ARSD College, University of Delhi

Lesson Plan

Course Name : B.Sc. (Hons) Mathematics						
Semester	**Course Code**	**Course Title**	**Lecture (L)**	**Tutorial (T)**	**Practical (P)**	**Credit (C)**
VI	32357609 (UPC)	DSE-3 (iii): Biomathematics CBCS (LOCF)	5	1	0	6
Teacher/Instructor(s)		ANIL KUMAR RAJAK				
Session		2021-22				

Course Objective:

The focus of the course is on scientific study of normal functions in living systems. The emphasis is on exposure to nonlinear differential equations with examples such as heartbeat, chemical reactions and nerve impulse transmission. The basic concepts of the probability to understand molecular evolution and genetics have also been applied.

Course Learning Outcomes: Apropos conclusion of the course will empower the student to:

- Learn the development, analysis and interpretation of bio mathematical models such as population growth, cell division and predator prey models.
- Learn about the mathematics behind heartbeat model and nerve impulse transmission model.
- Appreciate the theory of bifurcation and chaos.
- Learn to apply the basic concepts of probability to molecular evolution and genetics.

Lesson Plan:

Unit No.	Learning Objective	Lecture No.	Topics to be covered
1.	Modeling Biological Phenomenon	1	Population growth and its illustration
		2-3	Administration of drugs and their illustration through examples
		4	Cell Division and illustration through examples
		5	Systems of linear ordinary differential equations.
		6-7	Heartbeat
		8-9	Nerve impulse Transmission
		10	Exercise questions discussion
		11-12	Chemical reactions (Law of Mass Action) and illustration through exercise questions
		13-15	Predator-prey models and exercise questions discussion
2.	Mathematics of Heart Physiology and Nerve Impulse Transmission	16	Epidemics (mathematical model), The Phase Plane
		17	Phase Plane and Jacobian Matrix
		18-20	Local Stability
		21-22	Stability and their illustrations
		23-24	Limit Cycles and its illustrations
		25	Exercise questions discussion

		26	Limit Cycle Criterion and Poincare-Bendixson Theorem
		27	Illustration with examples
		28-29	Forced Oscillations and its illustrations
		30	Exercise questions discussion
		31	Mathematics of heart physiology : The local model
		32	The threshold effect and illustration.
		33-35	The phase plane analysis and the heartbeat model
		36-37	A model of the cardiac pacemaker
		38-40	Excitability and repetitive firing
		41	Travelling Waves
		42	Exercise questions discussion
3.	Bifurcation and Chaos	43-44	Bifurcation and its illustration through examples
		45	Bifurcation of a limit cycle and illustration through examples, Hopf Bifurcation
		46-47	Discrete bifurcation and period-doubling
		48-49	Chaos and its illustrations
		50	Stability of limit cycles
		51-53	The Poincare Plane and illustration through examples
		54-55	Examples and exercise questions discussion
4.	Modeling Molecular evolution and Genetics	56	Matrix models of base substitutions for DNA sequences
		57	Jukes -Cantor model
		58	Kimura models
		59	Phylogenetic distances
		60	Examples and exercise questions discussion
		61	Constructing phylogenetic tree: Phylogenetic trees
		62-63	Unweighted pair-group method with arithmetic means (UPGMA) and illustration with examples
		64-65	Neighbor joining method and illustration with examples
		66	Genetics: Mendelian genetics
		67-68	Probability distributions in genetics
		69-70	Doubt discussion and exercise questions discussion

Evaluation Scheme:

No.	Component	Duration	Marks
1.	Internal Assessment		25
	• Quiz		
	• Class Test		
	• Attendance		
	• Assignment		
2.	End Semester Examination	3 hr	75

Details of the Course		
Unit	**Contents**	**Contact Hours**
I	**Modeling biological phenomenon**: Population growth, administration of drugs cell division, system of linear ordinary differential equations, heartbeat, nerve impulse transmission, chemical reactions, predator prey model	15
II	**Mathematics of Heart Physiology and Nerve Impulse Transmission:** Stability and oscillations: epidemics, Phase plane and Jacobian matrix, Local	27

