

List of DC Courses for B. Tech and Dual Degree B. Tech + M. Tech in Mathematics and Computing

	Course Number	Courses	L	T	P	C	Remarks
1	EEL 308	Computer Architecture	3	0	0	3	DC in MT5
2	EEP 308	Digital Systems Lab (Arch + Embedded)	0	0	3	1.5	DC in MT5
3	MAL 102	Differential Equations	3	0	0	3	New
4	MAL 103	Optimization Methods and Applications	3	0	0	3	DE in MT5
5	MAL 104	Linear Algebra and Applications	3	0	0	3	DC in MT5
6	MAL 105	Algebra	3	0	0	3	DE in MT5
7	MAL 106	Probability and Stochastic Processes	3	1	0	4	DC in MT5
8	MAL 107	Numerical Methods and Computation	3	0	0	3	DC in MT5
9	MAL 122	Real and Complex Analysis	3	1	0	4	DC in MT5
10	MAL 180	Discrete Mathematical Structures	3	1	0	4	DC in MT5
11	MAL 342	Analysis and Design of Algorithms	3	1	0	4	DC in MT5
12	MAL 358	Operating Systems	3	0	2	4	DC in MT5
13	MAL 383	Theory of Computation	3	0	0	3	New
14	MAL 390	Statistical Methods	3	1	0	4	DC in MT5
15	MAL 411	Functional Analysis	3	0	0	3	New
16	MAL445	Computational Methods for Differential Equations	3	0	2	4	New
17	MAL 782	Data Mining	3	0	2	4	DE in MT5
18	MAP 290	Computing Laboratory	0	0	4	2	DC in MT5
19	MAD 833	Project (BTP)	0	0	8	4	
	Total Credit					63.5	

(B.S. Panda)
HOD Maths

COURSE TEMPLATE

1.	Department /Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	BTP 1
3.	L-T-P structure	0 - 0 - 8
4.	Credits	4
5.	Course number	MAD 333
6.	Status (<i>category for program</i>)	DC

7.	Pre-requisites (<i>course no./title</i>)	120 EC
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NO

9.	Not allowed for (<i>indicate program names</i>)	Any programme other than MT6
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course All Faculty Members of the Department	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To carryout innovative work on the assigned topic.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): contents will be related to topic related to the courses undertaken by the student in the programme.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
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12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	As per project
19.2	Hardware	Computing machines
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	Computing Laboratory
19.5	Equipment	computing lab with some softwares depends on project
19.6	Classroom infrastructure	NIL

19.7	Site visits	NIL
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20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	100%
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 3-1-2013

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	DIFFERENTIAL EQUATIONS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 102
6.	Status (<i>category for program</i>)	DC for Maths and PLC for Others

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 260
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Harish Kumar, VVK Srinivas Kumar, Mani Mehra, SCS Rao, K.Sreenadh	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce the basic concepts of well-posedness, stability and qualitative properties of solutions of initial and boundary value problems of Ordinary and Partial Differential equations. Strength of these concepts in engineering and real world problems will be highlighted.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Systems of differential equations, Existence and uniqueness theorems for initial value problems of semilinear and nonlinear ODEs, continuous dependence and well-posedness; Comparison theorems of Sturm, Sturm-Liouville eigenvalue problems; Phase-plane analysis, Linear and Non-linear stability, Liapunov functions and applications; First order Partial differential equations, Method of characteristics, local and global solutions, envelope of solutions, complete and general solutions; Second order equations: Heat and Wave equation, fundamental solutions, method of eigenfunctions, Duhamel's principle. Maximum principles for Heat and Laplace equation, Green's functions.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Systems of differential equations, fundamental matrix.	4
2	Existence and uniqueness theorems, Grownwalls inequality, uniqueness and well-posed ness of initial value problems.	4
3	Comparison theorems of Sturms, Sturm-Liouville eigenvalue problems, existence of eigenvalues, eigenfunctions and some qualitative properties.	4
4	Phase-plane analysis, Linear stability.	4
5	Nolinear stability, Liapunov functions and applications.	4
6	First order Partial differential equations, envelop of solutions, complete and general solutions.	2
7	Method of characteristics for linear and semilinear first order PDE	3
8	Methods for solving second order equations, heat and wave equations in one variable, heat kernals and elementary solutions	4
9	D'Alembert's formula, weak solutions, Duhamels principle.	3
10	Maximum priciples and Green's functions for Heat and Laplace equations	4
11	Problems solving sessions outlined in the lecture classes	6
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- 1.G.F.Simmons, Differential equations with applications and historical notes, Tata Mc Graw Hill, 2011
2. R.C.McOwen, Partial Differential Equations: Methods and Applications, Printice Hall, 2004
- 3.L.C. Evans, Partial Differential Equations: Second Edition (Graduate Studies in

Mathematic), AMS, 2002

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Nil
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Nil
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	Microphone, Blackboard and Projector.
19.7	Site visits	Nil

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Nil
20.2	Open-ended problems	Nil
20.3	Project-type activity	10%
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	OPTIMIZATION METHODS AND APPLICATIONS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 103
6.	Status (<i>category for program</i>)	DC for Maths and PLC for Others

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 526
8.2	Overlap with any UG/PG course of other Dept./Centre	CHL 774, MEL 221
8.3	Supercedes any existing course	MAL 210

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B Chandra, S Dharmaraja, Aparna Mehra, B S Panda, SCS Rao	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): This is the first course in optimization designed to provide a quantitative approach to study various models and methods of linear programming and nonlinear programming. The course aims to demonstrate how the powerful capabilities of optimization can enable in reducing costs, improving efficiency, using resources effectively and providing benefits in many other key dimensions in engineering / industry / managerial / decision making problems.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Linear programming - formulation through examples from engineering / business decision making problems, preliminary theory and geometry of linear programs, basic feasible solution, simplex method, variants of simplex method. Duality and its principles, interpretation of dual variables, dual simplex method. Linear integer programming, applications in real decision making problems, methods to solve linear integer programs, transportation problems: theory and methodology, assignment problems. Zero-sum matrix games, saddle point,	
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	linear programming formulation of matrix games, network optimization problems LPP formulation. Nonlinear programming, Lagrange function, KKT optimality conditions, sufficiency of KKT under convexity, quadratic programming, Wolfe's method, applications of quadratic programs.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Linear programming problems (LPP), formulations, notion of optimal solution, graphical interpretation of optimality	2
2	Convex sets, convex functions in context of LPP, extreme point, basic feasible solutions (BFS), fundamental theorem of LPP, relationship between extreme point of feasible set and BFS of LPP.	5
3	Initial BFS and a method of improving current BFS, simplex algorithm, artificial variable and its interpretation in context of feasibility, case of unbounded LPP, two phase method.	8
4	Dual linear program, duality theorems, complementary slackness theorem, Economic interpretation of dual variables, dual simplex method.	5
5	Linear integer program, applications, cutting plane algorithm, branch and bound algorithm	6
6	Transportation programming problems (TPP), uni-modular matrix, optimal solution of TPP, assignment problems, Hungarian Method	5
7	Matrix games, notion of saddle point, rule of dominance, LPP and matrix game equivalence, Network optimization, formulation (only) of network optimization problems as LPP.	3
8	Nonlinear programming, Lagrange function, KKT optimality conditions, sufficiency of KKT under convexity	3
9	Quadratic programming problems (QP), Wolfe's method, dual of QP, applications of QP in support vector machines and other related areas	5
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. V Chvatal, Linear Programming, W. H. Freeman Publishers, 1983.
2. M S Bazarra, J J Jarvis, H D Sherali, Linear Programming and Network Flows, Wiley, 2009.
3. H A Taha, Operations Research: An Introduction, 9TH ED., Pearson, 2006.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Nil
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Nil
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	Microphone, Blackboard and Projector.
19.7	Site visits	Nil

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Nil
20.2	Open-ended problems	Nil
20.3	Project-type activity	15% (Some assignments involving understanding, modeling and solving some real life problems, like case study, can be included along side the regular exams. Also, some computer programming base assignments can be designed).
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	80-90% theory based analytic examples/problems

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	LINEAR ALGEBRA AND APPLICATIONS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 104
6.	Status (<i>category for program</i>)	DCfor Maths and PLC for Others

7.	Pre-requisites (course no./title)	MAL 101
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 503
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 255

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course S. Kundu, R. Sarma, A. Tripathi , SCS Rao and many others.	
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12.	Will the course require any visiting faculty?	No
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13.	Course objective (<i>about 50 words</i>): Basic linear algebra is introduced in the first year course MAL101. MAL255 is designed for mathematics and computing students to have exposure of linear algebra beyond introduction. Application of cetrtain topics of linear algebra in mathematics is also included.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduce Fields: fields of numbers, finite fields. Review basis and dimension of a vector space, linear transformations, eigenvalue and eigenvector of an operator. LU Factorization. Some applications giving rise to Linear Systems Problems Dual and double dual of a vector space and transpose of a linear transformation. Diagonalizability of linear operators of finite dimensional vector spaces, simultaneous triangulization and simultaneous diagonalization. The primary decomposition theorem - diagonal and nilpotent parts.	
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	Inner product spaces, Gram-Schmidt orthogonalization, best approximation of a vector by a vector belonging a given subspace and application to least square problems. Adjoint of an operator, hermitian, unitary and normal operators. Singular Value Decomposition and its applications. Spectral decomposition. Introduction of bilinear and quadratic forms.
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15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Fields: Subfields of the field of complex numbers, Finite fields.	2
2	Review basis and dimension of a vector space, linear transformations, eigenvalue and eigenvector of an operator. LU Factorization. Some applications giving rise to Linear Systems Problems	5
3	Dual and double dual of a vector space and transpose of a linear transformation.	2
4	Diagonalizability of linear operators of finite dimensional vector spaces, simultaneous triangulization and simultaneous diagonalization.	5
5	The primary decomposition theorem - diagonal and nilpotent parts.	4
6	Inner product spaces, Gram-Schmidt orthogonalization, best approximation of a vector by a vector belonging a given subspace and application to least square problems.	5
7	Adjoint of an operator, Self adjoint operators.	4
8	Hermitian, unitary and normal operators.	5
9	Spectral decomposition.	4
10	Singular Value Decomposition and its applications.	3
11	Introduction of bilinear and quadratic forms.	3
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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COURSE TOTAL (14 times 'P')		####

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. K. Hoffman and R. Kunze, Linear Algebra(2e), Prentice Hall India, 1989.
2. David C. Lay, Linear Algebra and its applications, third edition, Pearson, 2006.
3. Serge Lang, Linear Algebra (undergraduate text in mathematics), 3rd edition, Springer, 1987.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Nil
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Nil
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	Microphone, Blackboard and Projector.
19.7	Site visits	Nil

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Nil
20.2	Open-ended problems	Nil
20.3	Project-type activity	10%
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	ALGEBRA
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 105
6.	Status (<i>category for program</i>)	DC for Maths and PLC for Others

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 256

9.	Not allowed for (indicate program names)	NII
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course R Barman, S Kundu, R.K. Sharma, R. Sarma, A. Tripathi	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): Introduction to certain abstract notions of modern algebra.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Preliminaries: Equivalence relations and partitions; Groups: Subgroups, Cyclic groups, Abelian groups, permutation groups; Lagrange's theorem, normal subgroups, quotient groups, isomorphism theorems. Direct product of groups, structure theorem of finitely generated abelian groups, Sylow's theorems and applications. Rings: Definition and examples, units and zero divisors. Ideals and quotients, principal ideals, prime ideals, maximal ideals, integral domain, PID, Euclidean domain, UFD. Modules over a commutative ring with unity: Free module, quotient module, exact sequences. Fields: Finite fields, field extensions, splitting fields.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Equivalence relation and partition.	2
2	Groups and subgroups, Cyclic groups, Abelian groups, permutation groups.	4
3	Lagrange's theorem, normal subgroup, quotient groups, isomorphism theorems.	6
4	Direct product of groups, structure theorem of finitely generated abelian groups.	4
5	Sylow's theorems and applications	5
6	Definition and examples of ring, units and zero divisors, ideals and quotients, principal ideal, prime ideal, maximal ideal, integral domain.	6
7	PID, Euclidean domain, UFD.	4
8	Free module, quotient module, exact sequences	4
9	Finite fields, field extensions, splitting field.	7
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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2		
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. I N Herstein, Topics in Algebra, 2nd Edition, Wiley India Pvt Ltd, 2006.
2. J A Gallian, Contemporary Abstract Algebra, 4th Edition, Narosa Book Distributors Private Ltd, 2004.
3. M Artin, Algebra, 2nd Edition, Pearson, 2010

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Nil
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Nil
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	Microphone, Blackboard and Projector.
19.7	Site visits	Nil

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Nil
20.2	Open-ended problems	Nil
20.3	Project-type activity	Nil
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	INTRODUCTION TO PROBABILITY THEORY AND STOCHASTIC PROCESS
3.	L-T-P structure	3 - 1 - 0
4.	Credits	4
5.	Course number	MAL 106
6.	Status (<i>category for program</i>)	DC for Maths and PLC for Others

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 140 , MAL 509 , MAL 725
8.2	Overlap with any UG/PG course of other Dept./Centre	EEL 433
8.3	Supercedes any existing course	MAL 250

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course S DHARMARAJA, NILADRI CHATTERJEE, APARNA MEHRA	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): The aim of the course is to provide the students with explanations and expositions of probability, stochastic processes concepts and theoretical concepts pertaining to handling various stochastic modeling	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Axioms of probability, Probability space, Conditional probability, Independence, Bayes' rule, Random variable, Some common discrete and continuous distributions, Distribution of Functions of Random Variable, Moments, Generating functions, Two and higher dimensional distributions, Functions of random variables, Order statistics, Conditional distributions, Covariance, correlation coefficient, conditional expectation, Modes of convergences, Laws of large numbers, Central limit theorem, Definition of Stochastic process, Classification and properties of stochastic processes, Simple Markovian stochastic processes, Gaussian processes, Stationary	
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	processes, Discrete and continuous time Markov chains, Classification of states, Limiting distribution, Birth and death process, Poisson process, Steady state and transient distributions, Simple Markovian queuing models (M/M/1, M/M/1/N, M/M/c/N, M/M/N/N, M/M/∞).
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Axioms of probability, Probability space, Conditional probability, Independence, Bayes' rule	4
2	Random Variable, Some common discrete and continuous distributions, Distribution of Functions of Random Variable	6
3	Moments, Generating functions	4
4	Two and higher dimensional distributions, Functions of random variables, Order statistics, Conditional distributions	6
5	Covariance, correlation coefficient, conditional expectation	4
6	Modes of convergences, Laws of large numbers, Central limit theorem	4
7	Definition, Classification, properties, Simple Markovian stochastic processes, Gaussian processes, Stationary processes	3
8	Definition, Classification of states, Limiting distribution	3
9	Definition, Birth and death process, Poisson process, Steady state and transient distributions	4
10	M/M/1, M/M/1/N, M/M/c/N, M/M/N/N, M/M/ ∞	4
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		####

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. P L Mayer, Introductory Probability and Statistical Applications, Addison-Wesley, 1966.
2. K S Trivedi, Probability and Statistics with Reliability, Queueing and Computer Science Applications, Wiley, second edition, 2001.
3. S M Ross, Introduction to Probability Models, Academic Press, ninth edition, 2000.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Nil
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Nil
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	Microphone, Blackboard and Projector.
19.7	Site visits	Nil

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	Nil
20.2	Open-ended problems	Nil
20.3	Project-type activity	Nil
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	70-80% theory and 20-30% theory based analytic examples/problems.

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	NUMERICAL METHODS AND COMPUTATIONS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 107
6.	Status (<i>category for program</i>)	DC for Maths and PLC for Others

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 524
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL 361
8.3	Supercedes any existing course	MAL 230

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course S.C.S.Rao, V.V.K. Srinivas Kumar, Mani Mehra, Harish Kumar, N Shravan Kumar	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce basic numerical methods and its error analysis useful for scientific computations.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Errors in computation: source and types of errors, error propagation. computer representation of numbers: floating point representation, rounding error and floating point arithmetic. Roots of nonlinear equation in one variable: Direct and iterative methods, order of convergence. Iterative methods for roots of nonlinear system of equations. Linear systems of equations: Direct and iterative methods, rate of convergence of iterative methods, Condition number and ill-conditioned systems. Interpolation: Lagrange, Newton divided difference formula, Newton's interpolations, errors in interpolation. Approximation: least square and uniform approximations. Differentiation: differentiation using interpolation formulas. Integration using interpolation: Newton-Cotes formulas,	
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	Gauss quadrature rules. Ordinary differential equations: Taylor, Euler and Runge-Kutta methods. Implementation of these methods.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Errors: sources and types of errors, error propagation Computer representation of numbers: floating point representation, rounding error and floating point arithmetic.	2
2	Roots of nonlinear equation in one variable: direct and iterative methods, order of convergence.	3
3	Iterative methods for roots of nonlinear systems of equations.	3
4	Linear systems of equations direct and iterative methods.	3
5	Rate of convergence of iterative methods,	3
6	Condition number and ill- conditioned of systems.	3
7	Interpolation: Lagrange, Newton divided difference formula, Newton's interpolations.Errors in interpolation.	4
8	Approximation: least square and uniform approximations.	4
9	Differentiation: differentiation using interpolation formulas.	3
10	Integration using interpolation: Newton-Cotes formulas, Gauss quadrature rules.	4
11	Ordinary differential equations: Taylor, Euler and Runge-Kutta methods.	4
12	Problems outlined in the lectures will be solved during the Tutorial sessions.	6
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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COURSE TOTAL (14 times 'P')		####

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Elementary Numerical Analysis: Algorithmic Approach, Samuel D. Conte, Boor.
2. Numerical Analysis (9th Ed.), Richard L. Burden, J. Douglas Faires, 2011.
3. Numerical Methods for Engineers (5th Ed.), S.C. Chapra, R.P. Canale, McGraw Hill, 2007.
4. Elementary Numerical Analysis (3e) K. Atkinson, W. Han wiley India, 2004.

