann, SRMIST	

SEMESTER IV

Course Code	PAS21P01L	Course Name	**Project** Work	Course Category	P	Project Work	L	T	P	C
							0	0	24	12

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Physics and Nanotechnology*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*Apply fundamental and disciplinary concepts/techniques to their principal fields of research*
CLR-2:	*Apply knowledge and skills acquired through earlier course work to the professional field of study.*
CLR-3:	*Able to identify, analyze, and solve problems in novel techniques of research through critical investigation.*
CLR-4:	*Integrate information from multiple sources and carry out the projects within multiple design constraints*
CLR-5:	*Apply oral, written and communication skills*
CLR-6:	*Utilize the skills, hard work, and commitment to achieve lifelong learning.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1:	*Demonstrate intelligence, ability, diligence and application of scientific learning for personal, societal, and professional ethical standards.*

	Continuous Learning Assessment (50% weightage)		Final Evaluation (50% weightage)	
	Review – 1*	Review – 2*	Project Report*	Viva-Voce
Project Work	20%	30 %	30 %	20 %

**includes submission of project work in the form of paper for presentation/publication in a conference/journal and/or preliminary filing of a patent with proof.*

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