Master of Technology in ***Computer Technology***
Department of Electrical Engineering

Overall credit structure

Category	PC	PE	OC	Bridge	Total
Credits	**24**	**18/21[1]**	**3/6[2]**	**3[3]**	**51**

Sem	Courses					Lecture Courses	Contact hrs/week				Credits
							L	T	P	Total	
I	***[PC-1]*** ELL782 Computer Architecture (3-0-0)	***[PC-3]*** ELL781 Software Fundamentals for Computer Technology (3-0-0)	***[Bridge]***[3] ELL780 Mathematical Foundations of Computer Technology (3-0-0)	***[PC-4]/[PE-1]*** ELLxxx (3-0-0)	***[PC-5]/[PE-2]*** ELLxxx (3-0-0)	5	15	0	0	15	15
II	***[PC-2]*** ELL783 Operating Systems (3-0-2)	***[PC-6]*** ELD780 Minor Project (0-0-4)	***[PC-4]/[PE-1]*** ZZyxxx (3-0-0)	***[PC-5]/[PE-2]*** ZZyxxx (3-0-0)		4	9	0	6	15	12
Summer: ***[PC-7]*** ELD801 Major Project Part 1 (for Project-based stream)											
III (Project-based)	***[PC-7]*** ELD880 Major Project Part 1 (0-0-12)	***[PE-3]*** ZZyxxx (3-0-0)	***[OE-1]*** ZZyxxx (3-0-0)			2	6	0	12	18	12
III (Course-based)	***[PE-3]*** ZZyxxx (3-0-0)	***[PE-4]*** ZZyxxx (3-0-0)	***[PE-5]/[OE-1]*** ZZyxxx (3-0-0)	***[PE-6]/[OE-2]*** ZZyxxx (3-0-0)		4	12	0	0	12	12

1 Related to point 2, below:

2 Those opting for the course-based stream can do a maximum of 6 OC credits; those opting for the project-based stream can do a maximum of 3 OC credits.

3 The bridge course can be waived and replaced by a Program Elective (PE), only with the permission of the Program Coordinator, if the background of the student is found to be appropriate enough

IV (Project-based)	***[PE-4]*** ELD881 Major Project Part 2 (0-0-24)					0	0	0	24	24	12
IV (Course-based)	***[PC-7]*** ELD880 Major Project Part 1 (0-0-12)	***[PE-5]/[OE-1]*** ZZyxxx (3-0-0)	***[PE-6]/[OE-2]*** ZZyxxx (3-0-0)			2	6	0	12	18	12

Notes:

- The example above considers only lecture courses (ZZLxxx). The total number of credits for Semesters II, III, and IV can be composed of other 3-credit laboratory courses (ZZPxxx) as well, as mentioned in the baskets below. If the course is that of the Department of Electrical Engineering, ZZ would be EL, for instance.
- A student has to choose from one of the ***five*** possible streams in the programme: Cognitive and Intelligent Systems (CIS), Embedded Intelligent Systems (EIS), Computer Communication and Networks (CCN), Multimedia Information Processing (MIP) and Internet Technologies (IT). This is reflected in the choice of the *Stream Core* list, below (PC-4 and PC-5). At least two PE lecture courses must be chosen from the PE list for the particular stream one has opted for.
- Any additional course taken by a student from the *Stream Core* list (after opting for PC-4 and PC-5) will be considered as a Program Elective (PE). For instance, if a student opts for the CIS stream, and after doing `Introduction to Machine Learning' and `Multimedia Systems' as PC-4 and PC-5, if the student opts to do Computer Networks and/or Embedded Systems and Applications, it/they will be considered as Program Electives (PEs).
- Courses temporarily mentioned in red colour: from other groups/Departments

Program Core (PC)

Course#	Title	L-T-P	Credits
ELL782	Computer Architecture	3-0-0	3
ELL781	Software Fundamentals for Computer Technology	3-0-0	3
ELL783	Operating Systems	3-0-2	4
ELD780	Minor Project	0-0-4	2
ELD880	Major Project Part 1	0-0-12	6

Program Core: Stream Core: Core courses (PC-4 and PC-5: choose two courses from this basket, depending on the stream opted for)

Course#	Title & Stream	L-T-P	Credits
ELL784	Introduction to Machine Learning (CIS, IT, EIS)	3-0-0	3
ELL785	Computer Communication Networks (CCN, IT)	3-0-0	3
ELL786	Multimedia Systems (MIP, CIS, CCN)	3-0-0	3
ELL787	Embedded Systems and Applications (EIS, MIP)	3-0-0	3

Bridge Course

Course#	Title	L-T-P	Credits
ELL780	Mathematical Foundations of Computer Technology	3-0-0	3

Program Electives (PE): General

Course#	Title	L-T-P	Credits
ELD881	Major Project Part 2	0-0-24	12
ELL810	Special Topics in Computers 1	3-0-0	3
ELL811	Special Topics in Computers 2	3-0-0	3
ELV780	Special Module in Computers	1-0-0	1
ELS880	Independent Study	3-0-0	3

Program Electives (PE): Stream: Cognitive and Intelligent Systems (CIS)

Course#	Title	L-T-P	Credits
ELL704	Advanced Robotics	3-0-0	3
ELL884	Information Retrieval	3-0-0	3
ELL789	Intelligent Systems	3-0-0	3
ELL882	Large-Scale Machine Learning	3-0-0	3
ELL799	Natural Computing	3-0-0	3
ELL796	Signals and Systems in Biology	3-0-0	3
ELL708	Systems Biology	3-0-0	3
ELL788	Computational Perception and Cognition	3-0-0	3
ELL891	Computational Linguistics	3-0-0	3
ELL886	Big Data Systems	3-0-0	3
ELL887	Cloud Computing	3-0-0	3
ELL741	Neuromorphic Engineering	3-0-0	3
ELL899	Neural Systems and Learning Machines	3-0-2	4
ELL888	Advanced Machine Learning	3-0-0	3
ELL793	Computer Vision	3-0-0	3
ELL715	Image Processing	3-0-0	3
ELL798	Agent Technology	3-0-0	3
ELL795	Swarm Intelligence	3-0-0	3
ELL794	Human-Computer Interface	3-0-0	3
ELL893	Cyber-Physical Systems	3-0-0	3
ELL883	Embedded Intelligence	3-0-0	3
ELL885	Machine Learning for Computational Finance	3-0-0	3
ELL890	Computational Neuroscience	3-0-0	3

Program Electives (PE): Stream: Embedded Intelligent Systems (EIS)

Course#	Title	L-T-P	Credits
ELP780	Software Lab	0-1-4	3
ELP781	Digital Systems Lab	0-1-4	3
ELL704	Advanced Robotics	3-0-0	3
ELL735	Analog Integrated Circuits	3-0-0	3
ELL734	MOS VLSI	3-0-0	3
ELL748	System-on-Chip Design and Test	3-0-0	3
ELL731	Mixed Signal Circuit Design	3-0-0	3
COLxxx	Synthesis of Digital Systems	3-0-0	3
ELL790	Digital Hardware Design	3-0-0	3
ELL720	Digital Signal Processing 1	3-0-0	3
COLxxx	System Level Design and Modelling of Digital Systems	3-0-0	3
ELL791	Testing and Fault Tolerance	3-0-0	3
ELL802	Adaptive and Learning Control	3-0-0	3
ELL767	Mechatronics	3-0-0	3
ELL766	Appliance Systems	3-0-0	3
ELL898	Pervasive Computing	3-0-0	3
ELL887	Cloud Computing	3-0-0	3
ELL728	Optoelectronic Instrumentation	3-0-0	3
ELL883	Embedded Intelligence	3-0-0	3
ELL899	Neural Systems and Learning Machines	3-0-2	4
ELL797	Energy-Efficient Computing	3-0-0	3
ELL733	Digital ASIC Design	3-0-2	4
ELP831	IEC Laboratory-I	0-0-6	3

Program Electives (PE): Stream: Computer Communication and Networks (CCN)

Course#	Title	L-T-P	Credits
ELP780	Software Lab	3-0-0	3
ELP782	Computer Networks Lab	0-1-4	3
ELP781	Digital Systems Lab	0-1-4	3
ELL711	Signal Theory	3-0-0	3
ELL894	Network Performance Modeling and Analysis	3-0-0	3
ELL889	Protocol Engineering	3-0-0	3
ELL892	Internet Technologies	3-0-0	3
ELL895	Network Security	3-0-0	3
ELL896	Mobile Computing	3-0-0	3
ELL897	Network Management	3-0-0	3
ELL723	Broadband Communication Systems	3-0-0	3
ELL714	Basic Information Theory	3-0-0	3
ELL724	Advanced Information Theory	3-0-0	3
ELL819	Telecom Switching and Transmission	3-0-0	3
ELL710	Coding Theory	3-0-0	3
ELL712	Digital Communications	3-0-0	3
ELL816	Satellite Communication	3-0-0	3
BSL818	Telecom Technologies	3-0-0	3
BSL817	Access Networks	3-0-0	3
ELL725	Wireless Communication	3-0-0	3
ELP712	Wireless Communication Lab	0-1-4	3
ELL717	Optical Communication Systems	3-0-0	3
ELL820	Photonic Switching and Networking	3-0-0	3
BSP775	Telecom Networks Lab 1	3-0-0	3

BSP858	Telecom Networks Lab 2	3-0-0	3
BSP881	Network Software Lab	0-1-4	3
ELL898	Pervasive Computing	3-0-0	3
ELL887	Cloud Computing	3-0-0	3
ELL797	Energy-Efficient Computing	3-0-0	3

Program Electives (PE): Stream: Multimedia Information Processing (MIP)

Course#	Title	L-T-P	Credits
ELL715	Digital Image Processing	3-0-0	3
ELL720	Digital Signal Processing 1	3-0-0	3
ELL792	Computer Graphics	3-0-0	3
CRL707	Human and Machine Speech Communication	3-0-0	3
ELL793	Computer Vision	3-0-0	3
ELL788	Computational Perception and Cognition	3-0-0	3
ELL882	Large Scale Machine Learning	3-0-0	3
ELL711	Signal Theory	3-0-0	3
ELL719	Detection and Estimation	3-0-0	3
ELL718	Statistical Signal Processing	3-0-0	3
ELL714	Basic Information Theory	3-0-0	3
ELL724	Advanced Information Theory	3-0-0	3
ELL710	Coding Theory	3-0-0	3

Program Electives (PE): Stream: Internet Technologies (IT)

Course#	Title	L-T-P	Credits
ELP781	Digital Systems Lab	0-1-4	3
BSP757	Embedded Telecom Systems Lab	0-1-4	3
ELL892	Internet Technologies	3-0-0	3
ELP780	Software Lab	0-1-4	3
ELP782	Computer Networks Lab	0-1-4	3
ELL798	Agent Technologies	3-0-0	3
ELL896	Mobile Computing	3-0-0	3
ELL884	Information Retrieval	3-0-0	3
ELL898	Pervasive Computing	3-0-0	3
ELL766	Appliance Systems	3-0-0	3
ELL895	Network Security	3-0-0	3
ELL765	Smart Grid Technology	3-0-0	3
ELL772	Planning and Operation of a Smart Grid	3-0-0	3
ELP855	Smart Grids Lab	0-1-4	3
ELL723	Broadband Communication Systems	3-0-0	3
ELL887	Cloud Computing	3-0-0	3
ELL797	Energy-Efficient Computing	3-0-0	3

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Computer Architecture
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL782
6.	**Status** *(category for program)*	Program Core

7.	**Pre-requisites** (course no/title)	None

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	ELL308 Computer Architecture (UG)
8.2	Overlap with any UG/PG course of other Dept./Centre	COL7xxx Architecture of Large Systems, COL4xx Computer Architecture (UG)
8.3	Supersedes any existing course	EEL601 Computer Architecture

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [x] 1st sem [ ] 2nd sem [ ] Either sem

11.	**Faculty who will teach the course** Santanu Chaudhury, Sumantra Dutta Roy, Turbo Majumder, S.M.K. Rahman, Sumeet Agarwal

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** The course intends to familiarise a student with developments in the architecture and application areas with computer systems, and their components: processors, cache, main memory, and disk systems. The course will examine parallelising operations in hardware to achieve higher performance throughputs, and at a software level as well: parallel algorithms on some sample architectures.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Instruction set design, pipelining, memory hierarchy design, parallelism in various forms, warehouse scale computers, specific topics such as Vector, SIMD, GPU architectures, Embedded Systems, VLIW, EPIC, Multi-core architectures

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Quantitative design and analysis; Instruction set samples	1
2	Instruction-level parallelism; Pipelining	6
3	Memory Hierarchy Design; Cache; Virtual Memory	6
4	Thread Level Parallelism	6
5	Data-Level Parallelism in Vector, SIMD, GPU Architectures	4
6	Warehouse Scale Computers; Blade Architecture; Interconnected Networks	8
7	Miscellaneous Topics: Hardware and Software for VLIW and EPIC; Multi-core Architectures; Storage Systems	11
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Review of Computer Organisation fundamentals; Pipelining, Memory hierarchy	20
2	Development and Implementation of Parallel Algorithms on sample architectures	22

19. Suggested texts and reference materials

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

J. L. Hennessey, D. A. Patterson. Computer Architecture: A Quantitative Approach, Fifth Edition, Morgan Kaufmann, 2011. A. Grama, A. Gupta, G. Karypis, V. Kumar. Introduction to PArallel Computing, Second Edition. Addison-Wesley, 2003.