	Stability, Stability, Limit Cycles, forced oscillations, Mathematics of heart physiology: Local Models, Threshold effect, Phase Plane analysis and heartbeat model, A model of the cardiac pacemaker, Mathematics of Nerve impulse transmission: excitability and repetitive firing, Travelling waves.	
III	**Bifurcation and Chaos:** Bifurcation, Bifurcation of a limit cycle, Discrete bifurcation and period-doubling, Chaos, Stability of limit cycles, Poincare Plane	13
IV	**Modeling Molecular Evolution and Genetics:** Modeling Molecular Evolution: Matrix models of base substitutions for DNA sequences, Jukes-Cantor model, Kimura model, Phylogenetic distances; constructing Phylogenetic Trees: Phylogenetic trees, Unweighted pair-group method with arithmetic mean (UPGMA) , Neighbor joining method; Genetics: Mendelian genetics, Probability distributions in genetics	15
	Total	**70**

Suggested Books:

Sl. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Allman, Elizabeth S., & Rhodes, John A. Mathematical Models in Biology: An Introduction. Cambridge University Press.	2004
2.	Jones, D. S., Plank, M.J., & Sleeman, B.D. Differential Equations and Mathematical Biology (2nd ed.), CRC Press, Taylor & Francis Group, LLC. Narosa Publishing House, New Delhi.	2009
	Additional Readings	
3.	Murray, J.D. An Introduction to Mathematical Biology (3rd ed.) Springer	2002
4	Myint-U, Tyn, Ordinary Differential Equations, Elsevier North-Holland, Inc	1977
5	Simmons, George F., & Krantz, Steven G. Differential Equations, MacGraw-Hill Education, Indian Reprint	2015
6	Strogatz, Steven H. Nonlinear Dynamics and Chaos (2nd ed.) Perseus Book Publishing LLC, Sarat Publication, Kolkata, India	2009

Mode of Evaluation:	Internal Assessment / End Semester Exam

Progress Report:

Unit No.	Learning Objective	Date	Topics to be covered
1.	Modeling Biological Phenomenon		Population growth and its illustration
			Administration of drugs and their illustration through examples
			Cell Division and illustration through examples
			Systems of linear ordinary differential equations.
			Heartbeat
			Nerve impulse Transmission
			Exercise questions discussion
			Chemical reactions (Law of Mass Action) and illustration through exercise questions
			Predator-prey models and exercise questions discussion
2.	Mathematics of Heart Physiology and Nerve Impulse Transmission		Epidemics (mathematical model), The Phase Plane
			Phase Plane and Jacobian Matrix
			Local Stability
			Stability and their illustrations
			Limit Cycles and its illustrations
			Exercise questions discussion
			Limit Cycle Criterion and Poincare-Bendixson Theorem
			Illustration with examples
			Forced Oscillations and its illustrations
			Exercise questions discussion
			Mathematics of heart physiology : The local model
			The threshold effect and illustration.
			The phase plane analysis and the heartbeat model
			A model of the cardiac pacemaker
			Excitability and repetitive firing
			Travelling Waves
			Exercise questions discussion
3.	Bifurcation and Chaos		Bifurcation and its illustration through examples
			Bifurcation of a limit cycle and illustration through examples, Hopf Bifurcation
			Discrete bifurcation and period-doubling
			Chaos and its illustrations
			Stability of limit cycles
			The Poincare Plane and illustration through examples
			Examples and exercise questions discussion
4.	Modeling Molecular Evolution and Genetics		Matrix models of base substitutions for DNA sequences
			Jukes -Cantor model
			Kimura models
			Phylogenetic distances
			Examples and exercise questions discussion
			Constructing phylogenetic tree: Phylogenetic trees
			Unweighted pair-group method with arithmetic means (UPGMA) and illustration with examples
			Neighbor joining method and illustration with examples
			Genetics: Mendelian genetics
			Probability distributions in genetics
			Doubt discussion and exercise questions discussion