University of Kerala

Discipline	**PHYSICS**				
Course Code	**UK4DSEPHY200**				
Course Title	**ATMOSPHERIC THERMODYNAMICS**				
Type of Course	**DSE**				
Semester	**IV**				
Academic Level	**200 - 299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 Hrs	-	2 Hrs	5 Hrs
Pre-requisites	1. The students should have a basic understanding of atomic and molecular structure 2. The students must have a fundamental idea of phase change and latent heat 3. The students must be familiar with the phenomena of scattering, absorption etc.				
Course Summary	• The course gives a comprehensive understanding of atmospheric thermodynamics. The first module gives an introduction to electromagnetic spectrum and blackbody radiation. This module also describes the nature of solar radiation and the blackbody spectrum of sun and earth. Laws of thermodynamics are discussed in the second module and establishes hydrostatic and hypsometric equations which are used in arriving at stability criteria in the atmosphere. In the third module the concept of air parcel and various conditions in lifting an air parcel are introduced. The role of aerosols and clouds in the global energy budget and climate are discussed in the fourth module. The fifth module describes how				

	radiative equilibrium is achieved through the interaction of solar and outgoing long wavelength radiation with the atmosphere. • The practical course is designed to equip students with the skills needed to understand and apply the basic thermodynamics processes. The course also aims to understand and analyse the structure of earth atmosphere its absorption and emission based on the data collected from various sources

BOOKS FOR STUDY:

1. Atmospheric Science : An Introductory Survey : Second Edition, John M Wallace and Peter V. Hobbs, ELSEVIER, 2006
2. Basis of Atmospheric Science, A Chandrasekhar, PHI., 2010
3. Physics of the Atmosphere and Climate : Murry L. Salby, Cambridge University Press

BOOKS FOR REFERENCE:

1. Essentials of Meteorology : An Invitation to the Atmosphere, C. Donald Ahrens
2. An Introduction To Atmospheric Physics, Cambridge University Press, Second Edition, David G. Andrews, 2010
3. Atmospheric Aerosols Properties and Climate Impact, Olivier Boucher, © Springer, 2015.

DETAILED SYLLABUS: THEORY

Module	Unit	Content	Hrs	CO No
I		**Solar and Terrestrial Radiation (Book : 1 – Chapter: 4; Book : 2 – Chapter: 4)**	**9**	
	12	Electromagnetic Spectrum – Atomic and Molecular Spectra- Black body Radiation	1	1
	3	Ideal gas equation	1	1
	4	Laws of Radiation –Kirchoff's Law- emissivity, absorptivity, reflectivity, transmittivity	2	1
	5	Wien's Displacement Law, Stefan's Law, Planck's Law	2	1
	6	Nature of Solar Radiation, Blackbody Spectrum of Sun and Earth	2	1
	7	Radiometric quantities – Spectral Radiance, Radiance, Spectral Irradiance, Irradiance	1	1

II	**Thermodynamics of the Atmosphere (Book : 1 – Chapter: 3, Book : 2 – Chapter: 3)**		**9**	
	8	Thermodynamic System, State variables	1	3
	9	First law of thermodynamics, Internal Energy, Heat capacity, Latent Heat, Adiabatic processes	1	3
	10	Reversible and irreversible processes, Second Law of Thermodynamics, Entropy	1	3
	11	Hydrostatic Equation, Geopotential, Scale height and Hypsometric equations	3	3
	12	Stability Criteria – stable, neutral and unstable	3	3
III	**Moisture and Atmospheric Stability (Book : 1 – Chapter: 3; Book : 2 – Chapter: 3)**		**9**	
	13	Hydrologic Cycle	1	3
	14	Moisture Variables	1	3
	15	Concept of an air parcel	1	3
	16	Processes that lift air – Orographic lifting, Frontal Lifting, Convergence, Localized convective lifting	1	3
	17	Adiabatic Lapse Rate, Saturated Adiabatic Lapse Rate	1	3
	18	Atmospheric Stability- Types of stability- Absolute Stability, Absolute Instability	2	3
	19	Concept of Static Stability- Unsaturated Air – Static Stability, Saturated Air- Conditional and Convective Instability	2	3
IV	**Aerosols and Clouds (Book : 3 – Chapter: 9; Book : 1 – Chapter: 5,6)**		**9**	
	20	Morphology of atmospheric aerosol - Continental aerosol, marine aerosol and stratospheric aerosol	2	2
	21	Microphysics of Clouds - Droplet growth by condensation and collision, Growth of ice particles	2	2
	22	Macroscopic Characteristics of cloud- Formation and classification, microphysical properties, Cloud dissipation	1	2