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

20.1	Software	MPI, threads libraries
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	Parallel Computing Mini Project
21.2	Open-ended problems	Parallel Computing Mini Project
21.3	Project-type activity	Parallel Computing Mini Project
21.4	Open-ended laboratory work	Parallel Computing Mini Project
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Software Fundamentals for Computer Technology
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL781
6.	**Status** *(category for program)*	PC for EET

7.	**Pre-requisites** (course no/title)	COL106

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [x] 1st sem [ ] 2nd sem [ ] Either sem

11.	**Faculty who will teach the course**

	Sumantra Dutta Roy, Sumeet Agarwal, Santanu Chaudhury

12.	**Will the course require any visiting faculty? (yes/no)**	no

13.	**Course objectives** *(about 50 words)***: On completion of the course, we expect a student to be able to do the following: (i) Choose the data structures that effectively model the information in a problem (ii) Judge efficiency trade-offs among alternative algorithms and data structures for implementations (iii) Apply algorithm analysis techniques to evaluate the performance of an algorithm and to compare data structures (iv) Apply object-oriented design principles (v) Apply design guidelines to evaluate alternative software designs (vi) Design dependable system**

14.	Course contents (about 100 words) (Include laboratory/design activities): Introduction, data structures for combinatorial optimization: heaps, union-find, Fibonacci heaps, dynamic trees, dynamic graph structure; Asymptotic analysis; Divide & conquer and graph algorithms: Graph search: Breadth first, depth first, topological sorting, Fast Fourier Transform, Matrix Multiplication, Shortest path algorithms; Additional Data Structures: Suffix trees & string matching, Splay trees & amortized analysis; Advanced algorithmic design techniques: Dynamic programming (edit distance, chains of matrix multiplication, etc.), Network flow and its use for solving problems; Linear and integer programming, NP-completeness, Randomized algorithms (hashing & global minimum cut), Approximation Algorithms; Object oriented Software design, Design of Dependable Software.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction	1
2	Data structures for combinatorial optimization: heaps, union-find, Fibonacci heaps, dynamic trees, dynamic graph structure	4
3	Asymptotic analysis	2
4	Divide & conquer and graph algorithms: Graph search: Breadth first, depth first, topological sorting, Fast Fourier Transform, Matrix Multiplication, Shortest path algorithms	5
5	Additional Data Structures: Suffix trees & string matching, Splay	5

	trees & amortized analysis	
6	Advanced algorithmic design techniques: Dynamic programming (edit distance, chains of matrix multiplication, etc.)	5
7	Network flow; Linear and integer programming	5
8	NP-completeness	2
9	Randomized algorithms (hashing & global minimum cut)	3
10	Approximation Algorithms	3
11	Object oriented Software design	5
12	Design of Dependable Software	2
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	C, C++/Java and Python Programming	20
2	UML	5
3	Requirement Analysis and Modeling	5
4	Fault-tolerant and persistent data structures	5
5	Online and Data Stream Algorithms	5

19. Suggested texts and reference materials

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

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L Rivest, Clifford Stein, Introduction to Algorithms 3e by MIT Press, 2009.
2. Bernd Bruegge, Allen H. Dutoit, Object-Oriented Software Engineering Using UML, Patterns and Java, Second Edition. Prentice Hall, 2004.

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

20.1	Software	Standard Compilers and Programming Environment
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	

20.6	Classroom Infrastructure	Multimedia Projector
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	15%
21.2	Open-ended problems	
21.3	Project-type activity	15%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Mathematical Foundations of Computer Technology
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL780
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	Nil

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	Slight overlap with ELL701 Mathematical Methods in Control
8.3	Supersedes any existing course	No

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [x] 1st sem [ ] 2nd sem [ ] Either sem

11.	**Faculty who will teach the course** Prof. Jayadeva, Prof. Santanu Chaudhury, Dr. Sumeet Agarwal

12.	**Will the course require any visiting faculty? (yes/no)**	May use

13.	**Course objectives** *(about 50 words)***: A significant fraction of Masters level students possess weak or inadequate skills in several areas of mathematics. This course is intended to provide Masters students with a concise treatment of multiple topics needed in many of the streams being offered, without being mathematically detailed.**

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)****:*** **Probability theory, stochastic processes, and statistical inference. Elements of real and complex analysis, and linear algebra. Optimization, with an emphasis on application and implementation.**

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Elements of probability and stochastic systems with reference to computer engineering problems (e.g., machine learning, computer networks, performance evaluation)	7
2	Basics of real and complex analysis; notion of generalised functions and distributions, distance between distributions	6
3	Linear Algebra, matrix operations in image and signal processing, basics of manifolds	7
4	Optimization: basics and types of optimization problems	3
5	Linear and Quadratic Programming, with applications in computer engineering	6
6	Nonlinear Optimisation, Global Optimisation	3
7	Hill climbing and Stochastic Optimisation	3
8	Monte Carlo simulations, Gibbs Sampling	3
9	Elements of Game Theory	4
COURSE TOTAL (14 times `L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours
	None	

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Probability and Statistics: theoretical foundations, inference techniques, approximate inference	10
2	Distributions	5
3	Differential and Partial Differential Equations	5
4	Linear Algebra: foundations, computational techniques (e.g., matrix inversion)	7
5	Optimisation: applications of different algorithms and comparative analyses	15

19. Suggested texts and reference materials

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

1. M. S. Bazaraa, H. D. Sherali, C. M. Shetty. Nonlinear Programming: Theory and Algorithms. Wiley, 2008.
2. S. Chandra et al. Numerical Optimization with Applications. Narosa Publishers, 2011.
3. S. Graham Kelly. Advanced Engineering Mathematics with Modeling Applications. CRC Press, 2008.
4. P. K. Bhattacharyya. Distributions: Generalized Functions with Applications in Sobolev Spaces. Walter de Gruyter Publishers, 2012.
5. S. S. Venkatesh. The Theory of Probability Explorations and Applications. Cambridge, 2012.
6. Peter Morris. Introduction to Game Theory. Springer, 1994.

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

20.1	Software	Matlab
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	

21.2	Open-ended problems	10%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Operating Systems
3.	**L-T-P Structure**	3-0-2
4.	**Credits**	4
5.	**Course Number**	ELL783
6.	**Status** *(category for program)*	Program Core

7.	**Pre-requisites** (course no/title)	Computer Architecture

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	ELLxxx Operating Systems (UG)
8.2	Overlap with any UG/PG course of other Dept./Centre	COLxxx Resource Management in Computer Systems
8.3	Supersedes any existing course	EEL602 Operating Systems

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [x] 2nd sem [ ] Either sem

11.	**Faculty who will teach the course** Santanu Chaudhury, Sumantra Dutta Roy, Subrat Kar, S.M.K. Rahman

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** The course introduces a student to various part of typical Operating Systems, and ways and means to interact with Operating Systems.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Processes and threads; CPU scheduling; concurrency, synchronisation; deadlocks; Memory management; files and I/O; Real-time operating systems; basics of Cloud computing

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction; Relation with Computer Architecture	1
2	Processes, Inter-process Communication	2
3	Threads	2
4	Concurrency Issues	6
5	Deadlocks	2
6	Memory Management	2
7	Files and I/O	2
8	Real-Time Systems	3

9	Multi-core/Multi-Processor Operating Systems	4
10	Energy Management in Operating Systems	4
11	Distributed Operating Systems	5
12	Case Studies: Linux, Android	6
13	Basics of Cloud Computing	3
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours
	File transfer application	3
	CPU Scheduling algorithms	5
	Concurrency control and synchronisation	5
	Shell design	5
	Hands-on experiments with Linux and Android	5
	Cloud computing experiments	5

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours

	Concurrency control and synchronisation	2
	Multi-core/Multi-Processor Operating Systems	5
	Real-time Operating Systems	5
	Energy Management in Operating Systems	5
	Distributed Operating Systems	5
	Linux and Android: case study	10
	Cloud computing: protocols, structures and experiments	10

19. Suggested texts and reference materials

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

A. Silberschatz, P. B. Galvin, G. Gagne. Operating System Concepts, Eighth Edition. John Wiley & Sons,Inc., 2008

W. Stallings. Operating Systems: INternals and Design Principles, Sixth Edition, PHI, 2008.

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

20.1	Software	Linux OS/PintOS/Android
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
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21. Design content of the course (Percent of student time with examples, if possible)

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2.	**Course Title** *(<45 characters)*	
3.	**L-T-P Structure**	
4.	**Credits**	
5.	**Course Number**	
6.	**Status** *(category for program)*	

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Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

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COURSE TEMPLATE

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2.	**Course Title** *(<45 characters)*	Information Retrieval
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL884
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	COL106, MTL106

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	EEL708

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** Santanu Chaudhury, Hiranmay Ghosh

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** To provide a background of information retrieval methods from local repositories, digital libraries, as well as web-scale data-sources. While the prime focus of the course will be text data, it will also include an introduction to content based retrieval for media data.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Motivation, evaluation, classical IR models, Indexing, ML techniques, Semantic search, MIR, Web-scale information retrieval, Query processing, User interfaces

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction. Modes of information access - retrieval and navigation. Motivation for local / web-scale information retrieval. Contextual / personalized information retrieval. Relationship with question-answering, information summarization. Issues: Authenticity of information, Advertisements, Search Engine 'optimization', spelling variations	3
2	Evaluation of retrieval performance: Precision, Recall, Recall-precision graph, F-measure, Alternate measurements, Clickthrough data and relevance, Discounted Cumulative Gain, Utility vs. variety, Real time performance (latency)	4
3	Classical retrieval models: Boolean, Vector space, Binary Independence, Bayesian. Word root extraction	4
4	Speeding up information retrieval. Indexing and retrieval. Index structures. Memory based and disk based index. B-Tree, Trie, Hashing. Index construction and compression.	5
5	Case Study: Introduction to Lucene/Solr	1
6	Retrieving similar documents. Notion of similarity. Machine learning techniques. K-Means, Agglomerative, DB-Scan, Canopy, Approximate clustering. Flat and hierarchical clustering. k-NN, ANN, Classification techniques: SVM, Bayesian classifier	6
7	Towards semantics. PoS Tagging, Term weighting, N-grams, N-gram indexing. Latent semantic indexing. Relevance feedback. Performance and scalability issues	5
8	Multimedia information retrieval. Motivation. Content and context. Annotations. Content based retrieval. Introduction to media features (image, motion image, audio), feature indexing (kD-Tree, BoW …), segmentation. multimodal information fusion.	5

9	Technologies for web-scale and distributed information retrieval. Crawling and indexing. Cross-language retrieval, Central and distributed indexing, Hadoop and map-reduce -- applications in retrieval, heterogeneous collections, P2P architecture (Napster), Agent based architecture. Link analysis (Page-rank algorithm). Hardware infrastructure for dynamic extensibility. Issues: Dynamic environment, query and update latency	5
10	Query languages, Query clustering (similar queries) and cacheing, User interfaces and visualization	4
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Term paper on search engine applications and related topics, e.g. Enterprise search engine, Social search engine, Music retrieval, Recommendation systems, Query answering, News summarization, Geographic information search, etc.	30
2	Hands-on with Lucene/Solr	12
3	Optional: Implementation of at least one of (a) media search engine, (b) distributed search engine, (c) relevance feedback and personalization (over Lucene), (d) k-NN search, etc.	

19. Suggested texts and reference materials

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

1. Manning, Raghavan and Schutze. Introduction to information retrieval. Cambridge, 2008. [Link]
2. Baeza-Yates & Ribeiro-Neto. Modern Information Retrieval. Addison Wesley, 1999.

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

20.1	Software	Lucene / Solr (Open source)
20.2	Hardware	Standard desktops / laptops
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	

20.8	Others (please specify)	

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

21.1	Design-type problems	20%
21.2	Open-ended problems	10%
21.3	Project-type activity	25%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Swarm Intelligence
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL795
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	None

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	No

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** **JD, SC, MS, SA**

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:Acquaint students with basics of swarm intelligence, evolutionary algorithms**

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)****: Swarm intelligence, distributed optimization, ant colony algorithms, PSO, firefly, bee, and related methods, applications and implementation issues.***

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1.	Swarm phenomena in nature, motivation in modelling, problem solving in nature	7
2.	Ant Colony optimization	8
3.	Applications, analysis	6
4.	Introduction to Swarm Robotics	6
5.	Implementation issues	4
6.	Firefly, Honeybee, and other evolutionary methods	8
7.	Convergence of swarm algorithms	3
COURSE TOTAL (14 times `L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	None	

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Differential and Partial Differential Equations	15
2	Simulating large swarms	12
3	Simulating swarm intelligence applications	15

19. Suggested texts and reference materials

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

Dorigo M. & T. Stützle (2004). Ant Colony Optimization. Cambridge, MA: MIT Press/Bradford Books

Bonabeau E., M. Dorigo & G. Theraulaz (1999). Swarm Intelligence: From Natural to Artificial Systems. New York, NY: Oxford University Press

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

20.1	Software	Matlab
20.2	Hardware	FPGA Kits
20.3	Teaching aids (videos, etc.)	Online
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	10%
21.2	Open-ended problems	20%
21.3	Project-type activity	25%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Intelligent Systems
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL789
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	ELL409 (25%)
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL333, CSL671
8.3	Supersedes any existing course	EEL758

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	Either sem

11.	**Faculty who will teach the course:** **Sumantra Dutta Roy, Sumeet Agarwal, Santanu Chaudhury**

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	Course objectives (about 50 words): Intelligent systems are designed to sense, interpret, reason and act on the external environment using AI techniques. Artificial intelligence provide rigorous mathematical tools for solving complex real-world problems. In this course, students will learn the foundational principles that drive design of intelligent systems and its applications. They will have practice in implementing some of these systems. Learning objective of the course is to equip students with the tools to tackle new AI problems they might encounter in life.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:* ***Introduction, Search, Markov Decision Process, Game Playing, Constraint Satisfaction, Bayesian Network, Logic, Planning, Searching with non-deterministic action***

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction	1
2	Search: Tree search, Dynamic programming, uniform cost search, A*, consistent heuristics, Relaxation	4
3	Markov Decision Process: Policy evaluation, policy improvement Policy iteration, value iteration Reinforcement learning: Monte Carlo, SARSA, Q-learning Exploration/exploitation, function approximation	6
4	Game Playing: Minimax, expectimax, Evaluation functions, Alpha-beta pruning, TD learning, Game theory	4
5	Constraint Satisfaction: Factor graphs, Backtracking search Dynamic ordering, arc consistency, Beam search, local search Conditional independence, variable elimination	4
6	Bayesian Network: Bayesian inference, Marginal independence Hidden Markov models, Forward-backward, Gibbs sampling, Particle filtering, Learning Bayesian networks, Laplace smoothing, Expectation Maximization	8
7	Logic: Syntax versus semantics, Propositional logic Horn clauses, First-order logic Resolution, Higher-order logics	9

	Markov logic; Semantic parsing	
8	Planning: the STRIPS language; forward planning; backward planning; planning heuristics; partial-order planning; planning using propositional logic; planning vs. scheduling.	3
9	Beyond classical search: searching with nondeterministic actions; searching with partial observations; online search agents; dealing with unknown environments.	3
COURSE TOTAL (14 times `L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
2	Algorithm Design: Branch and Bound; Dynamic Programming	5
3	MRF and CRF	10
4	Chess Playing Strategy	10
7	Prolog and Logic Programming	8
7	Non-monotonic Logic	10
7	Rule based System	5
7	Description Logic	10

19. Suggested texts and reference materials

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

1. Russell and Norvig. Artificial Intelligence: A Modern Approach, Pearson Press, 2010, 3rd Edition.
2. Koller and Friedman. Probabilistic Graphical Models. MIT Press 2009.
3. Sutton and Barto. Reinforcement Learning: An Introduction, MIT Press, 2nd Edition (on the web).
4. Bratko, Ivan. Prolog Programming for Artificial Intelligence, 4th Edition, Addison-Wesley, 2012.