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Projector, black board.
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	REAL AND COMPLEX ANALYSIS
3.	L-T-P structure	3 - 1 - 0
4.	Credits	4
5.	Course number	MAL 122
6.	Status (<i>category for program</i>)	DC

7.	Pre-requisites (<i>course no./title</i>)	MAL 100, MAL 101
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 513, MAL 514
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL122

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course S. Kundu, A. Tripathi, A. Nagar, K. Sreenadh, S. Sampath, Shravan Kumar, A. Priyadarshi	
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12.	Will the course require any visiting faculty?	No
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13.	Course objective (<i>about 50 words</i>): To introduce the basic concepts of metric spaces and complex analysis.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Metric spaces: Definition and examples. Open, closed and bounded sets. Interior, closure and boundary. Convergence and completeness. Continuity and uniform continuity. Connectedness, compactness and separability. Heine-Borel theorem. Pointwise and uniform convergence of real-valued functions. Equicontinuity. Ascoli-Arzelà theorem. Limits, continuity and differentiability of functions of a complex variable. Analytic functions, the Cauchy-Riemann equations. Definition of contour integrals, Cauchy's integral formula and derivatives of analytic functions. Morera's and Liouville's theorems. Maximum modulus principle. Taylor and Laurent series. Isolated singular points and residues. Cauchy's residue theorem and applications.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Metric spaces: Definition and examples. Open, Closed and Bounded sets. Interior, Closure and Boundary.	5
2	Convergence and Completeness. Continuity and Uniform Continuity.	4
3	Connectedness, Compactness and Separability. Heine-Borel Theorem.	6
4	Pointwise and Uniform Convergence. Equicontinuity. Ascoli-Arzelà theorem.	6
5	Limits, continuity and differentiability of functions of a complex variable. Analytic functions, the Cauchy-Riemann equations.	4
6	Definition of contour integrals, Cauchy's integral formula and derivatives of analytic functions.	5
7	Morera's theorem and Liouville's theorem. Maximum modulus principle.	4
8	Taylor and Laurent series. Isolated singular points and residues.	5
9	Cauchy's residue theorem and applications.	3
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Problems based on the topics covered in the lecture classes will be discussed during the tutorial sessions.

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. C. D. Aliprantis and O. Burkinshaw, Principles of Real Analysis, 3rd Edition, Academic Press, 1998.
2. J.W. Brown and R.V. Churchill, Complex Variables and Applications, 8th Edition, McGraw Hill, 2009.
3. Walter Rudin, Principles of Mathematical Analysis, 3rd Edition, McGraw Hill, 1976.

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Microphone and Black Board
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	DISCRETE MATHEMATICAL STRUCTURES
3.	L-T-P structure	3 - 1 - 0
4.	Credits	4
5.	Course number	MAL 180
6.	Status (<i>category for program</i>)	DC

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 705
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL 105
8.3	Supercedes any existing course	MAL 180

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B S Panda, A. Tripathi, Rupam Barman, A.Mehra, Niladri Chatterjee	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce proof techniques, certain discrete structures and their theories, the role of discrete structure in applications.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Logic : Propositional Logic: language of propositional logic, truth table, natural deduction, predicate logic: language of predicate logic, Logical inference with Quantifiers. Proof techniques: Introduction to different standard proof techniques. Set Theory: Review of Basic Set Operations, cardinality of a set. Relations : Types of relations, operations of relations and applications, Poset, topological ordering; Congruence arithmetic; Combinatorics : Counting techniques: Pigeon Hole principle, inclusion exclusion principle, recurrence relation and generating function;	
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	Graph Theory : Graph as a discrete structure, Modeling applications using graphs, Hamiltonian graphs, Planar graphs, Graph coloring, Matching;
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Logic: Propositional and predicate	6
2	Proof techniques	2
3	Set Theory and Relations and their application	4
4	Congruence arithmetic	4
5	Combinatorics: Counting techniques	4
6	Recurrence relation, generating function	3
7	Basics of graphs and their representations	4
8	Trees	3
9	Hamiltonian, Eulerian, and planar graphs	5
10	Coloring, matching	5
11		2
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Problems based on the topics covered in the lecture classes will be discussed during the tutorial sessions.

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. K.H. Rosen, Discrete Mathematics and its applications, McGraw Hill International edition, 4th edition, 1999.
2. Trembly and Manohar, Discrete Mathematical Structures with applications to computer science, TMH, 1997.
3. C.L. Liu, Elements of Discrete Mathematics, McGraw Hill, 1968.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Nil
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Nil
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	Black board, Microphone.
19.7	Site visits	Nil

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	Nil
20.2	Open-ended problems	Nil
20.3	Project-type activity	Nil
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	ANALYSIS AND DESIGN OF ALGORITHMS
3.	L-T-P structure	3 - 1 - 0
4.	Credits	4
5.	Course number	MAL 342
6.	Status (<i>category for program</i>)	DC

7.	Pre-requisites (<i>course no./title</i>)	MAL 180
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL 356
8.3	Supercedes any existing course	MAL 342

9.	Not allowed for (<i>indicate program names</i>)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B S Panda, Niladri Chatterjee	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce some models of computation, the techniques for analyzing algorithms, specific algorithm design methods such as the greedy method, divide and conquer, dynamic programming, to study the concept of NP-Completeness, and to introduce the notion of approximation algorithm for NP-hard Problems.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Models of computation: RAM and Turing Machines; Algorithm Analysis techniques; Basic techniques for designing algorithms: dynamic programming, divide-and-conquer and Greedy; DFS, BFS and their applications; Some Basic Graph Algorithms; linear time sorting algorithms; NP-Completeness and Approximation Algorithms	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to Algorithm; Models of Computation: RAM Model and Turing Machine Model; Analysis of algorithm: Worst case; Time complexity, Space Complexity; Role of Data Structures in Algorithm Analysis	5
2	Asymptotic Notations: Big Oh, small oh, Big Omega, and small omega, theta notations; recurrences and Analysis of Recursive algorithms	5
3	Divide and Conquer Technique	5
4	Greedy Techniques	5
5	Dynamic Programming Technique	5
6	DFS, BFS, and their Applications	2
7	Basic Graph Algorithms	3
8	Linear time sorting algorithms	2
9	Introduction to NP-completeness	6
10	Introduction to Approximation algorithm for NP-hard optimization problems	4
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Problems based on the topics covered in the lecture classes will be discussed during the tutorial sessions.

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Cormen, Leiserson, Rivest and Stein, Introductions to Algorithms, PHI, 2nd Edition, 2002.
2. Jon Kleinberg and Eva Tardos, Algorithm Design, Pearson Education, 2006.
3. Horowitz, Sahni and Rajsekharan, Computer Algorithms, Galgotia Pubs. Pvt. Ltd, 2001.
4. Aho, Hopcroft and Ullman, The Design and Analysis of Algorithms, AWL, 1987.

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Nil
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Nil
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	Microphone, Black Board and Projector.
19.7	Site visits	Nil

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Nil
20.2	Open-ended problems	Nil
20.3	Project-type activity	20%
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	OPERATING SYSTEMS
3.	L-T-P structure	3 - 0 - 2
4.	Credits	4
5.	Course number	MAL 358
6.	Status (<i>category for program</i>)	DC

7.	Pre-requisites (<i>course no./title</i>)	MAL 342
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL 373,EEL358
8.3	Supercedes any existing course	MAL 358

9.	Not allowed for (<i>indicate program names</i>)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B S Panda, Niladri Chatterjee, B. Chandra	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To provide an understanding of the functions of an OS, an insight into functional modules of an OS, study the concepts underlying the design and implementation of OS, the design of UNIX OS. hands on experience on Systems Programming through a number of programming assignments.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Operating Systems functions, Basic Concepts, Notion of a process, concurrent processes, problem of mutual exclusion, Deadlock, process Scheduling, memory management, multiprogramming, File systems; time sharing systems and their design consideration.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Basic Concepts: Bootstrapping, Disk Basics, OS installation, What is an OS?, Types of OS, Design approaches, Introduction to UNIX OS	5
2	Overview of Computer System structure; H/W support for Multitasking OS; Overview of Operating System Structure	5
3	Process Management: introduction to process and threads, interprocess synchronization and communication; UNIX IPC	8
4	Process Management: Process Scheduling, UNIX scheduler, Deadlocks	7
5	Memory Management: Paging and Segmentation; Virtual Memory	8
6	File management: UNIX file Systems, File System Interface, File System Implementation	5
7	I/O Systems: Overview of I/O systems; Disk management and Scheduling	4
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10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Introduction to Unix commands	2
2	Introduction to system call	2
3	Implementing an I/O library Under Linux	6
4	creation of process	2
5	Multithreading	2
6	message passing and interprocess communication	6
7	Implementing different scheduling algorithms	4
8	Designing a prototype Shell	4
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10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Silberschatz, Galvin, and Gagne, Operating System Concepts, 6th Edition, John Wiley and Sons, Inc., 2002.
2. M. J. Back, The design of the Unix Operating Systems, PHI, 1986.
3. W.R. Stevens, Advanced programming in the UNIX environment, AWL, 1998.

4. B.Kernighan and Ritchie, The C programming Language, PHI,1993

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Linux OS, C compiler
19.2	Hardware	PC
19.3	Teaching aides (videos, etc.)	Nil
19.4	Laboratory	Computing Laboratory
19.5	Equipment	Nil
19.6	Classroom infrastructure	Microphone and Projector.
19.7	Site visits	Nil

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Nil
20.2	Open-ended problems	Nil
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	40%
20.5	Others (please specify)	Nil

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	THEORY OF COMPUTATION
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 383
6.	Status (<i>category for program</i>)	DC

7.	Pre-requisites (course no./title)	MAL342
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL342
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL705
8.3	Supercedes any existing course	NO

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Niladri Chatterjee, B. S. Panda	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To develop the rigor and skills required to precisely present and prove various properties of computations, state and prove properties of various formal languages and models of computation, enable the students to be capable of giving sound arguments for why a given problem is, or is not, (computationally) solvable and if a problem is solvable, precisely establish whether possible solutions are feasible.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction to the Theory of Computation: Proof Techniques, Basic concepts of language, Grammar and Automata; Chomsky Hierarchy, Regular Languages, Finite automata, Equivalence, DFA and NFA, Minimization, Myhill-Nerode Theorem; Context Free Grammar, Pushdown Automata their equivalence and Application, Properties of Context-Free Languages; Turing Machine, Recursive and Recursively Enumerable Languages; Undecidability,	
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	Rice's Theorem, Post's Correspondence Problem, Complexity Theory, Intractable Problems.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to the Theory of Computation: Proof Techniques, Basic concepts of language, Grammar and Automata; Chomsky Hierarchy	2
2	Automata: DFA, NFA, Moore and Mealy Machines, Equivalence of DFA and NFA	6
3	Regular Languages and regular expressions, Minimization, Pumping Lemma, Myhill-Nerode Theorem;	8
4	Context Free Grammar, Pushdown Automata their equivalence and Application, Properties of Context-Free Languages; CNF and GNF, Application and Parsing	8
5	Turing Machine, Context Sensitive Languages, Linear Bounded Automata, Recursive and Recursively Enumerable Languages;	8
6	Undecidability, Rice's Theorem, Post's Correspondence Problem.	4
7	Complexity Theory: time and space hierarchy theorems, polynomial time computations, P v/s NP, NP-completeness and PSPACE-completeness.	6
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10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
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5		
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7		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. J. E. Hopcroft and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, Pearson Education, 2004
2. P. Linz, An Introduction to Formal Languages and Automata Narosa 2010
3. H.R. Lewis and C. H. Papadimitriou, Elements of the Theory of Computation Pearson 2004
4. Michael Sipser, Introduction to the Theory of Computation (2nd edition), Thompson Course Technology, Indian Edition, 2007

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Microphone, Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	STATISTICAL METHODS
3.	L-T-P structure	3 - 1 - 0
4.	Credits	4
5.	Course number	MAL 390
6.	Status (<i>category for program</i>)	DC

7.	Pre-requisites (course no./title)	MAL250
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 250, MAL140, MAL 522
8.2	Overlap with any UG/PG course of other Dept./Centre	NO
8.3	Supercedes any existing course	MAL 390

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Niladri Chatterjee, S. Dharmaraja, Aparna Mehra	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To provide the students with explanations and expositions of statistical concepts, theoretical concepts pertaining to handling of data sets and drawing inference from them and to understand the techniques of non-parametric methods and time series data analysis.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Basic concepts and Data Visualization: Measures of central tendency, Dispersion, Skewness, Kurtosis, Data Representation using Histogram, Pie Chart, Boxplot, Biplot, Multi Dimensional Scaling etc. Revision of Probability Distribution: Emphasis on Normal, Chi-Square, Student's T, F distributions; Order Statistics: Different Order Statistics and their single and joint Distribution; Sampling Distribution of Mean, Variance; Random Number Generation: Generation of Random Numbers following certain distributions; Theory of Estimation (Point and Interval) Properties of an estimator, MVUE,	
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	BLUE, Cramer-Rao Inequality, Rao-Blackwell Theorem; Testing of Hypothesis: Mean and Variance, Confidence Interval, Neyman-Pearson Lemma; Non-Parametric Methods Run Tests, Rank Tests, Signed Rank Tests, Kruskal Wallis Test, Kolmogorov-Smirnov Test etc.; Regression Analysis Linear Regression, Multiple Regression, Logit, Probit, Regression; TimeSeries Analysis: Time Series Decomposition, Smoothing and Moving Averages, ARIMA Models
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Basic concepts and Data Visualization: Measures of central tendency, Dispersion, Skewness, Kurtosis, Data Representation using Histogram, Pie Chart, Boxplot, Biplot, Multi Dimensional Scaling etc.	4
2	Revision of Probability Distribution: Emphasis on Normal, Chi-Square, Student's T, F distributions	2
3	Order Statistics: Different Order Statistics and their single and joint Distribution	4
4	Sampling Distribution of Mean, Variance	4
5	Random Number Generation Generation of Random Numbers following certain distributions	4
6	Theory of Estimation (Point and Interval) Properties of an estimator, MVUE, BLUE, Cramer-Rao Inequality, Rao-Blackwell Theorem	6
7	Testing of Hypothesis: Mean and Variance, Confidence Interval, Neyman-Pearson Lemma	4
8	Non-Parametric Methods Run Tests, Rank Tests, Signed Rank Tests, Kruskal Wallis Test, Kolmogorov-Smirnov Test etc.	6
9	Regression Analysis Linear Regression, Multiple Regression, Logit, Probit, Regression	4
10	TimeSeries Analysis: Time Series Decomposition, Smoothing and Moving Averages, ARIMA Models	4
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Problems based on the topics covered in the lecture classes will be discussed during the tutorial sessions.