	23	Radiative transfer in aerosol and cloud - Scattering by molecules and particles, Radiative transfer in a cloudy atmosphere	2	2
	24	Roles of cloud and aerosol in climate - Involvement in the global energy budget, Involvement in chemical processes	2	2
V*	**Interaction of Radiation with Atmosphere (Book : 1 – Chapter: 4)**		**9**	
	25	Solar short wavelength radiation and Outgoing Long wavelength Radiation	1	4
	26	Absorption of Solar Radiation by Atmosphere- Radiative Transfer –Beer Lambert's Law	2	4
	27	Atmospheric Window	2	4
	28	Scattering and emission of Solar Radiation	2	4
	29	Radiative Equilibrium of Earth, Global Mean energy Balance, Horizontal Distribution of Radiative transfer	2	4

DETAILED SYLLABUS: PRACTICALS

Part A – At least 5 Experiments to be performed		**CO No**
Sl No	**Name of Experiment**	
1	To determine the melting point of ice and boiling point of water.	5
2	The effect of salt on the Boiling point of Water	5
3	To determine the specific heat capacity of a given solid by the method of mixtures.	5
4	Phase transition-determination of melting point of wax	5
5	Plotting of Solar irradiance data	6
6	Plotting of Outgoing Longwave Radiation	6
7	Plotting of vertical profile of atmospheric temperature and pressure over various locations	6
8	Study of Solar Spectrum	6

Part B* – At least One Experiment to be performed		
9	Study of photoelectric effect and determination of Planck's constant	6
10	Determination of Stefan's constant	6

COURSE OUTCOMES

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Review the basics of black body radiation and radiation laws	R	PSO-1,3
CO-2	Distinguish the cloud microphysics and interpret the morphology of aerosols and impact of aerosols in climate	U	PSO-1,3
CO-3	Remember the concept of thermodynamics and apply in to the atmosphere system to establish the stability criteria of the atmosphere and the factors affecting stability	R, U, Ap	PSO-1,3
CO-4	Discuss the process of absorption, emission and scattering of radiation in the planetary atmosphere	U	PSO-1,3
CO-5	Employ the basic thermodynamics concepts of boiling point, melting point, phase change, etc and elucidate the thermodynamics laws	U, Ap	PSO-1,3,7
CO-6	Analyse the variation in the structure of atmosphere and solar spectrum and Estimate the changes in the incoming and outgoing radiation	U, An	PSO-1,3,7

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ATMOSPHERIC THERMODYNAMICS

Credits: 3:0:1 (Lecture: Tutorial: Practical)

CO No.	CO	PO / PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
CO-1	Review the basics of black body radiation and radiation laws	PO1,2/ PSO-1,3	R	F	L	-
CO-2	Distinguish the cloud microphysics and interpret the morphology of aerosols and impact of aerosols in climate	PO1/ PSO-1,3	U	C	L	-
CO-3	Remember the concept of thermodynamics and apply in to the atmosphere system to establish the stability criteria of the atmosphere and the factors affecting stability	PO1,2/ PSO-1,3	R,U, Ap	F,C	L	-
CO-4	Discuss the process of absorption, emission and scattering of radiation in the planetary atmosphere	PO1/ PSO-1,3	U	C	L	-

CO-5	Employ the basic thermodynamics concepts of boiling point, melting point, phase change, etc and elucidate the thermodynamics laws	PO1,2,3/ PSO-1,3,7	U, Ap	C,P	-	P
CO-6	Analyse the variation in the structure of atmosphere and solar spectrum and Estimate the changes in the incoming and outgoing radiation	PO1,2,3/ PSO-1,3,7	U, An	C,P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO-1	1	-	2	-	-	-		1	2	-	-	-	-	-	-
CO-2	2	-	2	-	-	-		1	-	-	-	-	-	-	-
CO-3	2	-	2	-	-	-	-	2	2	-	-	-	-	-	-
CO-4	2	-	2	-	-	-	-	2	-	-	-	-	-	-	-
CO-5	1	-	2	-	-	-	2	2	2	2	-	-	-	-	-
CO-6	1	-	2	-	-	-	2	2	2	2	-	-	-	-	-

Correlation Levels:

Level	-	1	2	3
Correlation	Nil	Slightly / Low	Moderate / Medium	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

CO No	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO-1	✓	-	-	✓
CO-2	✓	-	-	✓
CO-3	✓	✓	-	✓
CO-4	✓	✓	-	
CO-5	✓	-	-	-
CO-6	✓	-	-	-