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

20.1	Software	Prolog, LISP
20.2	Hardware	Standard PCs
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	

20.6	Classroom Infrastructure	Multimedia Projector
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	20%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Large Scale Machine Learning
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL882
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	ELL784 Introduction to Machine Learning

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course Jayadeva, Sumeet Agarwal, Santanu Chaudhury, Sumantra Dutta Roy**

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	Course objectives (about 50 words): Applications involving millions or even billions of data items such as documents, user records, reviews, images or videos are not that uncommon. The goal of this course is to introduce fundamental concepts of large-scale machine learning. The course will make use of examples from real-world settings from various fields including Vision and Information Retrieval. The course will prepare students to evolve a new dimension while developing models and optimization techniques to solve a practical problem - scalability.

14.	Course contents (about 100 words) (Include laboratory/design activities): Introduction, Randomized Algorithms, Matrix Approximations (low-rank approximation, decomposition, sparse matrices, matrix completion), Large Scale Optimization, Kernel Methods (fast training), Boosted Decision trees, Dimensionality Reduction (linear and nonlinear methods), Distributed Gibbs Sampling, Sparse Methods/Streaming (sparse coding...); Applications

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1.	Introduction	1
2.	Randomized Algorithms	3
3.	Matrix Approximations	5
4.	Large Scale Optimisation	6
5.	Large Scale Kernel Methods	6
6.	Large Scale Learning using Boosted Decision trees	3
7.	Dimensionality Reduction	4
8.	Distributed Gibbs sampling	3
9.	Sparse Methods	6
10.	Application Domain Examples (Ad placement, Vision Problems, Speech Recognition)	5

	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
2.	Distributed and Parallel Processing: Data Parallelism, Task parallelism	6
	Use of GPU's for Large Scale Learning for Vision	8

	Reconfigurable Computing for Deep Learning	8
	Machine Learning with Multi-core Systems	8
	Concurrent Programming Framework: CUDA, MPI, MapReduce, DryadLINQ	12

19. Suggested texts and reference materials

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

1. Charu C. Aggarwal (Eds.),, Data Classification-Algorithms & Applications, Chapman/CRC Press, 2015
2. Ron Bekkerman, Mikahil Blemko, John Langford (eds.), Scaling up Machine Learning, Cambridge, 2012
3. Jimmy Lin & Aek Kolcz, Large Scale Machine Learning at twitter, SIGMOD ’12, May 20–24, 2012, Scottsdale, Arizona, USA.
4. Dhruba Borthakur et al., Apache Hadoop Goes Realtime at Facebook, SIGMOD’11, 2011.

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

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	30%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Signals and Systems in Biology
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL796
6.	**Status** *(category for program)*	Programme Elective for EET

7.	**Pre-requisites** (course no/title)	

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	Either sem

11.	**Faculty who will teach the course** Sumeet Agarwal, Kushal Shah, Shaunak Sen

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** This course will be an attempt to look at how ideas and tools from electrical engineering can be applied to understand the workings of living organisms. We will be looking at both the *signals* that characterise biological information and dynamics, and the *systems* which integrate these and carry out the functionality of life.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:* ***Introduction to Cell Biology (DNA and Proteins); Introduction to Evolution; Modelling Evolution (Genetic Algorithms, Quasispecies); Genomic Signal Processing; Transcriptomic/Proteomic signals; Regulatory networks and dynamics; Protein interaction networks; Signal transduction and metabolic networks; Evolvability and Learning. Project activities on these topics (involving the use of online biological databases and bioinformatics software tools); Student presentations and Journal Club.***

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to Cell Biology: DNA and Proteins	3
2	Introduction to Evolution: How did all the complexity of life emerge in the first place?	3
3	Modelling Evolution: Genetic Algorithms, Quasispecies	3
4	Introduction to Signal Processing and Random Processes	3
5	Identification of gene coding regions	2
6	Identification of origin of replication	1
7	Periodicities of DNA sequences	1
8	How random/correlated is a DNA sequence?	1
9	DNA phylogeny	1
10	Transcriptomic/Proteomic signals: How do genes and proteins actually put genomic information into practice?	3
11	Regulatory networks and dynamics: Information flow between different biological components, Regulatory motifs, Mechanisms of control life	6

	employs to maintain stability and functionality, Reverse engineering from expression data	
12	Protein interaction networks: Structure of connections between life's building block, Role of modularity in biology	3
13	Signal transduction and metabolic networks	3
14	Evolvability and Learning	3
15	Student presentations and journal club	6
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N/A	

17. Brief description of laboratory activities

Module no.	Description	No. of hours
	N/A	

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Genomic signal processing: Study of research papers and corresponding software tools; exploration of online genomic databases	15
2	Systems & network biology: Study of research papers and corresponding software tools; exploration of online biological databases (transcriptomic/proteomic/metabolomic)	15
3	Journal club: Study of contemporary research papers on chosen topics (outside of those discussed in lectures)	12

19. Suggested texts and reference materials

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

Genetic Algorithms

[Introduction]

- Introductory slides: http://lancet.mit.edu/~mbwall/presentations/IntroToGAs/
- Introductory article by John Holland: http://www2.econ.iastate.edu/tesfatsi/holland.gaintro.htm

[Application to evolving biomolecular oscillators]

- http://www.la-press.com/ga-based-design-algorithms-for-the-robust-synthetic-genetic-oscillator-article-a2078
- http://www.la-press.com/design-of-synthetic-genetic-oscillators-using-evolutionary-optimizatio-article-a3584

Quasispecies

- http://www.ploscompbiol.org/article/info%3Adoi%2F10.1371%2Fjournal.pcbi.0010061
- http://www.biomedcentral.com/1471-2148/5/44

Genomic Signal Processing

- Lecture slides on signal processing and random processes: http://web.iitd.ac.in/~kkshah/eel205.html
- NCBI: ftp://ftp.ncbi.nlm.nih.gov/genomes

Identification of gene-coding regions in DNA sequence

- S. Tiwari et. al., Prediction of probable genes by fourier analysis of genomic sequences. Bioinformatics 13, 263 (1997)
- C. Yin and S-T. Yau, A Fourier Characteristic of Coding Sequences: Origins and a Non-Fourier Approximation. J. Computational Biology 12, 1153 (2005)
- I. Grosse et. al., Species independence of mutual information in coding and noncoding DNA. Physical Review E 61, 5624 (2000)
- R. Bose and S. Chouhan, Alternate measure of information useful for DNA sequences. Physical Review E 83, 051918 (2011)
- N. Subramanian and R. Bose, Dipole angular entropy techniques for intron-exon segregation in DNA. Europhysics Letters 98, 28002 (2012)

Identification of promoter regions

- A. Krishnamachari, V. Mandal and Karmeshu, Study of DNA binding sites using the Renyi parametric entropy measure. J. Theoretical Biology 227, 429 (2004)
- S. P. Pandey and A. Krishnamachari, Computational analysis of plant RNA Pol-II promoters. BioSystems 83, 38 (2006)

- A. Kanhere and M. Bansal, Structural properties of promoters: similarities and differences between prokaryotes and eukaryotes. Nucleic Acids Research 33, 3165 (2005)

Identification of replication origin in DNA sequence

- J. R. Lobry, Origin of replication of Mycoplasma genitalium. Science 272, 745 (1996)
- J. Mrazek and S. Karlin, Strand compositional asymmetry in bacterial and large viral genomes. PNAS USA 95, 3720 (1998)
- A. Grigoriev, Analyzing genomes with cumulative skew diagrams. Nucleic acids research 26, 2286 (1998)
- R. Zhang and C. T. Zhang, Multiple replication origins of the archaeon Halobacterium species NRC-1. Biochemical and Biophysical Research Communications 302, 728-734 (2003)
- K. Shah and A. Krishnamachari, Nucleotide correlation based measure for identifying origin of replication in genomic sequences. BioSystems 107, 52 (2012)

Periodicities of DNA sequence

- E. N. Trifonov, 3-, 10.5-, 200- and 400-base periodicities in genome sequences. Physica A 249, 511 (1998)
- K. Shah and A. Krishnamachari, On the origin of three base periodicity in genomes. BioSystems 107, 142 (2012)
- H. Herzel, O. Weiss and E. N. Trifonov, 10–11 bp periodicities in complete genomes reflect protein structure and DNA folding, Bioinformatics 15, 187 (1999)
- J. Mrazek, Comparative Analysis of Sequence Periodicity among Prokaryotic Genomes Points to Differences in Nucleoid Structure and a Relationship to Gene Expression, J. Bacteriology 192, 3763 (2010)

Randomness/Correlation properties of DNA sequence

- W. Li, The study of correlation structures of DNA sequences:a critical review. Computers Chem. 21, 257 (1991)
- R. F. Voss, Evolution of long-range fractal correlations and 1/f noise in DNA base sequences. Phys. Rev. Lett. 68, 3805 (1992)
- C. K. Peng et. al., Long range correlations in nucleotide sequences. Nature 356, 168 (1992)
- P. B. Galvan et. al., Compositional segmentation and long-range fractal correlations in DNA sequences. Physical Review E 53, 5181 (1996)
- S. Hod and U. Keshet, Phase transition in random walks with long-range correlations. Physical Review E 70, 015104(R) (2004)

Phylogeny

- Ming Li et. al., An information-based sequence distance and its application to whole mitochondrial genome phylogeny. Bioinformatics 17, 149 (2001)
- M. Dehnert et al, Genome Phylogeny Based on Short-Range Correlations in DNA Sequences. J. Computational Biology 12, 545 (2005)

Systems Biology (overview)

- http://www.sciencemag.org/content/295/5560/1662
- http://www.annualreviews.org/doi/full/10.1146/annurev.genom.2.1.343
- U. Alon. An Introduction to Systems Biology: Design Principles of Biological Circuits. Chapman & Hall/CRC, 2007.

Protein Interaction Networks

- http://www.nature.com/nature/journal/v402/n6761supp/full/402c47a0.html
- http://web.iitd.ac.in/~sumeet/riv10.pdf [Tutorial]
- http://web.iitd.ac.in/~sumeet/han04.pdf [Proposes Date and Party Hubs]
- http://web.iitd.ac.in/~sumeet/dpcomb.pdf [Our Refutation of Date and Party Hubs]

Regulatory Networks

- http://www.nature.com/nchembio/journal/v4/n11/full/nchembio.122.html
- http://www.sciencedirect.com/science/article/pii/S0303264708002608
- http://www.cell.com/abstract/S0092-8674%2807%2901416-X
- http://web.iitd.ac.in/~sumeet/Bonneau06.pdf [The Inferelator Algorithm]
- http://web.iitd.ac.in/~sumeet/Durzinsky11.pdf [Petri Net Reconstruction]

Evolution and Evolvability

- http://dl.acm.org/citation.cfm?id=1462156
- http://www.sciencedirect.com/science/article/pii/S0079610713000990

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

20.1	Software	MATLAB; some publicly available bioinformatics tools
20.2	Hardware	Standard PCs
20.3	Teaching aids (videos, etc.)	Some online videos (available on YouTube) will be used
20.4	Laboratory	Computing facilities
20.5	Equipment	N/A

20.6	Classroom Infrastructure	Multimedia projector
20.7	Site visits	N/A
20.8	Others (please specify)	N/A

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

21.1	Design-type problems	10%
21.2	Open-ended problems	20% (current research in bioinformatics & systems biology)
21.3	Project-type activity	50%
21.4	Open-ended laboratory work	N/A
21.5	Others (please specify)	N/A

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Computational Perception and Cognition
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL788
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	None

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	No

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** TG, SC, SA, HG

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	Course objectives (about 50 words): This course in an introduction to current methods used in computational perception. It also examines different facets of cognitive processing. The course also discusses how knowledge about human perception and cognitive processing may be used to guide design of engineering systems.

14.	Course contents (about 100 words) (Include laboratory/design activities): Introduction: Philosophical & Psychological models, Cognitive models & Bayesian Inferencing framework; Visual Perception of 3D space & scene; Perceptual processes for Object recognition & memorization; Auditory Perception; Haptic Perception; Attentional mechanism in multimedia perception; Applications: Image & video quality assessment, compression; Audio quality assessment, compression & indexing; Haptic interfaces; Cognitive Architecture; Computational Consciousness, Cognitive Robotics & Other applications

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction	1
2	Perception (uni- and multi-modal) Vision, Hearing, taste, touch,olfaction	5
3	Higher order perception like object and pattern recognition (Biological and computational perspective)	4
4	Visual Perception of 3D space & scene Perceptual processes for object recognition & memorization	4
5	Attentional mechanism in multimedia perception , modelling perception, cognition & behaviour in real-time applications.	4
6	Executive function like planning & monitoring of complex behaviour, learning, memory and knowledge representations	5
7	Mental Imagery, Computational Model of Consciousness	3
8	Applications: Image & video quality assessment, compression Cognitive models & Bayesian Inferencing	3
	Audio quality assessment compression & indexing Haptic interfaces	3

10	Haptic Interfaces	2
11	Cognitive Architecture, Cognitive Robotics	3
12	Real world Applications (In Technology development, Health care, Defence, Industries etc.)	5
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Sensory Processing Pathway of Brain	15
2	Cognitive models of Perception-action cycle	15
3	Design of Assistive Appliances	15

19. Suggested texts and reference materials

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

1. Sensation and Perception - 3rd edition. By Jeremy M. Wolfe, Sinaeur Associates Ltd, 2012.
2. H. A. Mallet, First Course in Computational Neuro-Science, Springer-Verlag, 2013
3. Randall C. O'Reilly and Yuko Munakata Computational Explorations in Cognitive Neuroscience: Understanding the Mind by Simulating the Brain, Bradford Books, MIT Press, 2000
4. Liliana Albertazzi, Gert J. van Tonder, and Dhanraj Vishwanath, Perception beyond Inference, MIT Press, 2010
5. Rajesh P. N. Rao, Bruno A. Olshausen, Michael S. Lewicki, (Eds.) Probabilistic models of the brain: perception and neural function, MIT Press, 2002
6. Proceedings of IEEE, Vol. 101, No. 9, September 2013.