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. R.J.Freund, W.J.Wilson and D.L. Mohr, Statistical Methods, Academic Press, 3e, 2012

2. A.L. Hayter, Probability and Statistics For Engineers, Cengage, Learning, 1 Indian edition 2009
3. A.M.Gun, M.K.Gupta B. Dasgupta Fundamentals of Statistics, World Press, 2002

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	projector
19.3	Teaching aides (videos, etc.)	Audio system
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Black board
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	FUNCTIONAL ANALYSIS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 411
6.	Status (<i>category for program</i>)	DC

7.	Pre-requisites (course no./title)	MAL 122
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 602
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	No

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course S Kundu, Anima Nagar, K.Sreenadh, Sivananthan Sampath, Shravan Kumar, Amit Priyadarshi	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce the basic concepts of functional analysis.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Review of some basic concepts in metric spaces and topological spaces; Normed linear spaces and Banach spaces, Examples of Banach spaces, Bounded linear operators and examples, Finite dimensional Banach spaces; Introduction of Lebesgue integration on real line, Fatou's lemma, monotone convergence theorem, dominated convergence theorem, Lp spaces; Hahn Banach extension theorem, Hahn Banach separation theorem, Uniform boundedness principle, Open mapping theorem, Closed graph theorem; Characterization of dual of certain concrete Banach spaces; Weak topology, Weak* topology, Banach-Alaoglu theorem; Schauder basis and separability, Reflexive Banach spaces, Best approximation in Banach spaces; Hilbert	
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	spaces and their geometry; Basic operator theory, Compact operators, Spectral theory of compact operators, Spectral theory of compact self-adjoint operators, Sturm-Liouville operators;
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Review of some basic concepts in metric spaces and topological spaces	3
2	Normed linear spaces and Banach spaces, Examples of Banach spaces, Bounded linear operators and examples, Finite dimensional Banach spaces	6
3	Lebesgue integration on real line, Fatou's lemma, monotone convergence theorem, dominated convergence theorem, L_p spaces, L_p spaces as examples for Banach spaces	5
4	Hahn Banach extension theorem, Hahn Banach separation theorem, Uniform boundedness principle, Open mapping theorem, Closed graph theorem	5
5	Characterization of dual of certain concrete Banach spaces Weak topology, Weak* topology, Banach-Alaoglu theorem	5
6	Schauder basis and separability, Reflexive Banach spaces, Best approximation in Banach spaces	4
7	Hilbert spaces and their geometry	4
8	Basic operator theory, Compact operators, Spectral theory of compact operators, Spectral theory of compact self-adjoint operators	4
9	Problems outlined in the lectures will be solved during the Tutorial sessions of lecture classes.	6
10		
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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1		
2		
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- 1) C. D. Aliprantis and O. Burkinshaw, Principles of real analysis, Elsevier, 1998.
- 2) P. D. Lax, Functional Analysis, Wiley, 2002.
- 3) B. V. Limaye, Functional Analysis, New Age International, 1996.
- 4) G. F. Simmons, Introduction to topology and modern analysis, Tata McGraw-Hill, 2004.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	NIL
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS
3.	L-T-P structure	3 - 0 - 2
4.	Credits	4
5.	Course number	MAL 445
6.	Status (<i>category for program</i>)	DC

7.	Pre-requisites (course no./title)	MAL 230
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 712
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course S.C.S. Rao, Mani Mehra, V.V.K.S. Kumar, Harish Kumar	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To train student in developing and implementing numerical methods for ODEs and PDEs	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Numerical methods for solving IVPs for ODEs: Difference equations, Routh-Hurwitz criterion, Test Equation. Single step methods: Taylor series method, explicit Runge-Kutta methods, convergence, order, relative and absolute stability. Multistep methods: Development of linear multistep method using interpolation and undetermined parameter approach, convergence, order, relative and absolute stability, Predictor Corrector methods. Solution of initial value problems of systems of ODEs. BVP: Finite difference methods for second order ODEs, Eigenvalue problems. PDEs: Finite difference methods for Elliptic PDEs, Consistency, stability and convergnce. Boundary Conditions. FD methods for Parabolic equations in 1D	
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	and 2D. Operator splitting methods, Convergence, stability and consistency of difference methods. Higher order methods. Introduction to Hyperbolic PDEs, FD methods. Upwind schemes, Consistency, stability and convergence of schemes. Second order schemes
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Numerical methods for solving IVPs for ODEs: Difference equations, Routh-Hurwitz criterion, Test Equation.	3
2	Single step methods: Taylor series method, explicit Runge-Kutta methods.	4
3	convergence, order, relative and absolute stability.	3
4	Multistep methods: Development of linear multistep method using interpolation and undetermined parameter approach, convergence, order, relative and absolute stability.	4
5	Predictor Corrector methods. Solution of initial-value problem of systems of ODES	4
6	BVP: Finite difference methods for second order ODEs, Eigenvalue problems	5
7	Finite difference methods for Elliptic PDEs, Consistency, stability and convergence. Boundary conditions.	7
8	FD methods for Parabolic equations in 1D and 2D. Operator splitting methods, Convergence, stability and consistency of difference methods. Higher order methods.	6
9	Introduction to Hyperbolic PDEs, FD methods. Upwind schemes, Consistency, stability and convergence of schemes. Second order schemes	6
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11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Implementation of Single step Methods and study of numerical order of convergence.	4
2	Multistep methods implementation. Predictor Corrector methods.	4

3	BVP: Implementation of FD schemes .	4
4	Finite difference methods implementation for Elliptic PDEs with different boundary conditions.	4
5	FD for Parabolic equations. Operator splitting and higher order methods.	6
6	FD Schemes for Hyperbolic PDEs.	6
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. J.D. Lambert, Computational Methods in Ordinary Differential Equations, Wiley Chichester, 1991.
2. M.K. Jain, Numerical Analysis of Differential Equations, Wiley Eastern, 1984.
3. P. Henrici, Discrete Variable Methods in Ordinary Differential Equations, Wiley, 1962.
4. G.D. Smith, Numerical Solution of Partial Differential Equation (3e), Clarendon Press, Oxford, 1985.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	NIL
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	DATA MINING
3.	L-T-P structure	3 - 0 - 2
4.	Credits	4
5.	Course number	MAL 782
6.	Status (<i>category for program</i>)	DC

7.	Pre-requisites (<i>course no./title</i>)	MAL 342
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supercedes any existing course	MAL 782

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B.Chandra, N.Chatterjee,	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): The course objective is to impart an in depth knowledge in Data Mining. It covers techniques in data mining viz. Association rule mining, Classification and clustering and its applications in Data Analytics.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction to Data Mining, Data Cleaning and transformation, Data synchronization with operational databases, Association rule mining, Sequence analys, mining complex data, Classification, knowledge Extraction and prediction, LIFT charts and ROC curves, Bagging and Boosting, Clustering techniques and application, Parallel and distributed data mining systems, data cubes and other visualizations.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to Data Mining, Data Cleaning and transformation	4
2	Data synchronization with operational databases	2
3	Association rule mining	9
4	Sequence analysis	2
5	mining complex data	3
6	Classification	6
7	knowledge Extraction and prediction	3
8	LIFT charts and ROC curves	1
9	Bagging and Boosting	1
10	Clustering techniques and applications	8
11	Parallel and distributed data mining systems	2
12	data cubes and other visualizations	1
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Association rule mining	6
2	Decision Trees, knowledge Extraction and prediction	10
3	Clustering techniques and applications	8
4	data cubes and other visualizations	4
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COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- 1.Jiawei Han, Micheline Kamber,Jian Pei "Data Mining: Concepts and Techniques" ,The Morgan Kaufmann Series in Data Management Systems,
- 2.Pang-Ning Tan, Michael Steinbach and Vipin Kumar, Introduction to Data Mining , Addison Wesley,

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Free software
19.2	Hardware	PC
19.3	Teaching aides (videos, etc.)	LCD
19.4	Laboratory	Large Lab with PC
19.5	Equipment	LCD projector
19.6	Classroom infrastructure	Normal
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	15% Assignments
20.2	Open-ended problems	20%
20.3	Project-type activity	15% Mini Projects
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	COMPUTING LAB
3.	L-T-P structure	0 - 0 - 4
4.	Credits	2
5.	Course number	MAP 290
6.	Status (<i>category for program</i>)	DC

7.	Pre-requisites (<i>course no./title</i>)	MAL 101, MAL 230
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAP 290

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B. Chandra, Mani Mehra, VVK Srinivas Kumar, Harish Kumar	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To train students in implementation of basic algorithms in numerical analysis and linear algebra using programming skills.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Programming concepts. Implementation of matrix operations, Complexity in Matrix Operations, Implementation of linear algebraic solvers; solution of systems of linear equations. Gauss elimination, LU decomposition and Iterative methods. Implementation of several Numerical Integration algorithms, Initial value problems and Boundary Value Problems for ODEs.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
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12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Programming concepts.	12
2	Implementation of matrix operations, Complexity in Matrix Operations.	8
3	Implementation of linear algebraic solvers; solution of systems of linear equations. Gauss elimination, LU decomposition.	8
4	Iterative methods for linear equations	8
5	Implementation of several Numerical Integration algorithms, Initial value problems.	8
6	Initial value problems and Boundary Value Problems for ODEs.	12
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10		
COURSE TOTAL (14 times 'P')		56

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Richard L. Burden, J. Douglas Faires, Numerical Analysis (9th Ed.), 2011.
2. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, Jon Wiley and sons, 2013

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	C/C++/MATLAB
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19.2	Hardware	Server
19.3	Teaching aides (videos, etc.)	Projector
19.4	Laboratory	Computing lab
19.5	Equipment	Desktops
19.6	Classroom infrastructure	NIL
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	40%
20.4	Open-ended laboratory work	30%
20.5	Others (please specify)	30% for laboratory activities

Date: 3-1-2014

(Signature of the Head of the Department)

DE Courses

SN	Course Number	Course Name	L	T	P	Total Credits
1	MAD 350	Mini Project	0	0	6	3
2	MAL 145	Number Theory	3	0	0	3
3	MAL146	Combinatorics	3	0	0	3
4	MAL260	Boundary Value Problems	3	0	0	3
5	MAL 270	Measure Integral and Probability	3	0	0	3
6	MAL 311	Parallel Algorithms	3	0	0	3
7	MAL 365	Mathematical Programming Techniques	3	0	0	3
8	MAL 373	Wavelets and Applications	3	0	0	3
9	MAL 375	Programming Languages	3	0	0	3
10	MAL 376	Graph Algorithms	3	0	0	3
11	MAL 381	Finite Element Theory and Applications	3	0	0	3
12	MAL 465	Parallel Computing	3	0	0	3
13	MAL 466	Multivariate Statistical Methods	3	0	0	3
14	MAL 468	Graph Theory	3	0	0	3
15	MAL 704	Numerical Optimization	3	0	0	3
16	MAL 710	Database Management Systems	3	0	2	4
17	MAL 717	Fuzzy Sets and Applications	3	0	0	3
18	MAL 720	Neurocomputing and Applications	3	0	0	3
19	MAL 731	Introduction to Chaotic Dynamical system	3	0	0	3
20	MAL 732	Financial Mathematics	3	0	0	3
21	MAL 733	Stochastic of Finance	3	0	0	3
22	MAL 735	Advanced Number Theory	3	0	0	3
23	MAL 738	Commutative Algebra	3	0	0	3
24	MAL 739	Representation of Finite Groups	3	0	0	3
25	MAL 741	Fractal Geometry	3	0	0	3
26	MAL742	Operator Theory	3	0	0	3
27	MAL 743	Fourier Analysis	3	0	0	3
28	MAL 744	Mathematical Theory of Coding	3	0	0	3
29	MAL 751	Symbolic Dynamics	3	0	0	3
30	MAL 754	Computer Graphics	3	0	0	3
31	MAL 755	Algebraic Geometry	3	0	0	3
32	MAL 756	Lie Algebras and Lie Groups	3	0	0	3
33	MAL757	Introduction to Algebraic Topology	3	0	0	3
34	MAL 760	Advanced Algorithms	3	0	0	3
35	MAL 761	Basic Ergodic Theory	3	0	0	3
36	MAL 766	Probability and Computing	3	0	0	3
37	MAL 770	Combinatorial Optimization	3	0	0	3
38	MAL 785	Natural Language Processing	3	0	0	3
39	MAL 792	Modern Methods in Partial Differential equations	3	0	0	3
40	MAL 793	Numerical Methods for Hyperbolic PDEs	3	0	0	3
41	MAL 794	Advanced Probability Theory	3	0	0	3
42	MAV 791	Special Module in Dynamical System	1	0	0	1

(B.S.Panda)
HOD Mathematics

COURSE TEMPLATE

1.	Department /Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	MINI PROJECT
3.	L-T-P structure	0 - 0 - 6
4.	Credits	3
5.	Course number	MAD 350
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAD 350

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course All Faculty Members of the Department	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To make in depth study of a particular topic.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Depends on the project topic.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1		
2		
3		
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6		
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9		
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11		
12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Project based
19.2	Hardware	Computing machines
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	PC, some softwares depending on the project
19.6	Classroom infrastructure	NIL
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	100%
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	NUMBER THEORY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 145
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 180
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 145

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course R. Barman, A. Tripathi	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): This course offers an introduction to classical and modern aspects of Number Theory.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Divisibility: basic definition, properties, prime numbers, some results on distribution of primes; Congruences: basic definitions and properties, complete and reduced residue systems, theorems of Fermat, Euler & Wilson, application to RSA cryptosystem, linear congruences and Chinese Remainder theorem, quadratic congruences, and Quadratic Reciprocity law; Arithmetical functions: examples, with some properties and their rate of growth; Continued fractions, and their connections with Diophantine approximations, applications to linear and Pell's equations; Binary quadratic forms; Partition: basic properties and results; Diophantine equations: linear and quadratic, some general equations	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Divisibility	3
2	Congruences	8
3	Arithmetical functions	4
4	Continued fractions, Diophantine approximations, Pell's equation	6
5	Binary quadratic forms	4
6	Theory of partitions	5
7	Diophantine equations	6
8	Discussion of problems	6
9	###	
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. I. Niven, H. S. Zuckerman & H. L. Montgomery, An Introduction to the Theory of Numbers, Fifth Ed., Wiley, 1991
2. G. H. Hardy & E. M. Wright, An Introduction to the Theory of Numbers, Fifth Ed., Oxford University Press, 1980
3. T. M. Apostol, Introduction to Analytic Number Theory, First Ed., Springer-Verlag, 1998

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL

19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	COMBINATORICS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 146
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 180
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 146

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B. S. Panda, A. Tripathi	
12.	Will the course require any visiting faculty?	NIL

13.	Course objective (<i>about 50 words</i>): This courses introduces various aspects of Combinatorics.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Basic counting techniques; principle of inclusion and exclusion; recurrences and generating functions; Sytems of Distinct Representatives & Hall's theorem; Extremal Set theory; Projective and combinatorial geometries; Latin squares; Designs & Steiner Triple Systems; Ramsey theory	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Basic counting techniques	4
2	Principle of Inclusion & Exclusion	2
3	Recurrences & Generating functions	6
4	Systems of Distinct Representatives	4
5	Extremal Set Theory	6
6	Latin Squares	4
7	Projective and combinatorial geometries	4
8	Designs & Steiner Triple systems	6
9	Ramsey theory	6
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. J. H. van Lint & R. M. Wilson, A Course in Combinatorics, Second Ed., Cambridge University Press, 2001
2. P. J. Cameron, Combinatorics: Topics, Techniques, Algorithms, First Ed., Cambridge University Press, 1995
3. V. Bryant, Aspects of Combinatorics, First Ed., Cambridge University Press, 1993
4. A. Tucker, Applied Combinatorics, Fifth Ed., Wiley, 2006

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
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19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	BOUNDARY VALUE PROBLEMS Text
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MAL 260
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 100, MAL101
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 235
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 260

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Harish Kumar, VVK Srinivas Kumar, Mani Mehra, SCS Rao, K.Sreenadh	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To introduce boundary value problems of Mathematical physics and engineering. The course starts with Fourier Series and boundary value problems of ODE. Students will be exposed to mathematical analysis and practical applications of boundary value problems that arise in Wave propagation, temperature distribution and briefly about modern topics like European options. Brief introduction to finite dimensional approximations are covered towards the end of the course.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Sturm Liouville problem, Boundary Value Problems for nonhomogeneous ODEs, Green's Functions. Fourier Series and Integrals: Periodic Functions and Fourier Series, Arbitrary Period and Half-Range Expansions, Fourier Integral theorem and convergence of series Parabolic equations: Heat equation, Fourier series solution, Different Boundary Conditions, Generalities	
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	on the Heat Conduction Problems on bounded and unbounded domains and applications in Option pricing. The Wave Equation: The Vibrating String, Solution of the Vibrating String Problem, d'Alembert's Solution, One-Dimensional Wave Equation The Potential Equation: Potential Equation in a Rectangle, Fourier series method, Potential equation in Unbounded Regions, Fourier integral representations, Potential in a Disk and Limitations. Higher Dimensions and Other Coordinates: Two-Dimensional Wave Equation: Derivation, Parabolic equation, Solution by Fourier series, Problems in Polar Coordinates, Temperature in a Cylinder, Vibrations of a Circular Membrane Finite dimensional approximations of solutions, piecewise linear polynomials and introduction to different methods like Galerkin and Petrov-Galerkin method
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15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Sturm Liouville problem, Boundary Value Problems for nonhomogeneous ODEs, Green's Functions.	4
2	Fourier Series and Integrals: Periodic Functions and Fourier Series, Arbitrary Period and Half-Range Expansions, Fourier Integral theorem and convergence of series	4
3	Parabolic equations: Heat equation, Fourier series solution, Different Boundary Conditions, Generalities on the Heat Conduction Problems on bounded and unbounded domains and applications in Option pricing.	6
4	The Wave Equation: The Vibrating String, Solution of the Vibrating String Problem, d'Alembert's Solution, One-Dimensional Wave Equation	6
5	The Potential Equation: Potential Equation in a Rectangle, Fourier series method, Potential equation in Unbounded Regions, Fourier integral representations, Potential in a Disk and Limitations.	6
6	Higher Dimensions and Other Coordinates: Two-Dimensional Wave Equation: Derivation, Parabolic equation, Solution by Fourier series, Problems in Polar Coordinates, Temperature in a Cylinder, Vibrations of a Circular Membrane.	6
7	Finite dimensional approximations of solutions, piecewise linear polynomials and introduction to different methods like Galerkin and Petrov-Galerkin method.	4
8	Problems based on lectures will be solved in problem solving sessions	6
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. D L. Powers, Boundary Value Problems and Partial Differential Equations, Elsevier Academic Press, London, UK (Fifth Edition), 2006.
2. R V. Churchill, Fourier Series and Boundary Value Problems, McGraw-Hill Book Company.
3. C. H Edwards and D E. Penney, Differential Equations and Boundary Value Problems-Computing and Modeling, Prentice Hall(Pearson) 2009 (Third Edition).