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

20.1	Software	MATLAB, Python, Psychtoolbox and other open source s/w
20.2	Hardware	PC
20.3	Teaching aids (videos, etc.)	Projector with internet connectivity, You Tube videos
20.4	Laboratory	Computer and hardware laboratory
20.5	Equipment	

20.6	Classroom Infrastructure	Multimedia Projector
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	20%
21.2	Open-ended problems	20%
21.3	Project-type activity	40% (term paper/project)
21.4	Open-ended laboratory work	20%
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Computational Linguistics
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL891
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	MTL106, COL106

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	COL772
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	Either sem

11.	**Faculty who will teach the course** Sumeet Agarwal, Rajakrishnan P. R. (HSS), Samar Husain (HSS)

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***: This course will provide an introduction to the systematic and quantitative study of language, focusing in particular on the view of language production/comprehension as a computational process, and looking at computational model and techniques that can be used to gain understanding of how language works.**

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)****: Introduction to language and linguistics; Mathematical foundations: statistics and machine learning; Introduction to corpus-based computational linguistics; Lexical analysis; Syntactic analysis; Semantic analysis; Discourse analysis; Psycholinguistics, computational cognitive models of language processing and evolution; Assignments and practical exercises involving the application of these techniques to real-word corpora***

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to language and linguistics	3
2	Mathematical foundations: statistics and machine learning	3
3	Introduction to corpus-based computational linguistics	2
4	Regular expressions and automata	3
5	Phonology and Morphology: n-grams, HMM-based models	5
6	Part-of-Speech taggers	3
7	Context-free grammars and probabilistic models	4
8	Advanced computational models of syntax, e.g., Combinatory Categorial Grammar (CCG) and Tree Adjoining Grammar (TAG) models	3
9	Natural language parsers	3
10	Hierarchical HMM parsers as cognitive or memory models	2
11	Processing and production models for South Asian languages	2
12	Meaning, word-sense disambiguation	4
13	Pragmatics: Discourse analysis	3
14	Modelling language evolution	2

COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N/A	

17. Brief description of laboratory activities

Module no.	Description	No. of hours
	N/A	

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Familiarisation with some standard corpora like the Hindi-Urdu Treebank	4
2	Lexical analysis: Study of prescribed research papers and other texts; use of actual corpora	10
3	Syntactic analysis: Study of prescribed research papers and other texts; study of parsing algorithms/models and application on real-world data	18
4	Semantics, pragmatics, language evolution: Study of prescribed research papers and other texts; computational approaches for these topics	10

19. Suggested texts and reference materials

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

Daniel Jurafsky and James H. Martin, Speech and Language Processing, 2nd Edition, Prentice Hall, 2008.

Christopher D. Manning and Hinrich Schütze, Foundations of Statistical Natural Language Processing, 1st Edition, MIT Press, 1999.

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

20.1	Software	Python
20.2	Hardware	Standard PCs
20.3	Teaching aids (videos, etc.)	N/A
20.4	Laboratory	Computing lab
20.5	Equipment	N/A
20.6	Classroom Infrastructure	Multimedia Projector
20.7	Site visits	N/A
20.8	Others (please specify)	N/A

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

21.1	Design-type problems	10%
21.2	Open-ended problems	20%
21.3	Project-type activity	50% (assignments and/or term paper)
21.4	Open-ended laboratory work	N/A
21.5	Others (please specify)	N/A

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Big Data Systems
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL886
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	Operating Systems

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** **Sumeet Agarwal, Santanu Chaudhury, Jayadeva**

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	Course objectives (about 50 words): This course is intended to expose students to modern large-scale data analysis systems. This course will prepare students to be able to build such systems as well as use them effectively to address analytics and data science challenges.

14.	Course contents (about 100 words) (Include laboratory/design activities): Introduction; Hadoop, Map-Reduce, GFS/HDFS, Bigtable/HBASE ; Extension of Map-Reduce: iMap-reduce (iterative), incremental map-reduce. SQL and Data-parallel programming, DryadLINQ. Data-flow parallelism vs. message passing. Data locality. Memory hierarchies. Sequential versus random access to secondary storage. NoSQL systems. NewSQL systems. Finding similar items and LSH; Search Technology: link analysis and Page-rank algorithm; Large Scale Graph Processing; Mining Streaming Data and Realtime analytics: Window semantics and window joins. Sampling and approximating aggregates (no joins). Querying histograms. Maintaining histograms of streams. Use of Haar wavelets. Incremental and online query processing: online aggregation

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1.	Introduction	1
2	Hadoop, Map-Reduce, GFS/HDFS, Bigtable/HBASE, Extension of Map-Reduce: iMap-reduce (iterative), incremental map-reduce.	10
3.	SQL and Data-parallel programming, DryadLINQ. Data-flow parallelism vs. message passing.	8
4.	NoSQL systems. NewSQL systems.	4
5	Finding similar items and LSH	4
6	Search Technology: Link-analysis & Page-rank algorithm;	4
7	Processing Large Scale Graphs	2
8	Mining Streaming Data and Real-time analytics: Window semantics and window joins.	5
9.	Sampling and approximating aggregates.. Querying histograms. Maintaining histograms of streams. Use of Haar wavelets. Incremental and online query processing: online aggregation	4

	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
2.	File System and Distributed File System	10
3.	Data base Technology - MONGO DB	10

7.	Advertisement on the Web	10
8.	Recommender System	10

19. Suggested texts and reference materials

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

1. Sherif Sakr, Mohamed Gaber, Large Scale and Big Data, Management and Processing, CRC Press, 2014
2. Jure Leskovec, Anand Rajaraman, Jeff Ullman, Mining of Massive Datasets, 2nd Edition, 2014

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

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	

21.2	Open-ended problems	
21.3	Project-type activity	15%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Cloud Computing
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL887
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	Operating Systems, Computer Architecture

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course Jayadeva, Subrat Kar, Santanu Chaudhury, Sumantra Dutta Roy**

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** This course will provide an opportunity to the students for learning about cloud computing Cloud has emerged as a leading paradigm for cost-effective, scalable, well-managed computing. Actual machines may be virtualized into machine-like services. The cloud computing infrastructure managing, sharing, scheduling, provisioning and geographic replication of resources and tasks provides a new architectural framework. Students, on completion of the course, will acquire the ability to design and use cloud environment. They will also achieve conceptual clarity about the technology of cloud platforms.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Introduction; Example System: Apple iCloud, Amazon-AWS; Fundamental Concepts: Cloud Characteristics, Cloud delivery models; Cloud Enabling Technology: broad-band network,virtualisation technology; Cloud Infrastructure Mechanisms: Logical Network Perimeter, Virtual Server, Cloud Storage Devices;Cloud Architecture:Workload Distribution Architecture,·Resource Pooling Architecture, Dynamic Scalability Architecture, Hypervisor Clustering Architecture, Load Balanced Virtual Server Instances Architecture,Elastic Resource Capacity Architecture,Elastic Disk Provisioning Architecture, Redundant Storage Architecture; Cloud Security: Encryption, Identity and Access management, Cloud-based Security Groups; Working with Cloud: Building Service Platforms, Cost Metrics, Pricing Models.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction; Example System: Apple iCloud, Amazon;	2
2	Fundamental Concepts: Cloud Characteristics, Cloud delivery models;	4
3	Cloud Enabling Technology: broad-band network, virtualisation technology;	4
4	Cloud Infrastructure Mechanisms: Logical Network Perimeter, Virtual Server, Cloud Storage Devices;	4
5	Cloud Architecture:Workload Distribution Architecture,·Resource Pooling Architecture, Dynamic Scalability Architecture, Hypervisor Clustering Architecture	10

6	Load Balanced Virtual Server Architecture, Elastic Resource Capacity Architecture,Elastic Disk Provisioning Architecture, Redundant Storage Architecture;	8
7	Cloud Security: Encryption, Identity and Access management, Cloud-based Security Groups;	6
8	Working with Cloud: Building Service Platforms, Cost Metrics, Pricing Models.	4
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1.	OS support for Cloud	5
2.	Privacy and Security issues in Cloud	10
3.	Virtualisation facility on Processors (e.g. ARM 7 architecture)	10
4.	Cloud Applications - Cloud based Communication, Cloud and mobile collaboration	10
5.	Handling Big Data on the Cloud	10

19. Suggested texts and reference materials

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

1. Thomas Erl , Ricardo Puttini, Zaigham Mahmood, Cloud Computing: Concepts, Technology & Architecture, The Prentice Hall 2013.
2. Raghuram Yeluri (Author), Enrique Castro-Leon , Building the Infrastructure for Cloud Security: A Solutions View, Apress Media, 2014
3. Nick Antonopoulos, Lee Gillam, Cloud Computing: Principles, Systems and Applications, Springer, 2012

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

20.1	Software	
20.2	Hardware	Access to Badal (institute Cloud)
20.3	Teaching aids (videos,	

	etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	15%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Neural Systems and Learning Machines
3.	**L-T-P Structure**	3-0-2
4.	**Credits**	3
5.	**Course Number**	ELL899
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	One of: ELL787 (Embedded Systems and Applications), COL788 (Embedded Computing), ELL734 (MOS LSI), Embedded Systems/VLSI Design at the UG level

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	No

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** **JD, SC, MS, SA, TG**

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:To acquaint students with the basics of biological neural networks, elements of modelling, analysis, and synthesis**

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)****: Introduction to biological neural systems, artificial neural network models, feedforward models, recurrent systems, analysis and applications***

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1.	Neurobiology of a single neuron, simple models	4
2.	The neuron as a classifier, complexity and capacity of a neuron classifier, linear threshold units	4
3.	Phase Locked Loop models of a neuron, analysis of PLL models, coupled neuron systems	4
4.	Circuit level realisations of biological models	4
5.	Applications to learning, convergence, learning rules, pruning networks	6
6.	Optimisation with neural systems, neurodynamical systems	6
7	Support Vector Machines, extensions, implementation in hardware, VLSI realisation, applications	5
7.	Hardware Realization of Neural Systems: VLSI and Embedded Hardware	5
8.	Feature Extraction, Feature Selection and implementation issues	4
COURSE TOTAL (14 times `L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	None	

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1.	Matlab Coding of neural circuits and systems	5
2.	Simulating PLL models in hardware, FPGA	5
3.	Neuron simulators	5
4.	Optimisation using neuro-dynamical systems	5
5.	Term Project	8

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1.	Frequency domain modelling of neurons	9
2.	Hardware realisation of neural systems	6
3.	Modelling biological systems in VLSI	9
4.	Simulating neuron models - unit, circuit, system levels	9
5.	Simulating ODE and PDE models, studying neurodynamical systems	9

19. Suggested texts and reference materials

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

Neural Networks: A Classroom Approach by Satish Kumar, Tata McGraw Hill, 2004.

K. Koch, Biophysics of Computation: Information Processing in Single Neurons, Oxford University Press, 2004.

Carver MEan and Mohammed Ismael. Analog VLSI implementations of neural systems. Kluwer Academic Publishers
Frank C. Hoppensteadt. An Introduction to the MAthematics of Neurons. Modelling in the Frequency Domain. Cambridge, 1997.
David MacKay. Information Theory, Inference and Learning Algorithms. Online book.

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

20.1	Software	Matlab
20.2	Hardware	FPGA Kits
20.3	Teaching aids (videos, etc.)	Online
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	10%
21.2	Open-ended problems	10%
21.3	Project-type activity	15%
21.4	Open-ended laboratory work	10%
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Natural Computing
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL799
6.	**Status** *(category for program)*	Program Elective for EET; DE for EE1 and EE3

7.	**Pre-requisites** (course no/title)	MTL106, COL106

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supersedes any existing course	No

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** Prof. Santanu Chaudhury, Prof. Jayadeva, Dr. B. K. Panigrahi, Dr. Sumeet Agarwal

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** The field of Natural Computing deals with a large family of techniques inspired by nature, including biological, social and physical systems. This course will provide an introduction to a broad range of natural computing algorithms and illustrate how they can be applied to real-world problems. On completion of the course, student should be able to: - comprehend different paradigms of natural computing - solve problems using natural computing

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Introduction to natural computing uncertainty handling: probability and fuzzy logic; evolutionary computing and problem solving as search; swarm intelligence ant colonies, swarm robotics; immunocomputing; introduction to DNA computing; basics of quantum computing

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to Natural Computing	2
2	Probabilistic reasoning and belief networks	8
3	Fuzzy logic and fuzzy rule-based systems	4
4	Evolutionary computing: GA, GP, Differential evolution	8
5	Swarm intelligence: Ant colony and other algorithms	4
6	Swarm robotics	2
7	Immuno-computing	5
8	Introduction to DNA computing	3
9	Basics of Quantum computing	4
10	Example applications	2
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Natural computing: Techniques inspired by nature, versus computation in natural systems. What are the similarities and differences? Study of research papers and texts.	12
2	Evolution as an algorithm for optimisation/learning; modelling/formalising biological evolution.	10
3	Distributed intelligence/computation in nature: the ‘wisdom of crowds’ in social/biological systems.	10
4	Immunology: The immune system as a cognitive system, with learning and memory.	10

19. Suggested texts and reference materials

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

1. Bart Kosko. Neural Networks and Fuzzy Systems: Dynamical Systems, Applications of Machine Intelligence. Prentice-Hall, 1992.
2. J. -S. R. Jang, C. -T Sun, E. Mizutani. Neuro-Fuzzy and Soft Computing. Pearson Education.
3. A. E. Eiben, J. E. Smith. Introduction to Evolutionary Computing (Natural Computing Series) 1st Ed., 2003, 2nd printing, 2007. ISBN: 978-3-540-40184-1
4. Leandro Nunes de Castro. Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications Chapman-Hill, 2010.
5. Judea Pearl. Causality: Models, Reasoning and Inference. Cambridge University Press, 2008.

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

20.1	Software	MATLAB/PSI M/PSPICE-ORCAD/Caspoc/MAXWELL/MAGNET
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	Classroom with the facility of projector, mic and sound system
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	40%
21.2	Open-ended problems	30%
21.3	Project-type activity	10%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Advanced Machine Learning
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL888
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	ELL784 Introduction to Machine Learning

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	No

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** JD, SC, SA, SDR

12.	**Will the course require any visiting faculty? (yes/no)**	May Use

13.	**Course objectives** *(about 50 words)*: **Advanced concepts in machine learning with a greater focus on current trends**

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)****: Advanced topics in machine learning, including Nonlinear Dimension Reduction, Maximum Entropy, Exponential Family Models, Graphical Models; Computational Learning Theory, Structured Support Vector Machines, Feature Selection, Kernel Selection, Meta-Learning, Multi-Task Learning, Semi-Supervised Learning, Reinforcement Learning, Approximate Inference, Clustering, and Boosting.***

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Dimensionality Reduction	5
2	Maximum Likelihood	3
3	Maximum Entropy methods	3
4	Computational Learning Theory	5
5	Graphical Models	5
6	Kernel Methods and Manifold Learning	5
7	Bagging and Boosting	3
8	Semi-Supervised Learning	5
9	Reinforcement Learning	4
10	Transfer learning	4
COURSE TOTAL (14 times `L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	None	

17. Brief description of laboratory activities

Module no.	Description	No. of hours
	None	

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Current research topics in compression and sparse representations: compressive sensing, sparse autoencoders etc.	10
2	Learning theory: how can it be used to design better learning algorithms?	10
3	Graphical models: Methods for inference, both exact and approximate	10
4	Studies of applications of different learning paradigms	12

19. Suggested texts and reference materials

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

Pattern Recognition and Machine Learning, Chris Bishop
Kernel Methods for Pattern Analysis, John Shawe-Taylor & Nello Cristianini

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

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	Multimedia Projector
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	10%
21.2	Open-ended problems	20%
21.3	Project-type activity	30%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Agent Technology
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL798
6.	**Status** *(category for program)*	Program Elective for EET

7.	**Pre-requisites** (course no/title)	None

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** Santanu Chaudhury, Hiranmay Ghosh

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** Intelligent agents and multi-agent systems is a key enabling technology for distributed large-scale problem solving. The objective of this course is to provide a foundation for various scientific and technical aspects of multi-agent systems.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** The course will comprise lectures on the various topics on agent technology and self-study on its applications in various domains. The topics are elaborated below. The material of the lectures will be gathered from text-books and recent research papers. The self-study will comprise study and analysis of typically 5-8 substantial research papers and will result in a term paper that will be evaluated.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	**Introduction:** Introduction to course structure. What are software agents, agent-based systems. Motivation, Properties of agents and environments. Agents as a software engineering paradigm. Agents as an AI paradigm. Agents and human society.	2
2	**Agent architecture (Abstract and concrete):** Reactivity and proactivity. Purely reactive agent architecture. Reasoning. Agent with states. Goal-directed (proactive) agents. Intelligent behavior and autonomy. Logic based architecture. B-D-I Architecture	4
3	**Agent Communication:** Introduction to multi-agent system. Speech-act theory. Communication layers - Syntactic and semantic. ACL and CL (e.g. KQML and KIF). Role of world model - introduction to semantic web and ontology.	6
4	**Cooperative Agent based systems:** Benevolence and self-interest in agents. Planning. Review of search techniques. Planning as a search problem. Centralized planning and distributed planning. Interaction protocol.	6
5	**Mobile agents:** Distributed systems architectures - mobile agents. Benefits and concerns. Types of mobility - logical mobility, cloning, migration. Static and dynamic itineraries. Communication challenges and solutions for mobile agents. Security risks and mitigation.	3
6	**Agent platforms and standardization:** Agent life-cycle. Agent platforms and their characteristics (life-cycle support). Standardization (Introduction to FIPA architecture and ACL). Mobile agent platforms. Mobility across	3

	platforms.	
7	**Agents with self-interest:** Rational decision-making. Concept of payoff and social welfare. Cooperation with conflict of interest. Mechanisms, protocols and strategies. Individual rationality, Pareto-efficiency and Social welfare. Zero-sum encounters. Nash equilibrium. Voting and auctions. Bargaining - Time-constrained negotiations. Reasoning with uncertainty.	6
8	**Learning in agent-based systems:** Motivation. Centralized learning and Interactive learning. Supervised, reinforcement and unsupervised learning.	6
9	**Swarm Intelligence / Evolutionary computation**	6
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Simulation of Agent System	20
2	Cognitive Agent Architecture	10
3	**Industrial applications of Agent-based systems:** Examples in Finance, Resource management, ATC, Infrastructure management, Crowd behavior modelling, Social simulations, Distributed sensing, Robotics	15

19. Suggested texts and reference materials

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

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

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	

20.8	Others (please specify)	

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

21.1	Design-type problems	10%
21.2	Open-ended problems	10%
21.3	Project-type activity	25%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	**Human-Computer Interface**
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL794
6.	**Status** *(category for program)*	Program Elective for EET

7.	**Pre-requisites** (course no/title)	

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	No

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** **JD, SC, HG, TG**

12.	**Will the course require any visiting faculty? (yes/no)**	Maybe

13.	**Course objectives** *(about 50 words)*: **Introduction to BCI/HCI**

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** **This course will present some of the necessary background in neuroscience and computational methods necessary to begin work in this emerging field that is rapidly acquiring growing significance.**

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction, brain function, neural function, encoding models, basis for BCI.HCI.	4
2	Population vector decoding, noise, pre-processing, Filtering methods	4
3	EEG basics	4
4	Bayesian methods, Gaussian models, multivariate techniques	4
5	Signal processing in BCI, Particle filter methods, decoding of motor cortical signals, probabilistic inference of arm motion	4
6	Mixture models	4
7	Adaptivity in BCI and Machine Learning	4
8	ERP Processing	4
9	CSP based BCI: Problems and basic solutions	4
10	Implementations	6
COURSE TOTAL (14 times `L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Senses, Perception and Human Interfaces	2
2	Haptic Sensing	3
3	Voice, Music and Audio	5
4	Visual Sensing, Gesture Interactions	5
5	EEG and ERP processing	6
6	3-D imaging and sensing	6
7	Eye gaze tracking	5
8	Multimodal interaction with perceptual user interfaces	5
9	Biometrics Applications	5

19. Suggested texts and reference materials

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

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

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	10%
21.2	Open-ended problems	10%
21.3	Project-type activity	25%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Cyber-Physical Systems
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL893
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	Embedded Systems and Applications

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course: Subrat Kar, I. N. Kar, Santanu Chaudhury**

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	Course objectives (about 50 words): Cyber-physical systems (CPSs) combine cyber capabilities (computation and/or communication) with physical capabilities (motion or other physical processes). Cars, aircraft, and robots are prime examples, because they move physically in space in a way that is determined by discrete computerized control algorithms. Designing these algorithms to control CPSs is challenging due to their tight coupling with physical behavior. This course will focus on designing Cyber-physical systems.

14.	Course contents (about 100 words) (Include laboratory/design activities): Introduction: core principles behind CPSs; Specification of CPS, CPS models: Continuous, Discrete, Hybrid, Compositional; Abstraction and System Architecture, Design by Invariants, Sensing and Fusion, Cloud of Robots/CPS; Case Studies: Healthcare, Smart Grid, Transportation

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction: Core Principles	2
2	Specification of CPS	1
3	Models: Modeling Dynamic Behaviour	1
4	Continuous Dynamics, Discrete Dynamics, Hybrid Systems	8
5	Composition of FSM and Concurrent models of Computation	6
6	System Architecture	2
7	Invariants and temporal logic	4
8	Sensing, Fusion, Actuation	4
9	Cloud of Robots, Mobile Social Network	4
10	Case Studies: Health Network, Smart Grid, Transportation	10

COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Controls: Fundamentals	15
2	Specification Languages and Logical Models	10
3	Networking Protocols	15

19. Suggested texts and reference materials

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

1. E. A. Lee and S. A. Seshia, Introduction to Embedded Systems - A Cyber-Physical Systems Approach, Edition 1.5, LeeSeshia.org, 2014.
2. Andre Platzer, Logical Analysis of Hybrid Systems: Proving Theorems for Complex Dynamics. Springer, 2010.

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

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	10%
21.2	Open-ended problems	10%
21.3	Project-type activity	25%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Computational Neuroscience
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL890
6.	**Status** *(category for program)*	Programme Elective for EET

7.	**Pre-requisites** (course no/title)	ELL784 Introduction to Machine Learning

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** Dr. Tapan K. Gandhi Dr. Sumeet Agarwal

12.	**Will the course require any visiting faculty? (yes/no)**	**Yes (for Special lectures)**

13.	**Course objectives** *(about 50 words)***:** Understanding how the brain works is one of the fundamental challenges in science today. This course approaches the search for mechanisms of information processing by the brain from a signal and image processing perspective, employing applications of cutting-edge machine-learning techniques to the analysis of neural data. Advancing our knowledge in this domain will have important applications to key problems in engineering and medicine.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)****: Fundamentals of brain anatomy and physiology, signals of brain, Brain signal recording and imaging techniques, Human experimentation study design, Processing the X-D neural data, Machine learning approaches, Graph theory and neural networks, Multivariate pattern analysis in 4D Imaging data, Statistical inferences, student projects and presentations.***

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction and course objectives	2
2	Fundamentals of Brain Anatomy and Physiology	4
3	Signals of the brain; Brain recording methodologies, tools & Techniques (EEG/MEG, ERP, fMRI, NIRS, TMS, DTI, DSI, MRS)	8
4	MR physics	1
5	Human experimental study design	2
6	Noise reduction and modelling brain	8
7	Methods of neural data processing (Various signal and image processing approaches including machine learning and graph theory)	9

8	Mathematical models of neuronal information processing and representations; artificial neural networks and deep learning as brain simulation approaches	8
	COURSE TOTAL (14 times `L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1		
2		
3		
4		
5		
6		

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	**Brain Signal acquisition (EEG/MEG)**	**3**

2	**Brain imaging (MRI/fMRI)**	**3**
3	**Brain Signal Processing**	**4**
4	**Volumetric Analysis of MRI data**	**8**
5	**Connectivity analysis of rfMRI data**	**8**
6	**Evoked MRI data analysis**	**8**
7	**Diffusion Tensor Imaging Analysis**	**8**

19. Suggested texts and reference materials

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

1) An Introduction to Event-Related potential Technique

By Steven J. Luck; MIT Press, 2005

2) Machine learning, A Probabilistic Perspective

By Kevin P. Murphy; MIT Press, 2012

3) Functional Magnetic Resonance Imaging

By Huettel, Song, McCarthy; 2nd Edition, Sinauer Associates, 2009

4) MEG: An Introduction to Methods

By Peter C. Hansen, Morten L. Kringelbach, Riitta Salmelin; Oxford, 2010

5) Neuroscience: Exploring the brain

By Bear, Connors and Paradiso

Publisher: William and Wilkins, 2015

6) Research Methods

Donald H. McBurney and Theresa L. White

Publisher: Thomson Wadsworth, 2010

7) Statistical Analysis of fMRI Data

F.G. Ashby

Publisher: MIT Press, Boston, MA, 2011

8) Face Perception

Vicki Bruce and Andy Young

Publisher: Psychology Press, 2012

9) Networks of the Brain
By Olaf Sporns
The MIT Press, 2010

10) BRAIN MAPPING: The Systems
By Arthur W. Toga & John C. Mazziotta
Academic Press, 2000

11) BRAIN MAPPING: The Methods
By Toga, Mazziotta
2nd Edition, Academic Press, 2002

12) BRAIN MAPPING: The Disorders
By Mazziotta, Toga, Frackowiak
Academic Press, 2000

13) Biological Psychology
By James W. Kalat
11th Edition, Cengage Learning, 2012

14) Diffusion MRI
By Derek K. Jones; Oxford Press, 2010

15) Methods of multivariate analysis
By Keith Hope; Gordon Breach, 1968

16) Neuroanatomy; An atlas of structures, sections and systems
By Duane E. Haines
8th Edition, LWW, 2011

17) The Human Brain in Photographs and Diagrams
By John Nolte and Jay B. Angevine, Jr.
Mosby, 2000

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

20.1	Software	**MATLAB, Python, other publicly available software**
20.2	Hardware	**Computers**
20.3	Teaching aids (videos, etc.)	**Videos from youtube**
20.4	Laboratory	**Experimentation room and Computing Facilities**
20.5	Equipment	
20.6	Classroom Infrastructure	Multimedia projector

20.7	Site visits	**MRI (NBRC/Mahajan Imaging center), MEG (NBRC) and TMS (AIIMS)**
20.8	Others (please specify)	

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

21.1	Design-type problems	**10%**
21.2	Open-ended problems	**20%**
21.3	Project-type activity	**50%**
21.4	Open-ended laboratory work	**20%**
21.5	Others (please specify)	**N/A**

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Introduction to Machine Learning

3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL784
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	MTL106

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	ELL409 (40%)
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL 341, COL 774, MAL 803
8.3	Supersedes any existing course	EEL709

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** Jayadeva, Santanu Chaudhury, Sumeet Agarwal, Hiranmay Ghosh, Sumantra Dutta Roy, Tapan Gandhi

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** To introduce the student to fundamental notions in statistical machine learning, and familiarise him/her with the most widely used algorithms for both supervised and unsupervised learning. Also, to provide the student with some hands-on experience of using machine learning techniques to model real-world data

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Introduction to Machine intelligence and learning; linear learning models; Artificial Neural Networks: Single Layer Networks, LTUs, Capacity of a Single Layer LTU, Nonlinear Dichotomies, Multilayer Networks, Growth networks, Backpropagation and some variants; Support Vector Machines: Origin, Formulation of the L1 norm SVM, Solution methods (SMO, etc.), L2 norm SVM, Regression, Variants of the SVM; Complexity: Origin, Notion of the VC dimension, Derivation for an LTU, PAC learning, bounds, VC dimension for SVMS, Learning low complexity machines - Structural Risk Minimisation; Unsupervised learning: PCA, KPCA; Clustering: Origin, Exposition with some selected methods; Feature Selection: Origin, Filter and Wrapper methods, State of the art - FCBF, ReliefF, etc; Semi-supervised learning: introduction; Assignments/Short project on these topics

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction; Probabilistic and Statistical Foundations	4
2	Linear models for regression and classification	4
3	Artificial Neural Networks	6
4	Support Vector Machines	6
5	Learning Theory; Complexity	3
6	Unsupervised Learning: Dimensionality reduction	4
7	Clustering	5
8	Probabilistic Graphical Models	4
9	Feature Selection	3
10	Semi-supervised Learning: Introduction	3
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N/A	

17. Brief description of laboratory activities

Module no.	Description	No. of hours
	N/A	

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
2.	Linear Models: Experimentation with different techniques discussed in class	6
3.	Neural Networks and SVMs: Applications on real-world data	12
4.	Learning theory: Reading of research papers and supplementary materials	4
5.	Unsupervised learning: Applications on real-world data	10
6.	Graphical models, feature selection, and semi-supervised learning: Reading of prescribed research papers and lecture notes; experimentation with different techniques discussed in class	10

19. Suggested texts and reference materials

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

C. M. Bishop, Pattern Recognition and Machine Learning (Springer Information Science and Statistics), 2007
Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004
David J. C. MacKay, Information Theory, Inference, and Learning Algorithms, Cambridge University Press, 2003.