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	MEASURE, INTEGRAL AND PROBABILITY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 270
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 100
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 270

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Subiman Kundu, Sravan Kumar, A Priyadarshi	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): The objective of this course is to study theory of Lebesgue integration and to assemble a complete set of measures- theoretic tools in order to study modern theory of probability.
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Measurable spaces, measurable sets, measurable functions, measure, outer measures and generation of measure, Lebesgue integration, basic integration theorem, comparison of Lebesgue and Riemann integrals, various modes of convergence of measurable functions, signed measure, Hahn and Jordan decomposition theorems, the Radon-Nikodym theorem, product measures and
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	Fubini's theorem, probability measures and spaces, independent events, conditional probability, theorem of total probability, random variables, distribution and distribution function of a random variable, independent random variable, expectation, convergence in distribution of a sequence of random variables, weak and strong laws of large numbers, Kolmogorov's zero-one law, the central limit theorem, identically distributed summands, the Linderberg and Lyapounov theorems.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Measurable spaces, measurable sets, measurable functions, measures, outer measures and generation of measures	8
2	Lebesgue integration, basic integration theorems, comparison of Lebesgue and Riemann integration	7
3	Various modes of convergence of measurable functions	3
4	Signed measure, Hahn and Jordan Decomposition theorems, the Radon-Nikodym theorem	4
5	Product measures and Fubini's theorem	3
6	Probability measures and spaces, independent events and random variables, conditional probability, expectation	7
7	Weak and strong laws of large numbers, Kolmogorov's zero-one law	6
8	The Linderberg and Lyapounov central limit theorems, infinitely divisible distributions	4
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COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. R. B. Ash and C. A. Doleans, Probability and Measure Theory, 2nd Ed, Academic Press, 2000.
2. M. Capinski and E. Kopp, Measure, Integral and Probability, 2nd Ed., Springer-Verlag, 2004.
3. Y. S. Chow and H. Teicher, Probability Theory, 3rd Ed., Springer-Verlag, 1997.
4. P. Billingsley, Probability and Measure, 2nd Ed., John Wiley & Sons, 2012.
5. R. G. Bartle, The Elements of Integration and Lebesgue Measure, 1st Ed., Wiley-interscience, 1995.

19. Resources required for the course (*itemized & student access requirements, if any*):

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-01-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	PARALLEL ALGORITHMS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MAL 311
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 230, MAL 342
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 465
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 311

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Harish Kumar, SCS Rao	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): Development and analysis of parallel algorithms in computational Mathematics.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Parallel architecture: Shared/local memory systems, pipelining, hypercubes, mesh, linear array etc. Degree of parallelism, Speed-up and efficiency of a parallel algorithm. Principles of parallel algorithm design. Basic communication operations. Parallel algorithms: searching and sorting, matrix-vector and matrix-matrix multiplication for dense, band and triangular matrices. Parallel algorithms for direct methods for dense, band and triangular matrices. Cholesky method. Solving recurrence relations. Parallel iterative methods for finite difference equations of elliptic boundary value problems: point-Jacobi, line Jacobi, block Jacobi methods, 2 colour and multicolour Gauss-Seidel, SOR, SSOR methods. Domain decomposition method in one and two dimensions. Parallel preconditioned conjugate gradient methods. Quadrant	
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	interlocking factorization.
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15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Parallel architecture: Shared/local memory systems, pipelining, hypercubes, mesh liner array, ectc. Degree of parallelism, Speed-up and efficiency of a parallel algorithm .	4
2	Principles of Parallel algorithm design. Basic communication operations.	6
3	Parallel algorithms: searching and sorting, prime finding algorithm, matrix-vector and matrix-matrix multiplication for dense, band and triangular matrices. Parallel algorithms for direct methods for dense, band and triangular matrices. Choleskey method. Solving recurrence relations.	8
4	Parallel iterative methods for finite difference equations of elliptic boundary value problems: point-Jacobi, line Jacobi, block Jacobi methods, 2 colour and multicolour Gauss-Seidal, SOR, SSOR methods.	7
5	Domain decomposition method in one and two dimensions.	5
6	Parallel preconditioned conjugate gradient methods.	3
7	Quadrant interlocking factorization.	3
8	Problem solving sessions	6
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. A. Grama, A. Gupta, G. Krypiss and V. Kumar, Introduction to Parallel Computing, 2nd edition, Pearson Education, 2003.
2. J.M. Ortega, Introduction to Parallel and Vector Solution of Linear Systems, Plenum Press, 1988.

3. M.J. Quinn, Parallel Computing: Theory and Practice(2e), Mc-Graw-Hill, 1994.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	MATHEMATICAL PROGRAMMING TECHNIQUES
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MAL365
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL210
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL856
8.3	Supercedes any existing course	MAL 365

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B Chandra, Aparna Mehra, B S Panda	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To show how to model a wide array of problems from engineering, sciences and management as mathematical programming problems – both linear and nonlinear, and explains various algorithms and techniques to compute their solutions. The course introduces nonlinear programming and multiobjective programming in detail with emphasis on solution algorithms.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Recall of linear programming simplex algorithm and dual problem; primal-dual simplex method, linear programs with upper bounds, network optimization, network simplex method for non-capacitated and capacitated networks; dynamic programming, principle of optimality, general insight followed by in-depth examples; complexity of simplex algorithm, Karmarkar's interior point method; nonlinear programming, KKT conditions, convex programs, linear fractional programming problems, Charnes and Cooper technique, convex simplex method, Rosen projection method; multiobjective programming	
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	problems, applications to engineering and sciences, Pareto efficient solution, linear multiobjective programs, weighted sum approach, scalarization schemes, goal programming.
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15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Mathematical programming overview with applications, recall of simplex algorithm of linear programs (LP) and dual programs, primal-dual simplex method, LP with bounded variables.	5
2	Network optimization, max flow-min cut, minimum cost network flow, network simplex method for non-capacitated and capacitated network problems	6
3	Dynamic programming, general insight, Bellman principle of optimality, in-depth examples	5
4	Complexity issues of simplex method, Karmarkar interior point method	3
5	Unconstrained optimization problems, steepest descent method, Newton method, conjugate direction and conjugate gradient methods	6
6	Nonlinear programming problems, KKT conditions, convex program, linear fractional program, Charnes and Cooper method, convex simplex method, Rosen projection method	6
7	Multiobjective programming problems (MP), applications to engineering and science, weak efficient solutions, Pareto efficient solutions	4
8	Weighted sum method, scalarization schemes, goal programming approach	7
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

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|---|
| 1. M S Bazarrar, H D Sherali, C M Shetty, Nonlinear Programming: Theory and Algorithms, John Wiley, 2006. |
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2. M Ehrgott, Multicriteria Optimization, Springer, 2005.
3. M S Bazarra, J J Jarvis, H D Sherali, Linear Programming and Network Flows, Wiley, 2009.
4. S P Bradley, A C Hax, T L Magnati, Applied Mathematical Programming, Addison Wesley, 1977.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microphone and projector
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	10%
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	80-85% examples/problems based on concepts.

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	WAVELETS AND APPLICATIONS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 373
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 411
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 890
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 373

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Mani Mehra, Sivananthan Sampath	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce the basic concepts of wavelets and their application in problems arising in science and engineering.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Basic Fourier Analysis: Fourier Series, convergence of Fourier series, Riesz Fischer theorem, Fourier transform of square integrable functions, Plancherel formula, Poisson Summation formula, Shannon sampling theorem, Heisenberg Uncertainty principle. Continuous Wavelet transform, Plancherel formula, Inversion formulas. Frames, Riesz Systems, discrete wavelet transform, Numerical algorithms. Orthogonal bases of wavelets, multi resolution analysis, smoothness of wavelets, compactly supported wavelets, cardinal spline wavelets. Tensor products of wavelets, Decomposition and reconstruction algorithms for wavelets, wavelet packets, recent development and applications.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Basic Fourier Analysis: Fourier Series, convergence of Fourier series, Riesz Fischer theorem, Fourier transform of square integrable functions, Plancherel formula, Poisson Summation formula, Shannon sampling theorem, Heisenberg Uncertainty principle	8
2	Continuous Wavelet transform, Plancherel formula, Inversion formulas	6
3	Frames, Riesz systems, discrete wavelet transform, Numerical algorithms	6
4	Orthogonal bases of wavelets, multi resolution analysis, smoothness of wavelets	6
5	Compactly supported wavelets, cardinal spline wavelets	6
6	Tensor products of wavelets, Decomposition and reconstruction algorithms for wavelets, wavelet packets	6
7	Recent development and applications.	4
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COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. E. Hernandez and G. Weiss, A First Course on Wavelets, CRC Press, 1996.
2. S. Mallat, A Wavelet Tour of Signal Processing, Academic Press, 1999.
3. M. A. Pinsky, Introduction to Fourier Analysis and Wavelets, AMS, 2002.
4. I Daubechies, Ten Lectures on Wavelets, SIAM, 1992.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	MATLAB
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microphone and projector
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	PROGRAMMING LANGUAGES
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL375
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	MAL383
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL 302
8.3	Supercedes any existing course	MAL 375

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Niladri Chatterjee, B S Panda	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To provide the fundamental concepts underlying the basic features of a programming language including syntax, structuring concepts and semantics. To introduce students with different program semantics, such as, operational, denotational, axiomatic. Also to familiarize students with different programming paradigms, in particular with logic-based and functional programming.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction to Programming Languages, syntax, semantics, reliability, efficiency and maintainability; Programming Fundamentals, Variables - values, referencing, run-time structures, dynamic allocation, typing, scoping, parameter passing; Lambda Calculus, concept and syntax, curried functions, reduction strategies, correlation with parameter passing; Introduction to Functional Programming, principles, syntax and semantics for LISP; Operational Semantics, specifying syntax, inference systems, structural induction, semantics of expression, semantic equivalence; Denotational	
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	Semantics, motivation, complete partial order, semantic functions, semantic equations, error handling; Domain Theory and Fixed Point Semantics, concepts, recursive definitions of function, elementary domains, product domains, sum domains, function domains; Introduction to Logic Programming - PROLOG
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to Programming Languages, syntax, semantics, reliability, efficiency and maintainability;	2
2	Programming Fundamentals, Variables - values, referencing, run-time structures, dynamic allocation, typing, scoping, parameter passing;	5
3	Lambda Calculus, concept and syntax, curried functions, reduction strategies, correlation with parameter passing;	5
4	Introduction to Functional Programming, syntax and semantics for LISP;	6
5	Operational Semantics, specifying syntax, inference systems, structural induction, semantics of expression, semantic equivalence;	4
6	Denotational Semantics, motivation, complete partial order, semantic functions, semantic equations, error handling;	4
7	Domain Theory and Fixed Point Semantics, concepts, recursive definitions of function, elementary domains, product domains, sum domains, function domains;	4
8	Introduction to Logic Programming - PROLOG	6
9	Problem solving activities	6
10		
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		46

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Carlo Ghezzi and M. Jazayeri Programming Language Concepts, Wiley, 3rd Edn, 2001.
2. K. Slonneger and B.L.Kurtz, Formal Syntax and Programming Languages, Addison Wesley, 1995.
3. G. Winskel, Formal Semantics of Programming Languages, An Introduction, The mIT Press, 5th Edition, 2001

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19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Prolog and LISP
19.2	Hardware	Linux PC
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Microphone, Tablet PC and Projector.
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	20%
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	GRAPH ALGORITHMS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 376
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 180, MAL 468
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL851
8.3	Supercedes any existing course	MAL 376

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course N Chatterjee, BS Panda, A Tripathi	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce basic graph algorithms and their implementations using appropriate Data structures. To introduce the role of graph theory in modeling applications in science and engineering and solving these applications using graph algorithms.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction to Graphs: Definition and basic concepts, Efficient representations of Graphs; Graph Searching: DFS and BFS; Application of Graph Searching: finding connected components, bi-connected components, testing for bipartiteness, finding cycle in graphs; Trees: Different MST algorithms, enumeration of all spanning trees of a graph; Paths and Distance in Graphs: Single source shortest path problem, All pairs shortest path problem, center and median of a graph, activity digraph and critical path; Hamiltonian Graphs: sufficient conditions for Hamiltonian graphs, traveling Salesman problem; Eulerian Graphs: characterization of Eulerian graphs, construction of Eulerian	
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	tour, The Chinese Postman problem; Planar Graphs: properties of planar graphs, planarity testing algorithm; Graph Coloring: vertex coloring, chromatic polynomials, edge coloring, planar graph coloring; Matching: maximum matching in bipartite graphs, maximum matching in general graphs; Networks: The Max-flow min-cut theorem, max-flow algorithm; NP-Complete Graph problems; Approximation algorithms for some NP-Hard graph problems; Algorithms for some NP-Hard graph problems on special graph classes;
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to Graphs: Definitions of some basic terms, representation of graphs	2
2	Graph Searching: BFS, DFS and their applications	4
3	MST: Kruskal's and Prim's algorithms, Implementation of these algorithms using advanced Data structures	4
4	Paths in Graphs: Single source and all pair shortest path problem, Greedy based solution, Dynamic Programming based solution to All Pairs shortest path problem	4
5	Planar Graphs: Basic properties, Planarity algorithm	4
6	Networks: : The Max-flow min-cut theorem, max-flow algorithm	4
7	Matching: Algorithm for Matching in Bipartite Graphs, Algorithm for Matching in General Graphs	4
8	Traveling Salesman problem:	3
9	NP-Complete Graph Problems: proving NP-Complete ness, Methods to tackle NP-Hard Graph Problems	4
10	Approximation Algorithms for NP-Hard Graph Problems	5
11	Solving NP-hard graph problems on some special graph classes	4
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		####

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. G Chatrand and O R Oellermann, Applied and Algorithmic Graph Theory, McGraw – Hill, Inc. 1993.
2. M C Golumbic, Algorithmic Graph Theory and Perfect Graphs, Elsevier, 2004
3. T H Cormen, C E Leiserson, R L Rivest, and C Stein, Introductions to Algorithms, PHI, 2nd Edition, 2002.
4. R Diestel, Graph Theory, Springer, 2005

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Microphone, Tablet PC and Projector.
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	15%
20.4	Open-ended laboratory work	20%
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	FINITE ELEMENT THEORY AND APPLICATIONS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 381
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	MAL 230, MAL 411
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 381

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Harish Kumar, VVK Srinivas Kumar, Mani Mehra, SCS Rao	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): Development and analysis of Finite element methods for boundary value problems.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Variational formulation of elliptic boundary value problems; Lax Milgram Lemma; Existence and uniqueness of solutions; equivalence of Galerkin and Ritz variational formulations; Triangulation of ordinary domains-rectangles, polygons, circles, ellipses, etc. Finite element problems; conforming and non-conforming methods, Ce'a's Lemma, Interpolation on simplexes in R^n , different Lagrange and Hermite finite elements, Affine, isoparametric, sub-parametric, super parametric finite elements; Triangulation using isoparametric mapping; approximation of boundary; Numerical Integration, construction of element stiffness matrices and assembly into global stiffness matrix, Skyline method of solution of finite element equations; Solution of model problems and	
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	computer implementation procedures; Asymptotic error estimate results; Eigenvalue problems of Laplace operator.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Variational formulation of elliptic boundary value problems; Lax Milgrams Lemma; Existence and uniqueness of solutions; equivalence of Galerkin and Ritz variational formulations.	6
2	Triangulation of ordinary domains-rectangles, polygons, circles, ellipses, etc. Finite element problems; conforming and non-conforming methods, Ce'a's Lemma	6
3	Interpolation on simplexes in R_n , different Lagrange and Hermite finite elements, Affine, isoparametric, sub-parametric, super parametric finite elements; Triangulation using isoparametric mapping; approximation of boundary.	9
4	Numerical Integration, construction of element stiffness matrices and assembly into global stiffness matrix, Skyline method of solution of finite element equation.	7
5	Solution of model problems and computer implementation procedures; Asymptotic error estimate results; Eigen value problems of Laplace operator.	8
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COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. O. Axelsson and V.A. Barker , Finite Element Solution of Boundary Value Problems, Academic Press, 1984.