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

20.1	Software	LINDO API, LINGO, MATLAB
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	Multimedia Projector
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	10%
21.2	Open-ended problems	10%
21.3	Project-type activity	30%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Multimedia Systems
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL786
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	None

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	EEL707 Multimedia Systems

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** Prof. Santanu Chaudhury, Dr. Brejesh Lall, Dr. Sumantra Dutta Roy

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** The focus of using computers today is primarily getting drawn towards multimedia data: sufio, images, graphics and video. This is a multi-disciplinary field, encompassing the domains of Computer Graphics, Signal, Image and Video Processing, Computer Vision, Computer Architecture and Embedded Systems, Operating Systems, Pattern Recognition and Machine Learning, Psychology, Data and Signal Compression and Coding, Computer and Communication Networks, and Information Management and Retrieval.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Multimedia signal processing; coding and compression; standards: logic, issues, future directions; Multimedia issues governing developments in computer architecture and embedded systems, computer and communication networks, operating systems; Search and retrieval.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Types of Multimedia Data (audio, music, graphics, animation, image, video, haptics and more); Signal Processing Fundamentals	1
2	Data representation	2
3	Images, Colour, Video	3
4	Digital Audio and Music	2
5	Graphics and Animation	3
6	Haptics	1
7	Basic Multimedia Coding and Compression: Lossless and lossy	4
8	Image Compression and Standards: JPEG	5
9	Video Compression and Standards: MPEG-1, 2, 4, 7 and H.264 and HEVC(H.265)	10
10	Audio Compression and Standards: MPEG	3
11	Computer Architecture and Embedded Systems for Multimedia Systems	1
12	Networks and Protocols for Multimedia Communication	1
13	Internet Multimedia Content Distribution	1
14	Multimedia over Wireless and Mobile Networks	1
15	Social Media Sharing; Cloud Computing	1
16	Search and Retrieval of Multimedia Data	3

	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
	Background study of basic signal processing	15

	Standards and their details	10
	Computer Architecture and Embedded Systems basics; application to Multimedia	3
	Computer and Communication Systems basics, application to Multimedia	2
	Operating Systems basics, application to Multimedia	3
	Search and Retrieval	10

19. Suggested texts and reference materials

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

1. Ze-Nian. Li, Mark S. Drew, Jiangchuan Liu. Fundamentals of Multimedia Pearson/Prentice-Hall, 2014.
2. Y. Wang, J. Ostermann, Y. Zhang. Video Processing and Communications, Prentice-Hall, 2002.
3. T. Ebrahimi, F. Pereira. The MPEG-4 Book, PRentice-Hall, 2002.
4. Ian E. Richardson. The H.264 Advanced Video Compression Standard. Second Edition, John Wiley and Sons, 2010.
5. Relevant papers

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

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	Lab with multimedia input and output devices to experiment with
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Computer Vision
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL793
6.	**Status** *(category for program)*	Program Elective for EET

7.	**Pre-requisites** (course no/title)	Image Processing, Machine Learning

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	COL780
8.3	Supersedes any existing course	EEL806 Computer Vision

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** Prof. Santanu Chaudhury, Dr. Sumantra Dutta Roy, Dr. Brejesh Lall, Dr. Sumeet Agarwal, Tapan Gandhi

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** Vision is all about examining images, and drawing semantic interpretation from it. The course will examine developments in the field over the years, right from estimating depth, to other high level tasks such as detecting faces. Developments in this field have been across some rather interdisciplinary and diverse areas, such as psychology, projective geometry, signal processing, and pattern recognition and machine learning.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Link between Computer Vision, Computer Graphics, Image Processing and related fields; feature extraction; camera models; multi-view geometry; applications of Computer Vision in day-to-day life.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Relation between Computer Vision, Computer Graphics, Image Processing	1
2	Image Analysis: Feature Detection, Active Contours, Segmentation	5
3	Photometry and Geometry; Invariants	3
4	Multiple View Geometry: 2-D and 3-D	6
5	Camera Models; Calibration	3
6	Alignment; Structure from Motion; Dense Motion Estimation	5
7	Visual Tracking	4
8	Computational Photography	6
9	Recognition	8
10	Miscellaneous Applications	1
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Relation and Links with Image Processing	2
2	Segmentation, Active Contours, Feature Detection	5
3	Affine Invariance: Image Morphing	5
4	Projective Invariance: Mosaicing	5
5	Camera models, calibration, stereo	5
6	Motion Estimation	5
7	Visual Tracking	5
8	Computational Photography	10

19. Suggested texts and reference materials

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

1. R. Szeliski. Computer Vision. Springer, 2011.
2. D. A. Forsyth, J. Ponce. Computer Vision: A Modern Approach. Pearson Education 2003.
3. S. J. D. Prince. Computer Vision: Models, Learning and Inference. Cambridge University Press, 2012.
4. R. I. Hartley, A. Zisserman. Multiple View Geometry in Computer Vision. Second Edition, Cambridge University Press, 2004.
5. O. Faugeras. Three-Dimensional Computer Vision: A Geometric Viewpoint. MIT Press, 1993
6. Relevant papers

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

20.1	Software	OpenCV (Open-source Computer Vision library)
20.2	Hardware	Computers, Cameras
20.3	Teaching aids (videos, etc.)	LCD projectors
20.4	Laboratory	
20.5	Equipment	Computers, Cameras
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	20%
21.2	Open-ended problems	30%
21.3	Project-type activity	50%
21.4	Open-ended laboratory work	All of the above are laboratory work
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Computer Graphics
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL792
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	None

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	COLxxx Computer Graphics
8.3	Supersedes any existing course	EEL754 Computer Graphics

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** Prof. Santanu Chaudhury, Dr. Sumantra Dutta Roy

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** Graphics involves taking in information about the coordinates of points, nature of surfaces, and lighting conditions, and generating a realistic image of the same. The course introduces the student to the basic physics and mathematics of the same, along with related algorithms and data structures.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Image formation: the mathematics, as well as photometry and colour; transformations; basic graphics primitives; texture mapping; image-based rendering

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
	Basic Primitives	3
	Photometry, colour, projective geometry	8
	Light and Optics, Shading, Ray Tracing	8
	Texture Mapping	10
	Graphics Data Structures	5
	Reflection and Transmission	3
	Architecture Issues	2
	Image-based Rendering	3
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Photometry: the physics of light	2
2	Projective geometry	3
3	OpenGL programming	10
4	Basic geometric primitives	5
5	Geometric Transformations	5
6	Rendering, texture mapping	5
7	Ray Tracing	5
8	Image-Based rendering	7

19. Suggested texts and reference materials

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

1. J. H. Hughes, A. van Dam, M. McGuire, D. F. Sklar, J. D. Foley, S. K. Feiner, K. Akeley. Computer Graphics. Third Edition, Addison-Wesley, 2014.
2. OpenGL Programming Guide: The Official Guide to Learning OpenGL Ver 4.3 (8th Edition), Addison-Wesley, 2013.

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

20.1	Software	OpenGL
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Embedded Intelligence
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL883
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	machine learning, embedded systems

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	No

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course**

	KP JD SC

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)*: **About 99% of all intelligent and adaptive systems are now on embedded platforms. This course aims to acquaint students with the basics of embedded intelligence, including application scenarios, challenges in embedding intelligence, hardware aspects, and how embedded intelligence will be critical in the IoT age.**

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** **basics of embedded, learning, and adaptive systems; sensors, nature of dynamic environments, hardware aspects**

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Sensors, sensor arrays, data generation, application scenarios	6
2	Information processing and learning mechanisms for embedded systems	6
3	Adaptive systems; algorithms for mobile sensing	14
4	Learning in stationary and dynamic environments; learning in the presence of uncertainty	8
5	Embedded Intelligence for IoT	4
6	Current Trends and Future Directions	4
COURSE TOTAL (14 times `L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

	None	

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Internet of Things and Contextual Processing	15
2	Applications on Prototyping hardware - Adruino board, etc.	15
3	Randomisation and Approximate algorithms for real-time implementation	15

19. Suggested texts and reference materials

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

Intelligence for Embedded Systems: A Methodological

Approach", C. Alippi, Springer, 2014;

Activity recognition from user-annotated acceleration data. L. Bao and S. S. Intille, Pervasive Computing, 2004

Toward Trustworthy Mobile Sensing. Peter Gilbert, Landon P. Cox, Jaeyeon Jung, and David Wetherall, HotMobile 2010.

Using Mobile Phones for Secure, Distributed Document Processing in the Developing World. Tapan Parikh, IEEE Pervasive Computing Magazine, April 2005

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

20.1	Software	MATLAB
20.2	Hardware	FPGA Kits
20.3	Teaching aids (videos, etc.)	Online
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Machine Learning for Computational Finance
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL885
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	Introduction to Machine Learning

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supersedes any existing course	No

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [x] Either sem

11.	**Faculty who will teach the course** **KP, JD, SC**

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)*: **Machine Learning now plays a significant role in the finance world. This course will deal with applications of machine learning in forecasting, optimization for market based applications, and algorithmic trading.**

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)*: **basics of embedded, learning, and adaptive systems; sensors, nature of dynamic environments, hardware aspects**

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Stationarity, Time series forecasting techniques	6
2	Analyzing returns; constant expected return model. Introduction to portfolio theory; computing efficient portfolios	8
3	Trading systems. Classification of trading systems based on life of a trade; classification based on nature of algorithms used; classification based on underlying instruments	
4	Creation of logic and pattern recognition. Technical analysis and indicators. Optimization methods for computational finance.	
5	Notion of risk. Types of risk. Measures of risk. Performance measures for strategies. Management of risk. Market neutral algorithms. Managing liquidity risk. Managing market risk. Managing model risk.	
6	Algorithm development process. Portfolio development process. Objectives of a balanced portfolio. Machine learning approaches to algorithmic trading. Use of forecasting. RRL based approaches. Learning the optimal position.	
COURSE TOTAL (14 times `L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	None	

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Time series forecasting	10
2	Fuzzy forecasting methods	10
3	Developing a simple strategy	5
4	Adding indicators	5
5	Adding stop loss and profit booking filters	10
6	Back testing on historical data	5
7	Assessing a strategy for deployment	5

19. Suggested texts and reference materials

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

Statistics and Data Analysis for Financial Engineering by David Ruppert, 2011

An Introduction to Statistical Learning: with Applications in R by Gareth James, et al.

Edward Leshik and Jane Cralle, An Introduction to Algorithmic Trading: Basic to Advanced Strategies (Wiley Trading), 2011. Ernie Chan, Algorithmic Trading: Winning Strategies and Their Rationale, Wiley, 2013.

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

20.1	Software	Matlab
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	Online
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	Developing a sample strategy and testing it on market data
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Embedded Systems and Applications
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL787
6.	**Status** *(category for program)*	Program core (stream core)

7.	**Pre-requisites** (course no/title)	UG Computer Architecture or PG Computer Architecture

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [X] Either sem

11.	**Faculty who will teach the course** 1. Santanu Chaudhury 2. Subrat Kar 3. Brejesh Lall 4. Turbo Majumder

12.	**Will the course require any visiting faculty? (yes/no)**	NO

13.	**Course objectives** *(about 50 words)***:** To provide a advanced level treatment of embedded systems, embedded firmware, embedded software, interfacing, hardware-software co-design and distributed networked embedded systems at a functional and behavioural level.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Introduction to embedded system. Architectural Issues: CISC, RISC, DSP Architectures. Component Interfacing, Software for Embedded Systems : Program Design and Optimisation techniques, O.S for Embedded Systems, Real-time Issues. Designing Embedded Systems : Design Issues, Hardware- Software Co-design, Use of UML. Embedded Control Applications, Networked Embedded Systems : Distributed Embedded Architectures, Protocol Design issues, wireless network. Embedded Multimedia and Telecommunication Applications: Digital Camera, Digital TV, Set-top Box, Voice and Video telephony

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Using embedded computers - philosophy of embedded system design	2
2	Formalism - Structural, behavioral description	6
3	CPUs and co-processors	4
4	Buses, memories, I/O interfacing	6
5	Development and debugging techniques	4
6	Program development	4
7	Processes	2
8	Operating systems	4
9	Hardware accelerators	2
10	System design techniques	4
11	Networks	4
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Design formalisms	10
2	System description and design	10
3	Hardware and software co-design	10
4	Development and debugging	14
		44

19. Suggested texts and reference materials

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

Wayne Wolf, Computers as components-Principles of embedded Computing Systems Design, Morgan Kaufman

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

20.1	Software	Unix, FOSS
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	Multimedia projector, Visualizer
20.4	Laboratory	Lab for assignments and term projects
20.5	Equipment	PC, embedded SBCs and peripherals,
20.6	Classroom Infrastructure	ONE class for 45 students
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Pervasive Computing
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL898
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	BSL818 Telecom Technologies/ ELL785 Computer Communication Networks

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course off the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [X] Either sem

11.	**Faculty who will teach the course** Subrat Kar, Swades De, Brejesh Lall, Santanu Chaudhury

12.	**Will the course require any visiting faculty? (yes/no)**	NO

13.	Course objectives (about 50 words): Pervasive Computing, also known as Ubiquitous Computing, is the consequence of having computing devices smaller in size, more powerful and connected. One can envision that almost any device, clothing, tools, appliances, cars, homes, human body, even coffee mug, can be embedded with chips to connect the device to an intelligent network of other devices. The course surveys the emerging hardware and software landscape of this subject. After doing the course, students are expected to understand the challenges for low-resourced communication and computing and the schemes to overcome these including intelligent reasoning. Students will get a feel for the complexity that cyber-physical systems bring.

14.	Course contents (about 100 words) (Include laboratory/design activities): Introduction, computer and network architectures for pervasive computing, mobile computing mechanisms, human-computer interaction using speech and vision, pervasive software systems, location mechanisms, practical techniques for security and user-authentication, and experimental pervasive computing systems.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Pervasive Computing: Vision and Challenges	2
2	Embedded Architectures	4
3	Pervasive Networks	6
4	Pervasive Naming and Context-Awareness	6
5	Pervasive Data access	5
6	Programming Environments for Pervasive Computing	5
7	Security in Pervasive Systems	6
8	Human Interaction in Pervasive Systems	8

	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
2	Embedded Processor Architecture	6
3	Wireless Networking Protocols including Bluetooth	6
4	IOT Middleware and IOT Ontology	4
5	Fundamentals of AI	8
8	Speech and Object Recognition techniques	8

		32

19. Suggested texts and reference materials

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

1. Mahadev Satyanarayanan (Eds.), Synthesis Lectures on Mobile and Pervasive Computing, Morgan-Claypool, 2014
2. Mohammad S. Obaidat (Edis.), Mieso Denko (Eds.), Isaac Woungang (Eds.) Pervasive Computing and Networking, Wiley, 2011.