2. T.J.T. Hughes, The Finite Element Method, Prentice Hall, 1987.
3. T.J. Chung, Finite Element Analysis in Fluid Dynamics, McGraw Hill, 1978.
4. S.C. Brenner and L.R. Scott, The Mathematical Theory of Finite Element Methods, Springer-Verlag, 1994.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	MATLAB
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	PARALLEL COMPUTING
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 465
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 342
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL 860
8.3	Supercedes any existing course	MAL 465

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Harish Kumar, B S Panda	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): Discusses the hardware and software issues in parallel computing, Investigates the interplay between architecture and algorithmic structure, Discusses the effect that these issues have on the complexity and efficiency of parallel programs, Teaches the basic techniques for designing and evaluating parallel algorithms, and Provides hand-on experience on parallel programming using message – passing interface (MPI).	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction to Parallel Computing: Need, Scope, issues and motivation; Models of Parallel Computation: Taxonomy of Parallel Architectures- SIMD, MIMD; PRAM model of computation; Interconnection Networks: Tree, Hypercube, Mesh etc, dynamic Interconnection Network; Routing and communication mechanisms for static interconnection networks; elementary Parallel algorithms: Parallel reduction, Parallel prefix sums, List ranking, preorder Tree traversal, Merging. Basic Communication Operations: point to	
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	point message transfer, broadcasting, all to all broadcasting, one to all and all to all personalized communication. Parallel programming Paradigm: Explicit versus implicit, shared address space versus Message Passing, data parallelism versus Control Parallelism; Introduction to Message passing Interface (MPI); Parallel Programming Using MPI; Performance and Scalability of Parallel Systems, Basic design techniques; Parallel Algorithms for matrix computation, sorting, graph algorithms, Mapping and scheduling.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction: Definition, Need, Scope, issues and motivation of parallel computing	3
2	Models of Parallel Computation: A taxonomy of parallel computation: SIMD and MIMD model, PRAM model, Interconnection network, Routing and communication in static interconnection network	3
3	Elementary parallel algorithms: Parallel reduction, prefix sums, list ranking, preorder tree traversal, merging	4
4	Basic Communication operations: simple message transfer between two processors, one to one Broadcast, All to all Broadcast, application of all to all broadcast, one to all personalized communication, all to all personalized communication	4
5	Parallel Programming Paradigms; explicit versus implicit parallel Programming, Shared address space versus message passing, data parallelism versus control parallelism	4
6	Introduction to MPI	2
7	Parallel programming using MPI	2
8	Performance and Scalability of parallel systems	2
9	Basic design techniques for parallel Algorithms	2
10	Matrix algorithms	5
11	Mapping and Scheduling	5
12	Graph algorithms	6
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		####

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. M.J.Quinn, Parallel Computing: Theory and Practice, McGraw Hill, 2nd Edition, 1994.
2. Vipin Kumar, A. Grama, and G. Karypis, Introduction to Parallel Computing, Benjamin/Cummings Publishing Company, 1994.
3. J. JaJa, An Introduction to Parallel Algorithms, Addison Wesley, 1992.

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19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Linux System, Parallel Computing Environment
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Microphone, Tablet PC and Projector.
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	25%
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	MULTIVARIATE STATISTICAL METHODS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MAL 466
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL390 or MAL522
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL390
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL466

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Niladri Chatterjee, S. Dharmaraja, Aparna Mehra	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To provide the students with the theory and application of multivariate statistical methods. The focus will be on understanding nature of measurement scales and associated errors, Assessing the impact of missing data, Factor Analytic techniques, Principal component Analysis, Multivariate Regression, Discriminant Analysis and Canonical Correlation Analysis	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction to Multivariate data, Geometry of a sample, mean and Covariance, Generalized Variance; Sample value of Linear combination of variables; Multivariate Normal Distribution, and its properties, Sampling from a Multivariate Normal population, Sampling distribution and Large sample Behaviour of Mean and Covariance, Inference about Mean Vector, Hotelling's T-square and Likelihood Ratio test, Confidence Region, Comparison of several Multivariate Populations, Multivariate Linear Regression Models, Inferences about regression models and parameters, Model checking, Fisher's	
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	Discriminant Analysis, Fisher's Discriminant Analysis, Principal Component Analysis, Introduction to Factor Analysis, Orthogonal Factor Models, Factor Rotation, Strategy for Factor Analysis; Canonical Correlation Analysis, Interpreting population by Canonical variables , Large Sample Inferences.
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15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction to Multivariate data, Geometry of a sample, mean and Covariance, Generalized variance; Sample value of Linear combination of variables.	4
2	Multivariate Normal Distribution and its properties, Sampling from a multivariate Normal population, Sampling distribution and Large sample Behaviour of Mean and Covariance	6
3	Hotelling's T-square and Likelihood Ratio test, Confidence Region	4
4	Paired comparison and repeated measure design, Comparing mean vectors from two populations, Comparing Several Multivariate population means (One way MANOVA) and Two way MANOVA	6
5	Least Square Estimations and their Geometries, Inferences about regression models and parameters, Model checking, Fisher's Discriminant Analysis	5
6	Principal components from Standardized variables, Summarizing sample variation by Principal components, Large Sample Inference	5
7	Introduction to Factor Analysis, Orthogonal Factor Models, Factor Rotation, Strategy for Factor Analysis	6
8	Introduction to canonical Covariance Analysis, Canonical Variates and canonical correlations, Interpreting population by Canonical variables, Large Sample Inferences	6
9		42
10		
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12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

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|---|
| 1. T. W. Anderson, An Introduction to Multivariate Statistical Analysis, 3rd Ed, Wiley Student Ed 2003. |
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2. Hair, Black, Babin, Anderson, Tatham, Multivariate Data Analysis, 6E, Pearson, 2009.
3. R.A. Johnson and D.W. Wichern Applied Multivariate Statistical Analysis, First Indian Reprint, Pearson, 2008

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Microphone and Projector
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	GRAPH THEORY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 468
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 180
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 468

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B S Panda, A. Tripathi	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To present a rigorous introduction to the fundamentals of Graph Theory; To enable the students to model various applications from Science and Engineering using Graphs.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction to Graphs: Definition and basic concepts; Trees: characterizations counting, minimum spanning tree; Paths and Distance in Graphs: Basic Definitions, center and median of a graph, activity digraph and critical path; Eulerian Graphs: Definition and Characterization; Hamiltonian Graphs: Necessary and sufficient conditions, Planar Graphs: properties, dual, genus of a graph; Graph Coloring: vertex coloring, chromatic polynomials, edge coloring, planar graph coloring; Matching and Factorizations: maximum matching in bipartite graphs, maximum matching in general graphs, Hall's marriage theorem, factorization; Networks: The Max-flow min-cut theorem, connectivity and edge connectivity, Menger's theorem; Graph and Matrices;	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to Graphs and Digraphs: Definitions of some basic terms, representation of graphs, Degree Sequence, characterization of graphical sequence	4
2	Trees: Characterizations, MST, counting of trees	4
3	Paths and distance in Graphs: Basic Definitions, center and median of Graphs, activity digraphs and critical paths	6
4	Eulerian Graphs: Characterization, Chinese posman problem; Hamiltonian Graphs: Necessary conditions, sufficient conditions,	6
5	Planar Graphs: Properties, Characterization	3
6	Graph Coloring: vertex coloring, chromatic polynomials, edge coloring, planar graph coloring, Constraint Graph coloring	5
7	Matching and Factorizations: maximum matching in bipartite graphs, maximum matching in general graphs, Hall's marriage theorem, factorization	5
8	Networks: The Max-flow min-cut theorem, max-flow algorithm, connectivity and edge connectivity, Menger's theorem	5
9	Graph and Matrices	4
10		
11	##	
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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7		
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10		
COURSE TOTAL (14 times 'P')		####

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. D B West, Introduction to Graph Theory, 2nd Edition, PHI 2002.
2. G Chatrand and O.R. Ollermann, Applied and Algorithmic Graph Theory, McGraw Hill, 1993.
3. J A Bondy and USR Murty, Graph Theory, Springer, 2008

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	20%
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	NUMERICAL OPTIMIZATION
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 704
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 210 or MAL526
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 704

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course B Chandra, Aparna Mehra, B S Panda	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To study numerical algorithms for unconstrained and constrained optimization problems. The emphasis will be on theoretical aspects and convergence analysis of algorithms but enough insight will be provided to ease their practical implementations.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Unconstrained optimization techniques - one dimensional methods like Fibonacci method, Golden section method; higher dimension methods: pattern search method, Nelder and Meed method; gradient based methods: Steepest descent method, Newton method, Conjugate direction and gradient method, Quasi-Newton methods. Constrained optimization techniques - penalty method, barrier method, cutting plane method, projection gradient method. Heuristic technique: like Genetic programming method to solve non-convex programs.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Some relevant concepts from linear algebra and multivariate calculus, like positive definite matrix, Hessian matrix, eigen values, eigen vectors, norm, convex functions and sets, local-global minima, rate and order of convergence etc.	3
2	Unconstrained optimization techniques - one dimensional methods: Fibonacci method, Golden section method, interpolation techniques, convergence analysis of all methods	6
3	Higher dimension methods: pattern search method, Hooke and Jeeves method, Nelder and Meed method	6
4	Gradient based methods: Steepest descent method, Newton method, Conjugate direction and conjugate gradient method, convergence analysis and numerical issues in these methods	9
5	Rank-updates, Quasi-Newton methods - DFP and BFGS, convergence analysis	4
6	Constrained optimization techniques - penalty method, barrier method, cutting plane method, projection gradient method, sequential quadratic programming approach	9
7	Heuristic techniques such as genetic algorithm or simulated annealing to solve non-convex programs.	5
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COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	NO	
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COURSE TOTAL (14 times 'P')	
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18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. J. Nocedal and S. J. Wright, Numerical Optimization, Springer Publications, 2006.
2. S. S. Rao, Engineering Optimization, John Wiley, 2009.
3. M. C. Joshi and K. M. Moudgalaya, Optimization Theory and Practice, Narosa, 2004.
4. R. Fletcher, Practical Method of Optimization, John Wiley, 2004.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	MATLAB
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microphone, Projector
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	20-25% programming based assignments
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 19-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	DATABASE MANAGEMENT SYSTEMS
3.	L-T-P structure	3 - 0 - 2
4.	Credits	4
5.	Course number	MAL 710
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 342
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL 332, CSL 771
8.3	Supercedes any existing course	MAL 710

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B.Chandra, B.S.Panda	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To impart an in depth knowledge in the area of Databases, Distributed databases and also to make the students highly proficient in designing a new database and retrieve information using query languages and database software.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction to database concepts: data independence, consistency, security and integrity; Types of data models and their conversion; Indexing; Database design: Functional dependencies, Normal forms, Decomposition of Relations; Relational Algebra and Relational Calculus; Query languages; Distributed databases; Transactions and concurrency control: Schedules and serializability, concurrency control techniques, locking mechanisms; Recovery and security: Types of failures and recovery manager, Transaction logging and checkpointing.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to database concepts: data independence, consistency, security and integrity	3
2	Types of data models and their conversion	4
3	Indexing	3
4	Database design: Functional dependencies, Normal forms, Decomposition of Relations	5
5	Relational Algebra and Relational Calculus	2
6	Query languages	8
7	Distributed databases	3
8	Transactions and concurrency control: Schedules and serializability, concurrency control techniques, locking mechanisms	8
9	Recovery and security: Types of failures and recovery manager, Transaction logging and checkpointing.	6
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COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Database design	2
2	SQL, Basic Queries	2
3	Nested Queries, Report generation	4
4	PL/SQL Programs	4
5	Handling Exceptions and Triggers	2
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COURSE TOTAL (14 times 'P')		14

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- 1.R Elmasri, S Navathe, Fundamentals of Database Systems, 6th Edition, Addison Wesley, 2010
2. A Silberschatz, H F Korth, S.Sudarshan, Database System Concepts , 6th Edition, McGraw-Hill ,2010

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Oracle
19.2	Hardware	Servers
19.3	Teaching aides (videos, etc.)	LCD projector
19.4	Laboratory	Computing lab
19.5	Equipment	LCD projector
19.6	Classroom infrastructure	Microphone and projector
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	20%
20.2	Open-ended problems	10%
20.3	Project-type activity	10%
20.4	Open-ended laboratory work	10%
20.5	Others (please specify)	50% class room work

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	FUZZY SETS AND APPLICATIONS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 717
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course N Chatterjee, Aparna Mehra	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To introduce the concept of fuzziness to model real world with imprecise descriptions. To build the necessary structure that the theory of fuzzy system must follow and then fill in the details through illustrations and real-life examples.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Fuzzy sets, fuzzy relations, matrix representation of fuzzy relations, fuzzy numbers, fuzzy arithmetic, Zadeh's extension principle, ordering fuzzy numbers, ranking functions; Fuzzy aggregation, t-norm, t-conorm, fuzzy negation, other aggregation operators, OWA operators; Fuzzy relational equations (FRE), algorithms to solve system of FRE; Fuzzy optimization, fuzzy linear program; Fuzzy measures, belief and plausibility, necessity and possibility, Sugeno and Choquet integrals on finite sets; Fuzzy logic and approximate reasoning, If-then-else rules, Mamdani model, TSK model, SAM model; Applications of fuzzy sets and logics in areas of image processing,	
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	control, AI, computing with words, etc.; Generalized fuzzy sets - like type2 fuzzy sets, rough sets, and Intuitionistic fuzzy sets.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Fuzzy sets, standard sets operations, support and normal fuzzy set, alpha cut, representation theorem, Zadeh extension principle, convex fuzzy set over real, fuzzy equivalence relation, matrix representation of fuzzy relations	4
2	Interval arithmetic, fuzzy numbers, triangular and trapezoidal fuzzy numbers, operations on fuzzy numbers, max and min of fuzzy numbers, ordering of fuzzy numbers via truth value and ranking functions, t-norm, t-conorm, negation, their relationships, general aggregation operators, OWA operators	4
3	Fuzzy relational equations, applications, system of fuzzy relational equations, algorithms for general system	6
4	Fuzzy optimization, Zimmermann symmetric model and different linear programming models, linear programs with fuzzy data, two phase approach, fuzzy linear programming duality and interpretation	6
5	Fuzzy measures, belief, plausibility, focal elements family, necessity and possibility distributions, fuzzy integrals, Sugeno and Choquet integral for finite sets	5
6	First order predicate calculus, logic operations, truth table, modus ponens, modus tollens, If-then rules, fuzzy logic, linguistic hedges, fuzzy implication, fuzzy-If-then rules, approximate reasoning, Mamdani model, TSK model, SAM model	9
7	Applications of fuzzy sets and numbers in areas of game theory, clustering techniques, image processing, fuzzy control, fuzzy AI, fuzzy automata theory, computing with words, and so on.	6
8	Generalized fuzzy sets – like type 2 fuzzy sets and Intuitionistic fuzzy sets, and their applications	2
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COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. T J Ross, Fuzzy Logic with Engineering Applications, 3rd ed, John Wiley, 2010.
2. C T Lin and C S George Lee, Neural Fuzzy Systems: A Neuro Fuzzy Synergism to Intelligent Systems, Prentice Hall, 1996.
3. G J Klir and B Yuan, Fuzzy Sets and Fuzzy Logics, Prentice Hall India, 1995.
4. K Peeva and Y Kyosev, Fuzzy Relational Calculus: Theory, Applications and Algorithms, World Scientific, 2004.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	MATLAB
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microphone and projector
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	20- 25 % (Term papers/group projects/computer programming assignments)
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	40-50% examples/problems are based on concept understanding.

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	NEUROCOMPUTING AND APPLICATIONS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 720
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	EEL 781
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 720

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B. Chandra	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To impart an in depth knowledge in the area of Neural Networks with applications in variety of areas like pattern classification, Character recognition etc.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Biological and Artificial Neuron, Perceptron model, Adaline model, Multilayered feedforward networks, Activation functions, Back-propagation algorithm and its improvements, Conjugate Gradient Neural Network, Applications of Back-propagation algorithm to Statistical Pattern Classification, Feature selection, Classification and regression problems, General Regression Neural Networks, Hopfield Network, Recurrent networks, Probabilistic Neural Networks, Kohonen's self-organizing maps with quadratic junctions and its applications to character recognition, Adaptive Resonance Theory model, Applications of ART model for knowledge acquisition.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Biological and Artificial Neuron, Perceptron model, Adaline model	3
2	Multilayered feedforward networks, Activation functions	3
3	Back-propagation algorithm and its improvements	6
4	Conjugate Gradient Neural Network	4
5	Applications of Back-propagation algorithm to Statistical Pattern Classification, feature selection	6
6	# $\hat{A} \hat{O} \hat{O} \hat{B} \hat{A} \hat{O} \hat{I} \hat{A} \hat{I} \hat{A} \hat{O} \hat{B} \hat{I} \hat{N} \hat{C} \hat{A} \hat{I} \hat{C}$	2
7	General Regression Neural Networks	2
8	Hopfield Network	4
9	2 $\hat{A} \hat{O} \hat{O} \hat{B} \hat{I} \hat{O} \hat{I} \hat{A} \hat{O} \hat{O} \hat{I} \hat{C}$	2
10	Probabilistic Neural Networks	3
11	Kohonen's self-organizing maps with quadratic junctions and its applications to character recognition	4
12	Adaptive Resonance Theory model, Applications of ART model for knowledge acquisition	3
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. S Haykin, Neural Networks: A Comprehensive Foundation, Prentice Hall, 2007
2. Li -Ming Fu, Neural Networks In Computer Intelligence Tata McGraw-Hill Education, 2003

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	MATLAB Neural Network tool box
19.2	Hardware	NIL

19.3	Teaching aides (videos, etc.)	LCD projector
19.4	Laboratory	Computing Lab
19.5	Equipment	Servers
19.6	Classroom infrastructure	NIL
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	INTRODUCTION TO CHAOTIC DYNAMICAL SYSTEMS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MAL 731
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 731

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Anima Nagar, Amit Priyadarshi	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To provide insight into elementary topics and current studies in the theory of chaotic dynamical systems. The focus will be on providing the students with basics in the area and introduce them to the fundamentals in this field.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Topics to be covered include chaos, elementary bifurcations. Sarkovski's theorem, recurrence and equidistribution, codes, symbolic dynamics and chaotic behaviour. Higher dimensional dynamics, including horseshoes, Henon map. Stability of systems.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Analysis of the dynamics	6
2	Dynamics of one-dimensional maps of both the interval and the circle	6
3	Topics - chaos, elementary bifurcations. Sarkovski's theorem,	6
4	Recurrence and equidistribution	6
5	Codes, symbolic dynamics and chaotic behaviour	6
6	Higher dimensional dynamics - including horseshoes, Henon map.	6
7	Stability of systems	6
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COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. S Elaydi, Discrete Chaos, Chapman & Hall/CRC, 2nd Edition, 2007.
2. K T Alligood, T D Sauer, J A Yorke, Chaos: An Introduction to Dynamical Systems, Springer, 2003.
3. B Devaney, An Introduction to Chaotic Dynamical Systems, Addison-Wesley, 1998.
4. B Hasselblatt and A Katok, A First Course in Dynamics, Cambridge University Press, 2010.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL

19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	FINANCIAL MATHEMATICS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MAL 732
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 210 or MAL 526
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	MEL 323, SML 873
8.3	Supercedes any existing course	MAL 732

9.	Not allowed for (<i>indicate program names</i>)	Students who have done MEL 323: Investment Planning.
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course S Dharmaraja, Aparna Mehra	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To equip students with a framework and basic techniques necessary for financial engineering. The main focus is on valuation of financial assets and more specifically derivative products. The course will introduce the concept of risk and relation between risk and return. The knowledge of risk and valuation will be integrated in optimal decision making. The models will be studied in discrete-time scenario.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Financial markets, Interest computation, value, growth and discount factors, derivative products, basic option theory: single and multi-period binomial pricing models, Cox-Ross-Rubinstein (CRR) model, volatility, Black-Scholes formula for option pricing as a limit of CRR model, Greeks and hedging, Mean-Variance portfolio theory: Markowitz model, Capital Asset Pricing Model (CAPM), factor models, interest rates and interest rate derivatives, Binomial tree models.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Financial markets, terminologies, basic definitions and assumptions, Interest rate, present value, future value, NPV, annuity and perpetuity	3
2	Market structure, no arbitrage principle, derivative products, forwards, futures – their valuation, dividend and non-dividend cases, options, swap, valuation concept, purpose and working of these products	5
3	Options-calls and puts, pay-off, profit diagrams, hedging and speculation properties of options, valuation of options using pricing and replication strategies, mathematical properties of their value functions, put-call parity	6
4	Risk neutral probability measure (RNPM) (discrete case), existence of RNPM, Binomial lattice model, Binomial formula for pricing both European style and American style options, dividend and non-dividend cases	6
5	CRR model, Black-Scholes formula derivation, Examples	4
6	Greeks and their role in hedging, delta-neutral portfolio, delta-gamma neutral portfolio	3
7	Portfolio optimization: introduction, risk, return, two-assets portfolio, Markowitz curve, efficient frontier, Multi-assets all risky portfolio, mean-variance Markowitz model, two fund theorem	5
8	Portfolio with one risk free asset, one fund theorem, CAPM, market line, beta, systematic and unsystematic risks, factor models, other risk measures, stochastic dominance and portfolio optimization	6
9	Interest rate and interest rate derivatives, coupon and zero-coupon bonds, Interest rate Binomial tree model for valuation	4
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11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. D. G. Luenberger, Investment Science, Oxford University Press, 2013.
2. M. Capiński and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, Springer, 2011.
3. J C Hull, Options, Futures and other Derivatives, Prentice Hall, 8th edn, 2011.
4. J H Cochrane, Asset Pricing, Princeton University, 2005.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microphone and projector
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	90-95% examples/problems are based on concept understanding.

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	STOCHASTICS OF FINANCE
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 733
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 250 or MAL 509
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 733

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course S Dharmaraja, Aparna Mehra	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To study the theory of stochastic processes and stochastic calculus that are behind the analysis of financial markets. In addition, it explains the theory with examples from finance. In short, it gives exposure to the stochastics behind financial mathematics.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Stochastic Processes; Brownian and Geometric Brownian Motion; Levy Processes, Jump-Diffusion Processes; Conditional Expectations and Martingales; Ito Integrals, Ito's Formula; Stochastic Differential Equations; Change of Measure, Girsanov Theorem, Martingale Representation Theorem and Feymann-Kac Theorem; Applications of Stochastic Calculus in Finance, Option Pricing, Interest Rate Derivatives, Levy Processes in Credit Risk.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Stochastic Processes; Brownian and Geometric Brownian Motion; Levy Processes, Jump-Diffusion Processes; Examples from Finance	8
2	Conditional Expectations and Martingales	6
3	Ito Integrals, Ito's Formula	8
4	Stochastic Differential Equations, Applications of Stochastic Calculus in Finance	8
5	Change of Measure, Girsanov Theorem, Martingale Representation Theorem and Feymann-Kac theorem	6
6	Applications of Stochastic Calculus in Finance, Option Pricing, Interest Rate Derivatives, Levy processes in Credit Risk	6
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. T Mikosch, Elementary Stochastic Calculus, with Finance In View, World Scientific, 2006.
2. S E Shreve, Stochastic Calculus for Finance, Vol. I & Vol. II, Springer, 2004.
3. F E Benth, Option Theory with Stochastic Analysis: An Introduction to Mathematical Finance, Springer, 2002.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
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19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	NIL
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	80-90% theory based examples/problems from finance.

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	ADVANCED NUMBER THEORY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 735
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL 145
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 735

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course R. Barman, A. Tripathi	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): This course offers an introduction to classical and modern aspects of Number Theory.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Divisibility, prime numbers, Bertrand's theorem, Congruences, complete & reduced residue systems, theorems of Fermat, Euler, Wilson & Wolstenholme, solutions of general congruences, study of linear and system of linear congruences, Chinese Remainder theorem, study of quadratic congruences, Quadratic, Cubic & Biquadratic Reciprocity laws, binary and ternary quadratic forms, Continued fractions, Diophantine approximations and applications to linear and Pell's equations, Arithmetical functions, properties, rate of growth, Distribution of primes, Dirichlet's theorem on primes in arithmetic progression, Prime Number theorem, Diophantine equations, special cases of the Fermat equation, introduction to classic and modern techniques.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Divisibility, prime numbers, Bertrand's theorem	5
2	Congruences, solutions of general congruences, study of linear and system of linear congruences, Chinese Remainder theorem, Quadratic Reciprocity Law	7
3	Cubic & Biquadratic Reciprocity laws, binary and ternary quadratic forms	5
4	Continued fractions, Diophantine approximations, Pell's equation	5
5	Arithmetical functions	4
6	Distribution of primes, Dirichlet's theorem on primes in arithmetic progression, Prime Number theorem	8
7	Diophantine equations, special cases of the Fermat equation, introduction to classic and modern techniques	8
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. K. Ireland & M. Rosen, A Classical Introduction to Modern Number Theory, Second Ed., Springer, 2004
2. I. Niven, H. S. Zuckerman & H. L. Montgomery, An Introduction to the Theory of Numbers, Fifth Ed., Wiley, 1991
3. T. M. Apostol, Introduction to Analytic Number Theory, First Ed., Springer-Verlag, 1998
4. G. H. Hardy & E. M. Wright, An Introduction to the Theory of Numbers, Fifth Ed., Oxford University Press, 1980

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 3-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	COMMUTATIVE ALGEBRA
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 738
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	MAL 256 or MAL 516
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	MAL256, MAL 755
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course R Barman, R. Sarma	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce the theory of commutative rings and modules over these rings.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Revision of Rings and Ideals: Prime and maximal ideals. Chinese remainder theorem, Nilradical, Jacobson radical, operations on ideals, extension and contraction; Module, submodule, quotient module, sums and products, Nakayama's lemma; Homomorphism, kernel, cokernel, direct sum, direct product, universal properties, free module, exact sequences, tensor product of modules and its exactness property; Rings and modules of fractions and functorial properties of fractions; Primary decomposition; Integral dependence, going-up and going down theorems, valuation rings; Chain conditions, Noetherian rings, Artinian rings, discrete valuation ring and Dedekind domains, fractional ideals; Completion: filtration, graded rings and modules; Dimension theory: Hilbert function, dimension theory of Noetherian local ring, regular local rings, transcendental dimension.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Revision of Rings and Ideals: Prime and maximal ideals.	2
2	Chinese remainder theorem, Nilradical, Jacobson radical, operations on ideals, extension and contraction.	5
3	Module, submodule, quotient module, sums and products, Nakayama's lemma. Homomorphism, kernel, cokernel, direct sum, direct product, universal properties, free module, exact sequences, tensor product of modules and its exactness property.	7
4	Rings and modules of fractions and functorial properties of fractions.	4
5	Primary decomposition.	2
6	Integral dependence, going-up and going down theorems, valuation rings.	3
7	Chain conditions, Noetherian rings, Artinian rings.	7
8	Discrete valuation ring and Dedekind domains, fractional ideals.	3
9	Completion: filtration, graded rings and modules.	3
10	Dimension theory: Hilbert function, dimension theory of Noetherian local ring, regular local rings, transcendental dimension.	6
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. M F Atiyah and I G Macdonald, Introduction of Commutative Algebra, Addison Wesley, 1969.
2. B Singh, Basic Commutative Algebra, World Scientific, 2011.
3. H Matsumura, Commutative ring Theory, Cambridge University Press, 1989.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	NIL
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	REPRESENTATION OF FINITE GROUPS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 739
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	MAL256
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course R. Sarma and R. K. Sharma	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): This course is to introduce representation theory of finite groups. This also includes combinatorial method of describing every irreducible representation of symmetric and alternating groups.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Revision of basic group theory. Definition and examples of representation. Subrepresentation, sum and tensor product of representations, irreducible representations; Character Theory: Character of a representation, Schur's Lemma, Maschke's theorem, Orthogonality relations for characters, decomposition of regular representation, number of irreducible representations of a group; Representation of subgroups and product of groups, induced representations; Group Algebra: Representations and modules; Decomposition of complex algebra $C[G]$ and Integrability properties of characters. Induced representations, restriction to subgroups, Reciprocity formula, Mackey's irreducibility criterion; Irreducible representations of symmetric groups (S_n)	
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	and alternating groups (A_n).
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Revision of basic group theory. Definition and examples of representation of finite groups.	3
2	Subrepresentation, sum and tensor product of representations, irreducible representations.	3
3	Character Theory: Character of a representation, Schur's Lemma, Maschke's theorem, Orthogonality relations for characters, decomposition of regular representation, number of irreducible representations of a group.	8
4	Representation of subgroups and product of groups, induced representations.	4
5	Group Algebra: Representations and modules. Decomposition of complex algebra $C[G]$ and Integrability properties of characters.	6
6	Induced representations, restriction to subgroups, Reciprocity formula, Mackey's irreducibility criterion.	7
7	Irreducible representations of symmetric groups (S_n) by Young tableaux.	6
8	Irreducible representations alternating groups (A_n).	5
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COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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6		
7		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. J P Serre, Linear Representation of Finite Groups, Springer, 1996.
2. C Musili, Representations of Finite Groups, First edition, Hindustan Book Agency, 2012.
3. W F Fulton and J Harris, Representation Theory: A first course, Springer, 1991.

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	FRACTAL GEOMETRY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 741
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 741

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Anima Nagar, Amit Priyadarshi	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To study the Fractal geometry as an interplay of analysis, algebra and their computing aspects. To explore exciting applications to the physics of nature both at the global and the local levels.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Code spaces, Hausdorff metric, Hausdorff measures, fractal dimensions, Hausdorff dimension, Box-counting dimensions, groups and rings of fractal dimension, semigroups of iterated function schemes(IFS) and self-similarity, Cantor sets, Cantor dusts, Koch Snowflake, Sierpinski's triangle, Diophantine approximation, chaos games, attractors, fractals, superfractals and multi fractal measures, Mandelbrot and Julia sets, random fractals, fractals in Brownian motion.	
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Metrics on sets, code spaces and measures on sets	5
2	Topological dimensions and Fractal dimensions	10
3	IFS and self-similarity	7
4	Examples of fractals	6
5	Superfractals and multi fractal measures	6
6	Mandelbrot and Julia sets	5
7	Random fractals	3
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

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| 1.G A Edgar, Measure, Topology, and Fractal Geometry, Springer Verlag, 1990.
2.K Falconer, Fractal Geometry, Mathematical Foundations and Applications, 2 nd Ed., Wiley, 2003.
3.M F Barnsley, Fractals Everywhere, 2 nd Ed., Academic Press, 1993.
4.M F Barnsley, Super Fractals, Cambridge University Press, 2006. |
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19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	OPERATOR THEORY
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MAL 742
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 411
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course S. Kundu, Amit Priyadarshi, Anima Nagar, S. Sivananthan, N. Shravan Kumar	
12.	Will the course require any visiting faculty?	no

13.	Course objective (<i>about 50 words</i>): To Introduce advanced topics of functional analysis for Pre-Phd students in Mathematics.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Weak and weak*-topologies, closed convex sets, weak compactness, Alaoglu's theorem, locally convex topologies, separation of points by linear functionals, Krein-Milman theorem, Stone-Weierstrass theorem. Normed algebras, resolvent, spectrum, spectral radius, functional calculus, spectral mapping theorem, Gelfand's theory of commutative Banach algebras Basic properties of compact operators, spectral theory of compact operators, Fredholm alternative, General theory of Schatten-von Neumann classes, Hilbert-Schmidt operators, trace and trace duality in finite dimensions, duality	
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	for Schatten-von Neumann classes Functional calculus for self-adjoint operators, square root of positive operators, polar decomposition, some topologies on $B(H)$, spectral measures, the spectral theorem for normal operators
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15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Weak and weak*-topologies, closed convex sets, weak compactness, Alaoglu's theorem	4
2	locally convex topologies, separation of points by linear functionals, Krein-Milman theorem, Stone-Weierstrass theorem.	5
3	Normed algebras, resolvent, spectrum, spectral radius, functional calculus, spectral mapping theorem, Gelfand's theory of commutative Banach algebras	10
4	Functional calculus for self-adjoint operators, square root of positive operators, polar decomposition	5
5	some topologies on $B(H)$, spectral measures, the spectral theorem for normal operators	8
6	Basic properties of compact operators, spectral theory of compact operators, Fredholm alternative	4
7	General theory of Schatten-von Neumann classes, Hilbert-Schmidt operators, trace and trace duality in finite dimensions, duality for Schatten-von Neumann classes	6
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COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- 1) P D Lax, Functional analysis, Pure and Applied mathematics: A Wiley Series of Texts, Monographs and Tracts, 2002.
- 2) J B Conway, A course in operator theory, American Mathematical Society (Graduate texts in Mathematics) Volume 21, 1999.
- 3) W B Rudin, Functional analysis, Mc Graw Hill Education, India, 2006.