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

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	20% on Networked Embedded Systems and Applications
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Digital Systems Lab
3.	**L-T-P Structure**	0-1-4
4.	**Credits**	3
5.	**Course Number**	ELP781
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	UG Computer Architecture PG Computer Architecture ELL787 Embedded Systems and Applications (concurrent registration allowed)

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [X] Either sem

11.	**Faculty who will teach the course** Subrat Kar Santanu Chaudhury Turbo Majumder Brejesh Lall

12.	**Will the course require any visiting faculty? (yes/no)**	NO

13.	**Course objectives** *(about 50 words)***:** To provide a advanced exposure to digital system design design using behavioural and structural descriptions, introduce the Hardware Design Lifecycle, design projects on single board computers FPGAs and interfacing of cyber-physical systems

15. Lecture Outline *(with topics and number of lectures)*

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

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1	Elements of Hardware Design Life Cycle (HDLC) and Product Design Life Cycle (PDLC)	4
2	Behavioral and structural design frameworks for digital systems, logic level synthesis	4
3	Embedded digital systems - SBCs and FPGAs	2
4	Hardware - software co-design, RTL synthesis, high level synthesis, simulation	2
5	Prototyping, aesthetics and ergonomics	2

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Elements of Hardware Design Life Cycle (HDLC) and Product Design Life Cycle (PDLC)	12
2	Behavioral and structural design frameworks for digital systems	12
3	Embedded digital systems - SBCs and FPGAs	7
4	Hardware - software co-design	7
5	Prototyping, aesthetics and ergonomics	8

		46

19. Suggested texts and reference materials

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

Wayne Wolf, FPGA based system design, Prentice Hall Petra Michel, Ulrich Lauther, Peter Duzy (Eds), The synthesis approach to Digital System Design

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

20.1	Software	Windows
20.2	Hardware	PC
20.3	Teaching aids (videos, etc.)	Visualizer, Multimedia Projector
20.4	Laboratory	ONE
20.5	Equipment	hardware debugger, logic analysers, oscilloscopes, SBCs, FPGA and CPLD based dev kits, software development tools and accessories
20.6	Classroom Infrastructure	ONE
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	70%
21.2	Open-ended problems	
21.3	Project-type activity	30%
21.4	Open-ended laboratory work	

21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Digital Hardware Design
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL790
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	Computer Architecture (UG or PG) ELL787 Embedded Systems and Applications (concurrent registration allowed

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [X] Either sem

11.	**Faculty who will teach the course** Subrat Kar Santanu Chaudhury Turbo Majunder Sumantra DuttaRoy

12.	**Will the course require any visiting faculty? (yes/no)**	NO

13.	**Course objectives** *(about 50 words)***:** To provide advanced level exposure to digital hardware design and interfacing design and techniques

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** To provide advanced level exposure to digital hardware design and interfacing, elements of hardware software co-design, synthesis of digital systems at logic/RTL and system levels, simulation aspects of synthesis

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	High level synthesis in designing digital systems	12
2	Logic level, RTL synthesis and system level synthesis	12
3	Simulations aspects of synthesis	12
4	Hardware software co-design	4
5	Engineering digital systems as products - UI , ergonomics and case studies	2
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

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

Petra Michel, Ulrich Lauther, Peter Duzy (Eds), The synthesis approach to Digital System Design

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

20.1	Software	Unix/Windows
20.2	Hardware	PCs
20.3	Teaching aids (videos, etc.)	Multimedia projectors
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	One
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	10%
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Testing and Fault Tolerance
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL791
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	Computer Architecture (UG or PG) ELL787 Embedded Systems and Applications

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [X] Either sem

11.	**Faculty who will teach the course** Subrat Kar Santanu Chaudhury Turbo Majumder Brejesh Lall

12.	**Will the course require any visiting faculty? (yes/no)**	NO

13.	**Course objectives** *(about 50 words)***:** To provide a advanced level course in testing and fault tolerance techniques for digital systems

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Introduction to testing, simulation, fault simulation, automatic test pattern generator, sequential logic tests, automatic test equipment, designing for testability, Built-In Self-Test (BIST), behavioral test and verification

15. Lecture Outline *(with topics and number of lectures)*

Module no.	**Topic**	**No. of hours**
1	Introduction to testing	8
2	Simulation	10
3	Fault simulation	8
4	Automatic test pattern generator	4
5	Sequential logic tests	4
6	Automatic test equipment	4
7	Designing for testability, Built-In Self-Test (BIST), behavioral test and verification	4
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Introduction to testing	8
2	Simulation	8
3	Fault simulation	8
4	Automatic test pattern generator	8
5	Sequential logic tests	8
6	Automatic test equipment	8
		48

19. Suggested texts and reference materials

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

Alexander Miczo, Digital Logic Test and Simulation, 2/e, John Wiley Rolf Isermann, Fault Diagnosis Systems-An introduction from Fault Diagnosis to Fault Detection to Fault tolerance, Springer, 2003

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

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	vISUALIZER, mULTIMEDIA PROJECTOR
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	10%
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Computer Communication Networks
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL785
6.	**Status** *(category for program)*	B.Tech, Dept. Elective for EE1, EE2 and EE5 MTech, Program Core for EET, JTM, Program Elective for EEE, EEN, EEA,

7.	**Pre-requisites** (course no/title)	ELL 711 (Signal Theory) or MAL 250 (Probability Theory and Stoc. Proc.) or equivalent

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	--
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL374, CSL672 20%
8.3	Supersedes any existing course	EEL473/EEL703

9.	**Not allowed for** (indicate program names)	--

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [x] 2nd sem [ ] Either sem 3rdYr, 2nd Sem. for EE1,EE2,EE5; 1stYr 2nd Sem. for MTech

11.	**Faculty who will teach the course** Swades De Jun Bae Seo

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** This course is intended to provide the protocol concepts of communication network systems with particular emphasis on the fundamental analytic concepts of wireline and wireless communication networks.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Theory/Lecture: Review of data communication techniques, basic networking concepts, layered network and protocol concepts, quality of service, motivations for cross-layer protocol design. Motivations for performance analysis, forward error correction and re-transmission performances, Markov and semi-Markov processes, Little's theorem, M/M/m/k, M/G/1 systems, priority queueing, network of queues, network traffic behavior. Concepts and analysis of multi-access protocols; contention-free and contention multi-access protocols. Basic graph theoretic concepts, routing algorithms and analysis. Suggsted lab Course content: Laboratory: Simulation and hardware experiments on different aspects of computer communication networks. Network traffic generation and analysis, differentiated service queues, network of queues using discrete event simulations.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Review of data communication techniques, basic networking concepts, network systems examples	6
2	Motivations for layered network and protocol concepts,	3
3	Quality of service, motivations for cross-layer protocol design	3
4	Forward error correction and re-transmission performances	3
5	Motivations for performance analysis, Markov and semi-Markov processes, Little's theorem	6
6	M/M/m/k, M/G/1 systems, priority queueing, network of queues	6
7	Network traffic behavior	3
8	Concepts and analysis of multi-access protocols; contention-free and contention multi-access protocols	6

9	Basic graph theoretic concepts, routing algorithms and analysis	6
	COURSE TOTAL (14 times 'L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities: (Optional, separate course (0-0-2))

Module no.	Description	No. of hours
1	Network traffic generation and analysis of traces; numerical verification using traffic distributions	4
2	Learning discrete event simulation tools	6
3	Simple point-to-point communication and queueing analysis	4
4	Differentiated traffic generation, reception, and analysis	4
5	Simulation of network of queues - open as well as closed network systems	4
6	Exploration of application-specific network performance analysis	4

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	TCP/IP programming and protocol-level implementation	10
2	Source-, channel-coding concepts	4

3	Queueing network performance simulation and verification of analysis	6
4	Graph theory and random graph concepts	6
5	Dynamic programming concepts	4
		30

19. Suggested texts and reference materials

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

1. A Leon-Garcia and I. Widjaja, Communication Networks, Tata-McGraw-Hill, 2nd. Ed., 2004.
2. Bertsekas and Gallager, Data Networks, Prentice-Hall, 2nd ed., 1992.
3. Kumar, Manjunath, and Kuri, Communication Networks, Morgan-Kaufmann, 2004.
4. (Reference) L. Kleinrock, Queueing Systems, vol.1, Wiley, 1975.
5. K. R. Fall and W. R. Stevens, TCP/IP Illustrated, Volume 1: The Protocols, Addison-Wesley, 2011

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

20.1	Software	Wireshark, NS2, MATLAB
20.2	Hardware	--
20.3	Teaching aids (videos, etc.)	Multimedia projector
20.4	Laboratory	(optional, separate course: ELP782, 0-1-4)
20.5	Equipment	--
20.6	Classroom Infrastructure	White-board/black-board mandatory, projection facility
20.7	Site visits	--
20.8	Others (please specify)	--

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Software Laboratory
3.	**L-T-P Structure**	0-1-4
4.	**Credits**	3
5.	**Course Number**	ELP780
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	ELL782 Computer Architecture OR ELL783 Operating Systems OR ELL781 Software Fundamentals for Computer Technology(concurrent registration allowed)

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	ELP773 Telecom Software 20%
8.2	Overlap with any UG/PG course of other Dept./Centre	CSL740 Software Engg 30% MAL745 Software Engg 30%
8.3	Supersedes any existing course	EEP702 Software Lab

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [] 1st sem [ ] 2nd sem [X] Either sem

11.	**Faculty who will teach the course** SUBRAT KAR

	SANTANU CHAUDHURY SUMEET AGARWAL SUMANTRA DUTTAROY	

12.	**Will the course require any visiting faculty? (yes/no)**	NO

13.	**Course objectives** *(about 50 words)***:** Students are expected to be familiar with the software development life cycle and work under Windows and/or LINUX/UNIX environments

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Experiments related to the following topics: advanced data structures and algorithms, compilers, GUI, component-based software design, distributed and web based applications, UML, firmware, database applications

15. Lecture Outline *(with topics and number of lectures)*

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

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1	Unix Programming Environment	1
2	Software Development Life Cycle: requirement analysis, design, coding and testing methods, specification, configuration management and change control; testing and software reliability estimation	2
3	Software frameworks and patterns; UML, Documentation. Validation. Quality assurance, safety.	2
4	Testing and test case generation. Software metrics.	2
5	Embedded firmware development - monitors, debuggers, RTOS	2
6	Bare metal programming, physical interfacing and device drivers, kernel programming	2
7	GUI design, dynamic web based interface design	1

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Advanced Unix programming	7
2	SDLC; SRS generation; coding best practices	12
3	Frameworks and software assurance, software audit	12
4	Embedded firmware programming	6
5	System and firmware level development and debugging	6
6	GUI design - using patterns and frameworks for effective UI	6

19. Suggested texts and reference materials

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

R.S.Pressman, Software Engineering, 7/e, McGraw Hill (Indian Ed)

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

20.1	Software	Unix OS / RTLinux/Montavista Linux, Windows / Windows CE,

		VHDL compilers
20.2	Hardware	PC
20.3	Teaching aids (videos, etc.)	Multimedia projector
20.4	Laboratory	ONE
20.5	Equipment	Protocol analyser, embedded / SBCs, emulators, hardware debuggers
20.6	Classroom Infrastructure	ONE for tutorials
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	20%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Computer Networks Lab
3.	**L-T-P Structure**	0-1-4
4.	**Credits**	3
5.	**Course Number**	ELP782
6.	**Status** *(category for program)*	B.Tech, Dept. Elective for EE1, EE2 and EE5 MTech, Program Core for EET, JTM, Program Elective for EEE, EEN, EEA,

7.	**Pre-requisites** (course no/title)	--

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	--
8.2	Overlap with any UG/PG course of other Dept./Centre	--
8.3	Supersedes any existing course	EEP703

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [x] 2nd sem [ ] Either sem 3rdYr, 2nd Sem. for EE1,EE2,EE5; 1stYr 2nd Sem. for MTech

11.	**Faculty who will teach the course** Swades De Jun Bae Seo

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** This course is intended to provide the protocol implementation concepts of communication network systems, and to be able to appreciate the connection between theoretical analysis and actual network system-level implementations.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Simulation and hardware experiments on different aspects of computer communication networks. Network traffic generation and analysis, differentiated service queues, network of queues using discrete event simulations.

15. Lecture Outline *(with topics and number of lectures)*

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

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1	Network traffic generation and analysis of traces; numerical verification using traffic distributions	4
2	Learning discrete event simulation tools	6
3	Simple point-to-point communication and queueing analysis	4
4	Differentiated traffic generation, reception, and analysis	4
5	Simulation of network of queues - open as well as closed network systems	4
6	Exploration of application-specific network performance analysis	4

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	TCP/IP programming and protocol-level implementation	10
2	Advanced research papers on case-by-case basis, per assignment	10
		20

19. Suggested texts and reference materials

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

1. K. R. Fall and W. R. Stevens, TCP/IP Illustrated, Volume 1: The Protocols, Addison-Wesley, 2011

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

20.1	Software	Unix / Windows, Wireshark, NS2, MATLAB
20.2	Hardware	PC with two network cards
20.3	Teaching aids (videos, etc.)	Multimedia projector
20.4	Laboratory	ONE
20.5	Equipment	--
20.6	Classroom Infrastructure	ONE classroom for tutorials White-board/black-board, projection facility
20.7	Site visits	--
20.8	Others (please specify)	--

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	**Network Performance Modeling and Analysis**
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL894
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	Probability Theory and Stochastic Processes (MAL 250, or ELL711, or equivalent). Having prior knowledge of network systems is not necessary.