- 4) J. Diestel, J. Harchow and A. Tonge, Absolutely summing operators, Cambridge University Press, 1995.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NI

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	FOURIER ANALYSIS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MAL 743
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 100
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course S. Sivananthan, N. Shravan Kumar	
12.	Will the course require any visiting faculty?	no

13.	Course objective (<i>about 50 words</i>): To Introduce topics of Fourier analysis for students in Mathematics.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Fourier Series - Definition, uniqueness, convolution, summability, convergence of Fourier series, Fourier series for square integrable functions, Plancherel theorem, Riesz-Fischer theorem, Gibb's phenomenon, divergence of Fourier series Applications of Fourier series – Isoperimetric inequality, Weierstrass approximation theorem, Weyl's equidistribution theorem, heat equation on the circle. Fourier transform – Schwartz space on $\mathbb{R}$, Fourier transform on the Schwartz space, Fourier transform of integrable and square-integrable functions, Poisson summation formula.	
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	Tempered distributions – Topology on the Schwartz space, tempered distributions and its properties, Fourier transform of tempered distributions. Applications – Uncertainty principle, Paley-Wiener theorem, Wiener's theorem, Shannon sampling theorem, multiplier theorem for integrable functions.
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15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Fourier Series - Definition, uniqueness, convolution, summability, convergence of Fourier series, Fourier series for square integrable functions,	7
2	Plancherel theorem, Riesz-Fischer theorem, Gibbs's phenomenon, divergence of Fourier series	5
3	Applications of Fourier series – Isoperimetric inequality, Weierstrass approximation theorem, Weyl's equidistribution theorem, heat equation on the circle.	5
4	Fourier transform – Schwartz space on $\mathbb{R}$, Fourier transform on the Schwartz space,	6
5	Fourier transform of integrable and square-integrable functions, Poisson summation formula.	6
6	Tempered distributions – Topology on the Schwartz space, tempered distributions and its properties, Fourier transform of tempered distributions.	6
7	Applications – Uncertainty principle, Paley-Wiener theorem, Wiener's theorem, Shannon sampling theorem, multiplier theorem for integrable functions.	7
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1) E M Stein and R Shakarchi, Fourier analysis: An Introduction, Princeton University Press,

2003.

- 2) R Bhatia, Fourier series, Hindistan Book Agency, 2nd Edition, 2010.
- 3) M Pinsky, Introduction to Fourier analysis and wavelets, American Mathematical Society, 2009.
- 4) Y Katznelson, An introduction to harmonic analysis, Cambridge Mathematical Library, 2004.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Department of Mathematics	
2.	Course Title (<i>< 45 characters</i>)	MATHEMATICAL THEORY OF CODING	
3.	L-T-P structure	3 - 0 - 0	
4.	Credits	3	
5.	Course number	MAL 744	
6.	Status (<i>category for program</i>)	DE	

7.	Pre-requisites (<i>course no./title</i>)	MAL 256 or MAL 516	
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)		
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL	
8.2	Overlap with any UG/PG course of other Dept./Centre	EEL 710	
8.3	Supercedes any existing course	NIL	

9.	Not allowed for (<i>indicate program names</i>)	NIL	
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem	
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11.	Faculty who will teach the course Anuradha Sharma, R. K. Sharma		
12.	Will the course require any visiting faculty?	No	

13.	Course objective (<i>about 50 words</i>): This course aims to familiarize the students with the applications of abstract algebra and number theory in the area of communication.		
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Review of communication channels, maximum likelihood and nearest neighbour decoding schemes, Hamming distance, Distance of a code. Structure of finite fields, Linear codes and their duals, Equivalence of linear codes, encoding with a linear code, decoding of a linear code, ISBN Code, Hamming codes. Hadamard matrix codes, Golay codes, Codes and Latin squares. Non-linear codes, Nordstrom-Robinson code, Kerdock codes, Preparata codes. Bounds in coding theory: Sphere-covering bound, Hamming bound and perfect codes, Singleton bound and MDS codes, Gilbert-Varshamov bound, Plotkin bound, Griesmer bound. Weight enumerators, MacWilliams Identity. Construction of new codes: Propagation rules, Reed-Muller codes, subfield codes.		
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	The structure of cyclic codes, encoding and decoding with a cyclic code, minimal codes, Some special cyclic codes including BCH codes and their decoding algorithm, Reed-Solomon codes, quadratic residue codes. Burst errors, Burst error-correcting codes, decoding of cyclic burst-error-correcting codes. Generalized Reed-Solomon codes, Alternant codes, Goppa codes, Sudan decoding for generalized RS codes.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Review of communication channels, maximum likelihood and nearest neighbour decoding schemes, Hamming distance, Distance of a code.	2
2	Structure of finite fields, Linear codes and their duals, Equivalence of linear codes, encoding with a linear code, decoding of a linear code.	4
3	ISBN Code, Hamming codes. Hadamard matrix codes, Golay codes, Codes and Latin squares.	4
4	Non-linear codes, Nordstrom-Robinson code, Kerdock codes, Preparata codes.	3
5	Bounds in coding theory: Sphere-covering bound, Hamming bound and perfect codes, Singleton bound and MDS codes, Gilbert-Varshamov bound, Plotkin bound, Griesmer bound.	5
6	Weight enumerators, MacWilliams Identity.	3
7	Construction of new codes: Propagation rules, Reed-Muller codes, subfield codes.	4
8	The structure of cyclic codes, encoding and decoding with a cyclic code, minimal codes, Some special cyclic codes including BCH codes and their decoding algorithm, Reed-Solomon codes, quadratic residue codes.	9
9	Burst errors, Burst error-correcting codes, decoding of cyclic burst-error-correcting codes.	2
10	Generalized Reed-Solomon codes, Alternant codes, Goppa codes, Sudan decoding for generalized RS codes.	6
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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5		
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8		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

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|---|
| 1. V. Pless, Introduction to the Theory of Error-Correcting Codes, 3 rd Edition, Wiley-Interscience(1998). |
|---|

2. W Cary Huffman & Vera Pless, Fundamentals of error-correcting Codes, Cambridge University Press, 2010.
3. S Ling & C Xing, Coding Theory: A first course, Cambridge University Press, 2004.
4. R M Roth, Introduction to Coding theory, Cambridge University Press, 2006

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microphone, Projector
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	SYMBOLIC DYNAMICS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MAL 751
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Anima Nagar, Amit Priyadarshi, Amitabh Tripathi	
12.	Will the course require any visiting faculty?	no

13.	Course objective (<i>about 50 words</i>): To introduce the students to basics in Symbolic Dynamics. We discuss the general theory of subshifts of finite type and sofic shifts. In particular we emphasize on the entropy and equivalences in shift spaces.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Shift Spaces, languages, subshifts of finite type, their graph representation, sofic shifts, their presentation and characterization, entropy, its properties, conjugacy, shift equivalence and dimension groups, zeta functions.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	shift spaces, full shifts, higher block shifts, languages	5
2	subshifts of finite type	5
3	graph representations of shifts of finite type	4
4	sofic shifts, characterization, representations	7
5	entropy: definition and properties	6
6	Perron-Frobenius theory, computing entropy	5
7	decomposition theorem, shift equivalence, dimension groups	6
8	Zeta functions	4
9		
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. D Lind and B Marcus, An introduction to Symbolic Dynamics and Coding, Cambridge university Press, 1995.
2. B Kitchens, Symbolic Dynamics, Springer, 1998
3. A. Dold and B. Eckmann edited, Dynamical Systems, Lecture Notes in Mathematics, Vol 1342, Springer, 1988.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL

19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	PRINCIPLE OF COMPUTER GRAPHICS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 754
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	EEL754/CSL781
8.3	Supercedes any existing course	MAL 754

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course N. Chatterjee, B S Panda	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce the basic principles and problems of computer graphics, the mathematical background to understand and implement these basic principles and to enable the students to write graphics program using OpenGL.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Overview of Graphics Systems; Raster Graphics: line and circle drawing algorithms, Windowing and clipping: Cohen - Sutherland line clipping, Cyrus beck clipping method, Polygon Clipping; 2D and 3D Geometrical Transformations: scaling, translation, rotation, reflection; 3D Object representation: Curves and Surfaces: cubic splines, Bezier curves B-splines, surface of revolution, sweep surfaces; viewing Transformations: parallel and perspective projection; Hidden line/surface removal methods; illuminations model; shading: Gouraud, Phong; Introduction to Ray-tracing; Programming practices with standard graphics libraries like open GL.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction and Overview of Graphics Systems	2
2	Basic Raster Graphics Algorithms for drawing 2D Primitives (Line, Circle, etc)	5
3	Introduction to OpenGL	3
4	2D Geometric transformation	3
5	2D Viewing and Clipping	4
6	3D Object representation: Curves and Surfaces: cubic splines, Bezier curves B-splines, surface of revolution, sweep surfaces;	5
7	3D Geometric Transformation	2
8	3D Viewing and Projection	5
9	Hidden surface detection and removal	5
10	Illumination Models and Surface rendering methodsAdvanced Concepts: Ray tracing, etc.	5
11		3
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. F.S. Hill, Jr. , Computer Graphics using Open GL, 2nd Edition, Pearson Education, 2003.
2. Foley, Van Dam, Feiner and Hughes, Computer Graphics, 2nd Edition, AWL, 1996.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Linux System
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL

19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Microphone and Projector.
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	25%
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	ALGEBRAIC GEOMETRY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL755
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	MAL256 or MAL516
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL755

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course R. Barman, R. Sarma	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To expose students to the fundamentals of Algebraic Geometry which is currently one of the most important subject in mathematics.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Rings of polynomials and their quotients, local rings, DVR, modules, free modules, exact sequences. Affine algebraic sets, The Hilbert basis theorem. Hilbert's Nullstellensatz. Affine varieties: Coordinate rings, polynomial maps, coordinate changes, rational functions. Local Properties of plane curves: Multiple points, tangent lines, multiplicities and local rings, intersection number. Projective varieties: projective algebraic sets, projective plane curves, linear systems of curves, Bezout's theorem, Max Noether's fundamental theorem and its applications. Variety, Morphisms and Rational maps: The Zariski topology, varieties and their morphism, dimension of varieties, rational maps. Resolution of singularities: Blowing up a point in affine and projective planes, quadratic transformations and nonsingular models of curves.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Rings of polynomials and their quotients, local rings, DVR, modules, free modules, exact sequences.	5
2	Affine algebraic sets, The Hilbert basis theorem. Hilbert's Nullstellansatz.	6
3	Affine varieties: Coordinate rings, polynomial maps, coordinate changes, rational functions.	6
4	Local Properties of plane curves: Multiple points, tangent lines, multiplicities and local rings, intersection number.	5
5	Projective varieties: projective algebraic sets, projective plane curve linear systems of curves,	6
6	Bezout's theorem, Max Noether's fundamental theorem and its applications.	6
7	Variety, Morphisms and Rational maps: The Zariski topology, varieties and their morphism, dimension of varieties, rational maps.	4
8	Resolution of singularities: Blowing up a point in affine and projective planes, quadratic transformations and nonsingular models of curves	4
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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8		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Fulton William, Algebraic Curves, Second Edition, Addison-Wesley, 1989.
2. Fulton William, Algebraic Curves, Third Edition, <http://www.math.lsa.umich.edu/~wfulton/> (freely available and copy right reserved by the author) 2008.
3. Musili, C., Algebraic Geometry for Beginners, First edition, Hindustan Book Agency, 2001.

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	LIE ALGEBRAS AND LIE GROUPS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 756
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL255
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 756

9.	Not allowed for (<i>indicate program names</i>)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course R Sarma and N Shravan Kumar	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce Lie Algebra and their connections with Lie groups.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Definition and examples, solvable and nilpotent Lie algebras, the Engel's theorem, Lie's theorem, Cartan's theorem, killing form. Representation theory of finite dimensional semisimple Lie algebras. The Weyl's theorem, representations of $sl(2, \mathbb{C})$, root space decomposition. Weyl group, Cartan subalgebras and classification of root systems; Definition and examples of matrix Lie groups. Exponential mapping, Baker-Campbell-Hausdorff formula. Representation theory of matrix Lie groups. Representation theory of $SU(2)$ and $SU(3)$.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Definition and examples.	3
2	Solvable and nilpotent Lie algebras, the Engel's theorem, Lie's theorem.	6
3	Cartan's theorem, killing form.	5
4	Representation theory of finite dimensional semisimple Lie algebras. The Weyl's theorem, representations of $sl(2, \mathbb{C})$.	7
5	Root space decomposition. Weyl group, Cartan subalgebras and classification of root systems.	7
6	Definition and examples of matrix Lie groups.	4
7	Exponential mapping, Baker-Campbell-Hausdorff formula.	5
8	Representation theory of matrix Lie groups. Representation theory of $SU(2)$ and $SU(3)$.	5
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11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. J E Humphreys, Introduction to Lie Algebras and Representation Theory, Springer-Verlag, 1972.
2. B C Hall, Lie Groups, Lie Algebra and Representations: An Elementary introduction, Springer, 2003.
3. K Erdmann and M J Wildon, Introduction to Lie Algebras, Springer, 2006.
4. A Baker, Matrix Groups: An Introduction to Lie Group Theory, Springer, 2002.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	NIL
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	INTRODUCTION TO ALGEBRAIC TOPOLOGY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 757
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	MAL245 or MAL601
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course A. Nagar and R. Sarma	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce the basics of algebraic topology.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Homotopy of paths, fundamental group, covering spaces, fundamental group of the circle, Retraction and application, van Kampen theorem and application. Universal cover and classification of covering spaces. Deck transformation and group actions. Simplicial and Singular homology, homotopy invariance, exact sequences- Mayer-Vietories Sequences, the equivalence of simplicial and singular homology.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Path homotopy, Fundamental group.	6
2	Converging spaces, path lifting lemma.	6
3	Fundamental group of the circle.	2
4	Retraction and application.	2
5	van Kampen theorem and application	6
6	Universal cover and classification of covering spaces	5
7	Simplicial homology	5
8	Singular homology	5
9	Exact sequences - Mayer-Vietoris exact sequence	3
10	Equivalence of simplicial and singular homology	2
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. W S Massey, A Basic Course in Algebraic Topology, Springer-Verlag, 1991.
2. A Hatcher, Algebraic Topology, Cambridge University Press, 2001.
3. A R Shastri, Basic Algebraic Topology, CRC Press, 2013.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL

19.6	Classroom infrastructure	NIL
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	ADVANCED ALGORITHMS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 760
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 342
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL 758
8.3	Supercedes any existing course	MAL 760

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course N Chatterjee, B S Panda	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce advanced concepts of algorithms;	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): MST: Fibonacci Heaps and $O(m \log \log n)$ time implementation of MST, Linear time MST verification Algorithm, A linear time randomized algorithm for MST, Finding min-cost arborescences; Dynamic Graph Algorithms; Review of NP-completeness; Introduction to NP-hard optimization problems; A brief introduction to LPP; Integer Programming Problem; Primal-Dual Algorithm; Approximation Algorithms: Primal-Dual Approximation Scheme; vertex cover, set cover, TSP; Hardness of Approximation; Introduction to Randomized Algorithms; Some basic Randomized algorithms; Probabilistic Method: Lovasz Local Lemma;	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Fibonacci Heaps and $O(m \log \log n)$ time implementation of MST, A linear time MST verification Algorithm	4
2	Introduction to randomized algorithm, randomized sorting, A linear time randomized algorithm for MST,	5
3	Dynamic Graph Algorithms	3
4	NP-hardness of optimization problem; some basic NP-Hard problems	5
5	Review of LPP, ILP; Primal-Dual Algorithms	6
6	Introduction to Approximation Algorithm, Approximation Algorithm to TSP, Vertex Cover	5
7	Primal- Dual Approximation Scheme and its applications	5
8	Probabilistic Method; Lovaz Local Lemma and its applications	5
9	Approximation Hardness	4
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. A. Schrijver, Theory of Linear and Integer Programming, Wiley, 1986.
2. N. Alon and J.H. Spencer, The Probabilistic Method, 2nd edition, Wiley, 2000.
3. V Vazirani, Approximation Algorithms, Springer, 2001.
4. R Motwani and P Raghavan, Randomized Algorithms, Cambridge University Press, 2000.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Linux System
19.2	Hardware	Nil

19.3	Teaching aides (videos, etc.)	Nil
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	Microphone and Projector.
19.7	Site visits	Nil

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Nil
20.2	Open-ended problems	Nil
20.3	Project-type activity	Nil
20.4	Open-ended laboratory work	25%
20.5	Others (please specify)	Nil

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	BASIC ERGODIC THEORY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 761
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Anima Nagar, Amit Priyadarshi, Amitabh Tripathi	
12.	Will the course require any visiting faculty?	NIL

13.	Course objective (<i>about 50 words</i>): To introduce the students to basics in Ergodic Theory. We discuss the Ergodic theorems due to Hopf, Birkhoff and von Neumann. We also introduce the concepts of entropy and topological pressure.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Measure spaces, Haar Measure, Poincare Recurrence Theorem, Hopf's Maximal Ergodic Theorem, Birkhoff's Ergodic Theorem, von Neumann's Ergodic Theorem, Isomorphism, Conjugacy and Spectral Isomorphism, Entropy, Topological Pressure and its relationship with Invariant Measures.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Basics of Measure spaces	6
2	Haar Measure	5
3	The Poincare Recurrence Theorem	3
4	Hopf's Maximal Ergodic Theorem	3
5	Birkhoff's Ergodic Theorem, von Neumann's Ergodic Theorem	4
6	Ergodicity, Mixing	4
7	Isomorphism, Conjugacy and Spectral Isomorphism	6
8	Entropy: basic properties	5
9	4DNDDEFAI04ACCOEATA RO OATACDIOEN Ø RE)IXAOFAIO- RACCOAC	6
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. P Walters, An introduction to Ergodic Theory, Graduate Texts in Mathematics, Springer, 1982.
2. M GNadkarni, Basic Ergodic Theory, Birkhauser, 1998
3. W Parry, Topics in Ergodic Theory, Cambridge University Press, 2004.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL

19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	PROBABILITY AND COMPUTING
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 766
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 342
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course N. Chatterjee, S. Dharmaraja, B S Panda	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): Understand basic concepts and tools in probability theory that are relevant to computing, including random variables, independence, moments and deviations, tail inequalities, occupancy problems, the probabilistic method, derandomisation and Markov chains.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Tools and Techniques: random variables; conditional expectation; moment bounds; tail inequalities; independence; coupon collection and occupancy problems; the probabilistic method; Markov chains and random walks; algebraic techniques; probability amplification and derandomisation. Applications: Sorting and searching; graph algorithms; combinatorial optimisation; propositional satisfiability; hashing; routing; random sampling; The Probabiistic Method, Models for Random Graphs; Markov Chains and	
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	Random Walks
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Events and Probability. Verifying matrix multiplication, min-cut algorithm	3
2	Discrete Random Variables and Expectation: Linearity of Expectation, Jensen's Inequality, Bernoulli and Binomial random Variables, Conditional Expectation, Geometric Distribution, Coupon Collector's problem, probabilistic Analysis of Quick Sort	6
3	Random Variables and Moments. Markov's and Chebyshev's Inequalities and their applications in randomized Median algorithm, randomised quicksort,	4
4	Chernoff Bounds. Las Vegas and Monte Carlo algorithms, set balancing, facility location, random rounding and permutation routing.	5
5	Markov Chains and Random Walks. Random-walk algorithms for 2-SAT, 3-SAT and undirected reachability.	4
6	Balls and Bins. Poisson approximation, random graphs and balanced allocations.	4
7	Pairwise Independence and Universal Hash Functions. Sampling, derandomization, perfect hashing.	5
8	The Probabilistic Method, Basic Counting Argument, Expectation Argument, Derandomization Using Conditional Expectations	6
9	Model for Random Graphs, Markov Chain and Random Walks	5
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. M Mitzenmacher and E. Upfal, Probability and Computing: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press, 2005.
2. R. Motwani and P. raghavan, Randomized Algorithms, Cambridge University Press, 1995.
3. J. Hromkovic, Design and Analysis of Randomized Algorithms, Springer, 2005

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Linux System
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Nil
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	Mike, Tablet PC and Projector.
19.7	Site visits	Nil

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Nil
20.2	Open-ended problems	Nil
20.3	Project-type activity	Nil
20.4	Open-ended laboratory work	25%
20.5	Others (please specify)	Nil

Date: 20-1-14

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	COMBINATORIAL OPTIMIZATION
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 770
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 210, MAL 342
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Aparna Mehra, B S Panda	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To present a rigorous introduction to the theory and algorithms and applications of Combinatorial Optimization.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Optimization problems, Convex sets and convex functions, Important combinatorial optimization problems, Convex hulls, Polytopes, Facets, Integral polytopes, Total Unimodularity, Total dual integrality, Background on Polytope and Linear programming; Matroids, Greedy algorithm, Properties, Axioms and constructions of matroids, Matroid Intersection problem, Applications of matroid intersection, Weighted matroid intersection. Heuristics and analysis of heuristics, Min-cost Arborescences; Submodular flows and applications; Mader's T-path and A-path theorems; Multiflows, cut-condition, Okamura-Seymour theorem.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction, motivation and examples of combinatorial optimization	2
2	Background in Polyhedra and Linear Programming: Farkas lemma, Weak and Strong Duality, Complementary Slackness; Faces, Decomposition of Polyhedra	4
3	Integer Polyhedra, Totally Unimodular Matrices, Examples, Network Matrices	4
4	Applications of Integral Polyhedra via Totally Unimodular Matrices: Bipartite Matchings, Single Commodity Flows, Interval Graphs; Gomory-Hu Trees for Undirected Graphs and Symmetric Submodular Set Functions	6
5	Non-bipartite Matching: Tutte-Berge Formula and Maximum Cardinality Matching Algorithm; Edmonds-Gallai Decomposition, Factor-Critical Graphs; Matching Polytope, Edge Covers; Primal-Dual Algorithm for Weighted Bipartite Matching; Edmonds Algorithm for Weighted Non-Bipartite Matching; Total Dual Integrality and Cunningham-Marsh Formula; T-joins and applications	8
6	Matroids: Definition, Duality, Intersection, Union, representation; Maximum Weight Independent Set in a Matroid, Greedy Algorithm, Independence and Base Polytopes; Matroid Polytope Integrality, Submodular Set Functions, Polymatroids, Ellipsoid based algorithm for Submodular Set Function Minimization;	8
7	Combinatorial Algorithm for Submodular Set Function Minimization	4
8	Arborescences and Branchings; Graph Orientations and Directed Cuts, Polymatroid Intersection; Submodular Flows and Applications; Multiflows and Disjoint Paths, Flow-Cut Gaps; Okamura-Seymour theorem, flow-cut gaps and embeddings	6
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COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. J Lee, A First Course in Combinatorial Optimization, Cambridge University Press, 2004.
2. C. Papadimitriou and K. Steiglitz, Combinatorial Optimization: Algorithms and Complexity, Prentice-Hall, 1982.
3. B. Korte and J. Vygen, Combinatorial Optimization: Theory and Algorithms, Algorithms and Combinatorics 21 Springer, Berlin Heidelberg New York, 2006.
4. L Schrijver: Combinatorial Optimization: Polyhedra and Efficiency, Vol-I to III, Springer-Verlag 2003;

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	20%
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 20-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	MATHEMATICS
2.	Course Title (<i>< 45 characters</i>)	NATURAL LANGUAGE PROCESSING
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 785
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (<i>course no./title</i>)	MAL 375
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	MAL 785

9.	Not allowed for (<i>indicate program names</i>)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B. Chandra, N. Chatterjee	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To familiarize students with basics of language processing and many modern day applications involving textual data analytics. On one hand it covers basics of different levels of language analysis and understanding. On the other hand it introduces basic problems of natural languages, such as, Machine Translation, Text Summarization, Word Sense Disambiguation, which are essentials for modern day Knowledge Retrieval and Management .	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Linguistic Essentials: Parts of speech and morphology, inflectional versus derivational morphology, Phrase structure and link grammar, Syntax and syntactic theory, Semantics - semantic annotations, semantic similarity, Syntactic and semantic Ambiguity, Anaphora and cataphora - resolution. Study of Words: Frequency N-grams, Word alignment in parallel corpora - length based, word based, cognate based, Word Sense Disambiguation - Supervised, unsupervised Techniques, Grammar: Markov Models, POS	
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	tagging, Context Free Grammar, Parsing - example-based parsing, Study of Divergence, Applications: Machine Translation - Example Based, Rule Based, Statistical, Summarization - Word Space Model, Random Indexing, multi Document summarization, Information Retrieval - vector based, term distribution based, Sentiment Analysis.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Linguistic Essentials: Parts of speech and morphology, inflectinal versus derivational morphology, Phrase structure and link grammar, Syntax and syntactic theory	4
2	Semantics - semantic annotations, semantic similarity, Syntactic and semantic Ambiguity, Anaphora and cataphora - resolution	6
3	Study of Words: Frequency N-grams, Word alignment in parallel corpora - length based, word based, cognate based, Word Sense Disambiguation - Supervised, unsupervised Techniques	6
4	Grammar: Markov Models, POS tagging, Context Free Grammar, Parsing - example-based parsing, Study of Divergence	8
5	Machine Translation - Example Based, Rule Based, Statistical	8
6	Summarization - Word Space Model, Random Indexing, multi Document summarization,	5
7	Information Retrieval - vector based, term distribution based, Sentiment Analysis.	5
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COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. J. Allen, Natural Language Understanding, Pearson Education, 2nd Ed, 2004
2. D. Jurafsky and D. Martin, Speech and Language Processing, 2nd Ed, 2003
3. C D Manning and H Schutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.
4. P. Koehn, Statistical Machine Translation, Cambridge University Press, 2010

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19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Python
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Projector, Microphone
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	25%
20.2	Open-ended problems	25%
20.3	Project-type activity	25%
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	MODERN METHODS IN PARTIAL DIFFERENTIAL EQUATIONS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 792
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	MAL602 or MAL411
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Harish Kumar, K. Sreenadh	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To introduce modern theory of partial differential equations to students who are interested to pursue the study of Differential equations. The course assumes basic understanding of functional analysis at UG level.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Review of Lebesgue integration and Classical function spaces, Spaces of infinitely differentiable functions and Holder spaces. Sobolev spaces: L^p spaces, Weak derivatives, Sobolev spaces, approximation to identity, approximation with smooth functions, trace spaces, Sobolev and Poincare inequalities, compact embeddings and negative order Sobolev spaces. Second order elliptic equations: Weak solutions, Lax-Milgram Theorem, Energy estimates, Fredholm-alternative, Regularity of weak solutions, Maximum principles and eigenvalue problems. Mountain Pass lemma and applications. Hardy's inequalities and their relation with Elliptic equations. Linear Evolution equations: Second order parabolic equations, existence and regularity of weak	
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	solutions, Maximum principles. Semi-group Theory: Generating, contraction semi-groups and applications.
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15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Review of Lebesgue integration and Classical function spaces, Spaces of infinitely differentiable functions and Holder spaces.	4
2	L^p spaces, Weak derivatives	4
3	Sobolev spaces, approximation to identity, approximation with smooth functions.	5
4	Trace spaces, Sobolev and Poincare inequalities, compact embeddings and negative order Sobolev spaces.	6
5	Second order elliptic equations: Weak solutions, Lax-Milgram Theorem, Energy estimates.	4
6	Fredholm-alternative, Regularity of weak solutions, Maximum principles and eigenvalue problems.	4
7	Mountain Pass lemma and applications, Hardy's inequalities and their relation with Elliptic equations.	4
8	Linear Evolution equations: Second order parabolic equations, existence and regularity of weak solutions, Maximum principles.	6
9	Semi-group Theory: Generating, contraction semi-groups and applications.	5
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. M Schechter, Modern methods in partial differential equations: an introduction, McGraw-Hill International Book Co., 1977.
2. L C Evan, Partial Differential Equation, Second Edition, American Mathematical Society, 2010.
3. Mc Owen, Partial Differential equations: Methods and applications, Pearson Education, 2004.

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	NIL
19.7	Site visits	NIL

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	NUMERICAL METHODS FOR HYPERBOLIC PDE 'S
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 793
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Harish Kumar, VVK Srinivas Kumar, Mani Mehra	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To Introduce numerical techniques for Hyperbolic Partial Differential Equations.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Scalar conservation laws: Method of characteristics, Shocks, Rarefactions, weak and entropy solutions, existence and uniqueness results, Finite volume schemes, Riemann solvers, Convergence of first order schemes. High-order schemes: Lax-Wendroff, TVD schemes, Limiters, ENO schemes, Higher order Runge-Kutta methods. Linear systems: Exact solutions, First- and high-order finite volume schemes. Non-linear Systems: Solutions of Riemann problems, First-Order finite volume schemes for systems. High-order schemes for systems: TVD Limiters. Finite-volume schemes on unstructured meshes. Hyperbolic systems with source term.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Scalar conservation laws: Method of characteristics, Shocks, Rarefactions.	4
2	Weak and entropy solutions, existence and uniqueness results.	3
3	Finite volume schemes, Riemann solvers, Convergence of first order schemes.	4
4	High-order schemes: Lax-Wendroff, TVD schemes, Limiters.	3
5	ENO Schemes. Higher order Runge-Kutta methods.	3
6	Linear systems: Exact solutions, First- and high-order finite volume schemes.	3
7	Non-linear Systems: Solutions of Riemann problems.	4
8	First-Order finite volume schemes for systems.	3
9	High-order schemes for systems: TVD Limiters.	3
10	Finite-volume schemes on unstructured meshes.	3
11	Hyperbolic systems with source term.	3
12	Problem Discussions	6
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- 1 R J LeVeque, Finite Volume methods for hyperbolic problems, Cambridge university Press, 2002..
- 2 E Godlewski and P A Raviart, Hyperbolic systems of conservation laws, Ellipses, Paris, 1991.
- 3 E F Toro, Riemann Solvers and Numerical methods for fluid dynamics, Springer, Berlin, 1997.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microphone and projector
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-01-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	ADVANCED PROBABILITY THEORY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	MAL 794
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	MAL 270
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Subiman Kundu	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): This course offers advanced topics in probability theory with applications to different probability models.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Notions of Stochastic Convergence and Related Convergence Theorems, Uniform Integrability, Weak and Strong Laws of Large Numbers, Speed of Convergence in the Strong Laws of Large Numbers, Martingales, Processes, Filtrations, Stopping Times, Discrete Stochastic Integral, Martingale Convergence Theorems and Their Applications, Levy's Continuity Theorem and Various Versions of Central Limit Theorem, Markov Chains, Discrete Markov Chains, Convergence of Markov Chains, Applications of Probability Theory to Fourier Series-Examples.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Notions of Stochastic Convergence and Related Convergence Theorems	3
2	Uniform Integrability	6
3	Weak and Strong Laws of Large Numbers, Speed of Convergence in the Strong law of Large Numbers	9
4	Martingales, Processes, Filtrations, Stopping Times, Discrete Stochastic Integral	5
5	Martingale Convergence Theorems and Their Applications	4
6	Levy's Continuity Theorem and Various Versions of Central Limit Theorem	5
7	Markov Chains, Discrete Markov Chains, Convergence of Markov Chains	8
8	Applications of Probability Theory to Fourier Series-Examples	2
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		

2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. A Klenke, Probability Theory- A Comprehensive Course, Universitext, Springer Verlag, 2008.
2. R B Ash and C A Doleans-Dade, Probability and Measure Theory, Second Edition, Academic Press, 2000.
3. M Adams and V Guillemin, Measure Theory and Probability, Birkhäuser, 1996.
4. T K Chandra, Laws of Large Numbers, Narosa Publishing House, 2012.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	Blackboard
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 20-1-2014

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Mathematics
2.	Course Title (<i>< 45 characters</i>)	SPECIAL MODULE IN DYNAMICAL SYSTEMS
3.	L-T-P structure	1 - 0 - 0
4.	Credits	1
5.	Course number	MAV 791
6.	Status (<i>category for program</i>)	DE

7.	Pre-requisites (course no./title)	NIL
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	NIL
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Visiting faculty	
12.	Will the course require any visiting faculty?	YES

13.	Course objective (<i>about 50 words</i>): To provide insight into more advanced topics and current research problems in the theory of dynamical systems. The focus will be on providing the students with basics in the area and introduce them to the current ongoing research in this field.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Basics - minimality, equicontinuity, recurrence, distality. Interplay of dynamical properties. Ergodicity. Symbolic dynamics. Relations arising from dynamical transformations and their Ellis semigroups. Entropy. Structure theorems. Decomposition theorems.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to dynamical systems - examples	2
2	Basics_ minimality, distality, recurrence...	2
3	Interplay of dynamical properties	2
4	Symbolic dynamics	2
5	Ergodicity and topological ergodicity	2
6	%i00DÚ	2
7	Decomposition theorems	1
8	Structure theorems	1
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		14

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Some research papers, preferred by the visiting faculty

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	NIL
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	NIL
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	NIL

19.7	Site visits	NIL
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20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NIL
20.2	Open-ended problems	NIL
20.3	Project-type activity	NIL
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	NIL

Date: 15-1-2014

(Signature of the Head of the Department)