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	**ELL473 (Computer Communication) – 15% overlap**
8.2	Overlap with any UG/PG course of other Dept./Centre	MAL740 (Queueing Networks for Computer Communication Systems) – 30% overlap SIL769 – 10% overlap
8.3	Supersedes any existing course	**None**

9.	**Not allowed for** (indicate program names)	--

10.	**Frequency of offering**	[ ] Every sem [x] 1st sem [ ] 2nd sem [ ] Either sem

11.	**Faculty who will teach the course** Swades De (EE) Jun Bae Seo (EE)

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)*: The course will cover the advanced mathematical concepts related to computer communication systems. Specific focus will be on performance modeling and analysis of queueing systems and networks. In view of connecting the concepts of queueing theory and stochastic optimization theory, it will also briefly touch upon the concepts of dynamic programming. Some programming exercises on network traffic generation with various distributions, traffic classification, and priority queueing exercises are planned within the lecture course curriculum. The course would be useful to the Masters/Dual-Degree and PhD students interested in doing project/research in the areas of computer communication networks and industrial systems performance modeling and analysis.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** 1) Network performance models and classifications 2) Hidden Markov Models (HMM) 3) Delay and throughput analysis using Markov models 4) Performance analysis with multi-class traffic 5) Renewal theory and regenerative processes 6) Performance analysis with semi-Markov traffic characteristics 7) Network performance analysis with interactive servers 8) Practical network traffic characterization 9) Network performance stability 10) Introduction to dynamic programming 11) Example network modeling scenarios in various engineering applications

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours

1	Network performance models and classifications	3
2	Hidden Markov Models (HMM) and network applications	3
3	Delay and throughput analysis using Markov models	5
4	Performance analysis with multi-class and priority traffic	4
5	Performance with Erlangian traffic, batch arrival and service processes	4
6	Renewal theory and regenerative processes	4
7	Performance analysis with semi-Markov traffic characteristics	5
8	Network performance analysis with interactive nodes/links	4
9	Network performance stability	2
10	Practical network traffic characterization	2
11	Introduction to dynamic programming	4
12	Example computer communication scenarios	2
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities: Not Applicable

Module no.	Description	No. of hours

17. Brief description of laboratory activities: Not applicable

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Renewal processes	4
2	Hidden Markov Models	6
3	Dynamic programming	10
4	Selected research papers	10

19. Suggested texts and reference materials

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

- L. Kleinrock, *Queueing Systems: vol. I - Theory*, Wiley, 1976.
- L. Kleinrock, *Queueing Systems: vol. II - Computer Applications*, Wiley, 1976.
- REFERENCE
  - R. G. Gallager, *Discrete Stochastic processes*, Mc-Graw Hill, 1996.
  - D. Gross and C. M. Harris, *Fundamentals of Queueing Theory*, Wiley, 3rd ed., 1998.
  - K. S. Trivedi, *Probability and Statistics with Reliability, Queueing, and Computer Science Applications,* John Wiley and Sons, 2nd ed., 2007.
  - A. Kumar, D. Manjunath, and J. Kuri, *Communication networking: an analytical approach*, Elsevier/ Morgan Kaufmann, 2004.
  - M. J. Neely, *Stochastic Network Optimization with Application to Communication and Queueing Systems*, Morgan & Claypool, 2010
  - L. Lakatos, L. Szeidl, and M. Telek, *Introduction to Queueing Systems with Telecommunication Applications*, Springer, 2013.
  - M. L. Puterman, *Markov Decision Processes: Discrete Stochastic Dynamic Programming*, Wiley, 2005.
  - Research papers

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

NOT APPLICABLE

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	--
21.2	Open-ended problems	Cutting-edge research papers
21.3	Project-type activity	Term-project on a chosen research topic that has components of network performance modeling evaluation (25%)
21.4	Open-ended laboratory work	--
21.5	Others (please specify)	--

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Protocol Engineering
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL889
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	ELL706 Operating Systems OR ELL818 Telecom Technologies

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [X] Either sem

11.	**Faculty who will teach the course** SUBRAT KAR SANTANU CHAUDHURY

12.	**Will the course require any visiting faculty? (yes/no)**	NO

13.	**Course objectives** *(about 50 words)***:** To provide a advanced level exposure to protocols, protocol specification and description languages and protocol verification with tools.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Principles, stages, specification formalisms (UML, SDL, ASN.1) of telecom protocol design, protocol software development process, computer aided protocol engineering, verification and testing of protocols, object oriented techniques in protocol development, kernel level development and programming of protocols.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to principles of communication protocols	10
2	Formal protocol description methods and techniques	10
3	Protocol design, design tools and verification	10
4	Protocol evaluation, implementation and testing	10
5	Case studies	2
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Introduction to principles of communication protocols - video tutorials	8
2	Formal protocol description methods and techniques - applying FDT to basic protocols	12
3	Protocol design, design tools and verification - testing and evaluation using UML and SDL compilers	12
4	Protocol evaluation, implementation and testing - programming test protocols	8
5	Case studies - library work, protocol formulation	8
		48

19. Suggested texts and reference materials

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

Behcet Sarikaya, Principles of Protocol Engineering and Conformance Testing, Ellis Horwood (available in Central Library)

Miroslav Popovich, Communication Protocol Engineering, Taylor & Francis, 2006

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

20.1	Software	SDL compiler
20.2	Hardware	PC
20.3	Teaching aids (videos, etc.)	Multimedia projector
20.4	Laboratory	
20.5	Equipment	Protocol Sniffers (software and hardware sniffers) for demo
20.6	Classroom Infrastructure	ONE
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Internet Technologies
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL892
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	(ELL783 Operating Systems OR BSL818 Telecom Technologies OR ELP780 Software Lab OR ELP775 Telecom Software lab-1)

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [X] Either sem

11.	**Faculty who will teach the course** SUBRAT KAR BREJESH LALL SANTANU CHAUDHURY

12.	**Will the course require any visiting faculty? (yes/no)**	NO

13.	**Course objectives** *(about 50 words)***:** To introduce web and network related technologies for information gathering, storage in repositories, search and retrieval for domain specific decision support systems.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Web and service oriented architectures, dynamic web site programming (client side and server side), web application development, web based repositories, UI design, XML, Web 2.0 and the semantic web, applications

15. Lecture Outline *(with topics and number of lectures)*

Module no.	**Topic**	**No. of hours**
1	Introduction to the Web	2
2	Fundamentals of networking and client-server architectures	8
3	Introduction to distributed architectures	6
4	Technologies for Services delivery	5
5	Storage and connecting to repositories	6
6	Virtualization and hypervisor technologies, VMs	2
7	PAAS, HAAS and SAAS based solutions	3
8	Dynamic programming - PHP, SQL, AJAX, JSON, DHTML, DOM and extensible schema - XML	6
9	The Semantic Web, Web 2.0	4
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Introduction to the Web	2
2	Fundamentals of networking and client-server architectures	4
3	Introduction to distributed architectures	6
4	Technologies for Services delivery	8
5	Storage and connecting to repositories	4
6	Virtualization and hypervisor technologies, VMs	4
7	PAAS, HAAS and SAAS based solutions	8
8	Dynamic programming - PHP, SQL, AJAX, JSON, DHTML, DOM and extensible schema - XML	10

9	The Semantic Web, Web 2.0	8
		54

19. Suggested texts and reference materials

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

Liyang Yu, Introduction to the Semantic Web and Semantic Web Services, Chapman and Hall/CRC, 2007 Developing Web Components, Jarrod Overson, Jason Strimpel, O'Reilly Media (Indian edition by Shroff Publishers)

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

20.1	Software	Unix
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	ONE with multimedia projector and audio speakers
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	20%
21.2	Open-ended problems	
21.3	Project-type activity	10%

21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Network Security
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL895
6.	**Status** *(category for program)*	Elective

7.	**Pre-requisites** (course no/title)	BSL818 Telecom Technologies ELL785 Computer Communication Networks

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [X] Either sem

11.	**Faculty who will teach the course** SUBRAT KAR BREJESH LALL

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** To provide exposure to network security standards, cryptographic methods, transport level security,and system security.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Introduction to cryptography, public key distribution and user authentication, TLS and wireless network security, secure email and PGP, IP security, system security - intrusion, malicious software and firewalls.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	**Topic**	**No. of hours**
1	Introduction to cryptography	8
2	Key distribution and User authentication	8
3	Transport Level Security and Wireless Network security	8
4	Secure mail and PGP	2
5	IP security	8
6	System security - intrusion, malicious software and firewalls	8
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module	**Description**	**No. of hours**

no.		

17. Brief description of laboratory activities

Module no.	Description	No. of hours
7		

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Introduction to cryptography	8
2	Key distribution and User authentication	7
3	Transport Level Security and Wireless Network security	8
4	Secure mail and PGP	8
5	IP security	10
6	System security - intrusion, malicious software and firewalls	8
		49

19. Suggested texts and reference materials

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

John E Canavan, The Fundamentals of Network Security, Artech House William Stallings, Network Security Essentials: Applications and Standards, 5/E, Prentice Hall

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

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	ONE
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Mobile Computing
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL896
6.	**Status** *(category for program)*	PE for CTECH, JTM, JOP, EEE

7.	**Pre-requisites** (course no/title)	ELL785 Computer Communication Networks

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	--
8.2	Overlap with any UG/PG course of other Dept./Centre	--
8.3	Supersedes any existing course	EEL858 Mobile Computing

9.	**Not allowed for** (indicate program names)	--

10.	**Frequency of offering**	[ ] Every sem [x] 1st sem [ ] 2nd sem [ ] Either sem

11.	**Faculty who will teach the course** Swades De Jun Bae Seo

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** The course is aimed at giving insights into the wireless communication and networking protocols, latest advances in wireless access and routing technologies, and upcoming directions to mobile computing. The term-project part of the project is aimed at preparing the students toward research in the area of wireless communication networks and mobile computing technologies.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Overview of mobile computing; introduction to GSM, 3GPP, 4G LTE, LTE-A standards; wireless networking protocols: mobile IP, ad hoc networks, wireless TCP; cognitive radio networks; data broadcasting; location and context awareness; QoS, QoE; disconnected or weakly connected operations; protocol and resource optimization; wireless security issues

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Overview of mobile computing, introduction to wireless network standards	6
2	Wireless networking protocols, mobile IP, ad hoc networks, wireless TCP	9
3	Cognitive radio network concepts, transport layer issues	6
4	Broadband data, unicast/broadcast concepts	6
5	Location/context awareness, QoS, QoE	3
6	Disconnected or weakly connected operations	3
7	Protocol and resource optimization issues	6
8	Wireless security issues	3
	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities: None

Module no.	Description	No. of hours

17. Brief description of laboratory activities: None

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Term-project on selected cutting-edge research topics	20
2	Wireless access standards	5
3	Optimization aspects	5
		30

19. Suggested texts and reference materials

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

1. Latest state-of-the-art research papers

2. Wireless Internet and Mobile Computing: Interoperability and Performance, Yu-Kwong Ricky Kwok, Vincent K.N. Lau, Wiley, 2007.
3. Mobile Wireless Communications, Micha Schwartz, Cambridge Press, 2005.
4. Wireless Networking, Kumar, Manjunath, and Kuri, Morgan Kaufmann, 2008.
5. Wireless Communications and Networking, V. K. Garg, Morgan Kaufmann, 2008.

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

20.1	Software	NS2, Qualnet, Matlab, Wireshark
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Network Management
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL897
6.	**Status** *(category for program)*	Program Elective

7.	**Pre-requisites** (course no/title)	ELL785 Computer Communication Networks, BSL818 Telecom Technologies

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [X] Either sem

11.	**Faculty who will teach the course** SUBRAT KAR BREJESH LALL

12.	**Will the course require any visiting faculty? (yes/no)**	NO

13.	**Course objectives** *(about 50 words)***:** The course will cover standards for management protocols, data models, and architecture, decentralized management, policy-based management, OSS, Management in IMS and SDN.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities)**:*** Activities, methods, operational procedures, tools, communications interfaces, protocols, and human resources that pertain to the operation, administration, maintenance, and provisioning of communications networks, network management standards, technologies; functional areas of fault management, configuration management, accounting management, performance management, and security management, major Internet and telecommunications standards for network management: SNMPv3, RMON, CMIP and TMN.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Network management and OSS	8
2	SNMP	4
3	CLI and TL1	4
4	Service provisioning	8
5	Telecom Operations Map (TOM & eTOM)	8
6	Configuration management, fault management, traffic management	4
7	Network Inventory management	4
8	NMS and NGN, NMS and SDN	2

	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Network management and OSS	7
2	SNMP	10
3	CLI and TL1	3

4	Service provisioning	3
5	Telecom Operations Map (TOM & eTOM)	7
6	Configuration management, fault management, traffic management	10
7	Network Inventory management	3
8	NGN for IMS, NGN for SDN	7
		50

19. Suggested texts and reference materials

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

W.Stallings, Network Management, IEEE Computer Society W.Stallings, SNMP, SNMPv2, and RMON: Practical Network Management, Addison-Wesley

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

20.1	Software	
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	Multimedia projector
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	ONE classroom
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	
21.2	Open-ended problems	

21.3	Project-type activity	10%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Electrical Engineering
2.	**Course Title** *(<45 characters)*	Energy-Efficient Computing
3.	**L-T-P Structure**	3-0-0
4.	**Credits**	3
5.	**Course Number**	ELL797
6.	**Status** *(category for program)*	PE for EET

7.	**Pre-requisites** (course no/title)	Architecture (UG/PG) and Operating Systems

8	**Status vis-a-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	No

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	[ ] Every sem [ ] 1st sem [ ] 2nd sem [X] Either sem

11.	**Faculty who will teach the course** Jayadeva, Santanu Chaudhury, Sumantra Dutta Roy, Subrat Kar

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)*: Students on completion of the course are expected to meet following learning Objectives 1. Understand the fundamentals of energy-efficient computing. 2. Understand energy-efficient operating systems. 3. Understand energy-efficient compilers. 4. Understand energy-efficient networks. 5. Understand energy-efficient data centers. and 6. Understand energy-efficient storage.

14.	***Course contents*** *(about 100 words) (Include laboratory/design activities):* Introduction and Motivation, Energy-Efficient Techniques in Operating Systems (Power Aware Scheduling, Adaptation for Multimedia Applications, Power aware memory and I/O device management, multiprocessor systems.), Storage, Compilers, Networks and Data Centers, Power management for Wearable devices and pervasive computing

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction and motivation	3
2	Operating System : Energy efficient Design and Power Management Power Aware Scheduling, Adaptation for Multimedia Applications, Power aware memory and I/O device management, Power Management in Multi-processor system.	10
3	Storage Systems:	6
4	Compilation for Energy Efficient Code Generation	5
5	Energy Efficient Techniques in Network: Power aware Routing, Topology Control, Sleep Schedule, Clustering, Power aware multi-cast	8
6	Energy Management for Data Centers	6
7	Power management in wearable and pervasive computing	4

	COURSE TOTAL (14 times `L')	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700/800 level courses)

Module no.	Description	No. of hours
1	Basics of Energy-Efficient computing	5

2	Energy issues in Operating Systems	10
3	Energy issues in Computer Architecture: processors, data centres, storage	10
4	Energy issues in Compilers	5
5	Energy issues in networks	7
6	Energy issues in wearable devices and pervasive computing	5

19. Suggested texts and reference materials

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

Power Aware Computing, R. Melhem, R. Graybill (Eds.), Springer, 2002 ISBN 0306467860.

Proceedings of ACM/IEEE Conference on Green Computing and Communications

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

20.1	Software	MATLAB
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	Multimedia projector
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom Infrastructure	ONE classroom, Multimedia projector
20.7	Site visits	
20.8	Others (please specify)	

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

21.1	Design-type problems	10%
21.2	Open-ended problems	5%
21.3	Project-type activity	15%
21.4	Open-ended laboratory work	10%
21.5	Others (please specify)	

Date: (Signature of the Head of the Department)