Annexure II: Course Content

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Center for Artificial Intelligence and Machine Learning		
2.	Course Title	**Python for Data Science & Essentials of Programming**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Institute Core			

Institute Core for all UG programs	NA
Programme Linked Core for:	All PG Executive Students
Departmental Core for:	NA
Departmental Elective for:	
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA
Programme Core for:	NA
Programme Elective for:	NA
Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	Every Quarter

9.	**Faculty who will teach the course**: TBD

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): Python is one of the most versatile and widely used scripting languages. It's clean and uncluttered Syntax as well as its straightforward design greatly contribute to this success and make it an ideal language for programming education. Its application ranges from web development to scientific computing. Especially in the fields of data science and artificial intelligence, it is the most common programming language supported by all major data-handling and analytical frameworks. This course provides a thorough introduction to the language and its main features, as well as Insights into the rationale and application of important adjacent concepts such as environments, testing, and version control. Also in this course, students will learn how to code for building data science / machine learning applications.

12.	**Course outcomes** (about 100 words): By the end of this course, students should: • Understand Python syntax and programming concepts. • Understand object-oriented concepts in Python. • Analyze and apply different methods for error handling in Python. • Understand important Python libraries related to data science and how to apply them to given programming tasks. • Understand concepts like environments and version control.

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): • Introduction to Data Science using Python • Python basic constructs • Object Oriented Programming in Python

	• NumPy for mathematical computing • SciPy for scientific computing • Data manipulation • Data visualization with Matplotlib • Machine learning libraries in Python - Pandas, Matplotlib, NumPy, scikit-Learn

	Detailed Contents	
Module no.	Topic	No. of hours
	Introduction to Data Science using Python • What is Data Science, what does a data scientist do • Various examples of Data Science in the industries • How Python is deployed for Data Science applications • Various steps in Data Science process like data wrangling, data exploration and selecting the model. • Introduction to Python programming language • Important Python features, how is Python different from other programming languages • Python installation, Anaconda Python distribution for Windows, Linux and Mac • How to run a sample Python script, Python IDE working mechanism • Running some Python basic commands • Python variables, data types and keywords.	6
	Python basic constructs • Introduction to a basic construct in Python • Understanding indentation like tabs and spaces • Python built-in data types • Basic operators in Python • Loop and control statements like break, if, for, continue, else, range() and more. • File Handling (I/O) and Exception Handling, Pandas	10

	Object Oriented Programming in Python • Understanding the OOP paradigm like encapsulation, inheritance, polymorphism and abstraction • What are access modifiers, instances, class members • Classes and objects • Function parameter and return type functions • Lambda expressions.	8
	NumPy for Mathematical Computing • Introduction to mathematical computing in Python • What are arrays and matrices, array indexing, array math, Inspecting a NumPy array, NumPy array manipulation	6
	SciPy for scientific computing • Introduction to SciPy • Functions building on top of NumPy, cluster, linalg, signal, optimize, integrate, subpackages, SciPy with Bayes Theorem.	6
	Data manipulation • Loading data from various files (.dat, .json, .h5, .txt, .csv, .xlsx etc.) • Example applications	3
	Data visualization with Matplotlib • Introduction to Matplotlib • Using Matplotlib for plotting graphs and charts like Scatter, Bar, Pie, Line etc. • Histogram and more • Matplotlib APIs	3
	Total Lecture hours	**42**

Brief description of tutorial activities (if applicable):

Modul	Description	No. of

e no.		hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief dDescription of module-wise activities pertaining to self-learning component
(if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

1. Wes McKinney: Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython, O'Reilly Media, 2017

Reference materials:

Supplementary reading material and other resources may be provided in class throughout the semest er.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Python

20.2	Hardware	NA
20.3	Teaching aids (videos, etc.)	Videos, course material, handouts.
20.4	Laboratory	NA
20.5	Equipment	NA
20.6	Classroom infrastructure	NA
20.7	Site visits	NA
20.8	Others (please specify)	

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

21.1	Design-type problems	NA
21.2	Open-ended problems	NA
21.3	Project-type activity	Industry Oriented Projects (14 hrs)
21.4	Open-ended laboratory work	NA
21.5	Others (please specify)	

Date: 15 January 2022 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Center/School proposing the course	Center for Artificial Intelligence and Machine Learning		
2.	Course Title	**Statistical Foundations for Machine Learning**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		

6.	Course Status (Course Category for Program): Departmental Core	
Institute Core for all UG programs		NA
Programme Linked Core for:		All PG Executive Students
Departmental Core for:		
Departmental Elective for:		
Minor Area / Interdisciplinary Specialization Core for:		
Minor Area / Interdisciplinary Specialization Elective for:		NA
Programme Core for:		NA
Programme Elective for:		NA
Open category Elective for all other programs (No if Institute Core)		

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	
9.	**Faculty who will teach the course**:	

10.	**Will the course require any visiting faculty?**	NO

11.	**Course objectives** (Why should one study this course?) (about 100 words): The objective of the course is to provide the fundamental knowledge of probability and random theory with an application to artificial intelligence and machine learning.

12.	**Course outcomes** (about 100 words): By the end of this course, students should: • Understand the concepts of random variables and random processes • Comprehend the various statistical models used for modeling for machine learning application • Apply the different detection and estimation rules in real time problems

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): • Fundamentals of Probability and Random Signal Theory

	• Random Processes and Convergence • Markov Chains and Applications • Frequentist Statistics and Regression • Bayesian Statistics and Hypothesis Testing

14.	Detailed Contents	
Module no.	Topic	No. of hours
1.	• **Fundamentals of Probability and Random Signal Theory** Probability spaces, Conditional probability, Independence, Random Variables, Discrete and Continuous random variables, Expectation Operator, Functions of random variables, Generating random variables, Multivariate Random Variables, Joint distributions of discrete and continuous variables, Functions of several random variables, Joint Moments, Generating multivariate random variables	9
2.	• **Random Processes and Convergence** Definition, Stationarity of random processes, Mean and autocovariance functions, Independent identically-distributed sequences, Power spectral density, Gaussian process, Poisson process, Random walk, Convergence of Random Processes, Types of convergence, Law of large numbers, Central limit theorem, Monte Carlo simulation	9
3.	• **Markov Chains and Applications** Time-homogeneous discrete-time Markov chains, Recurrence, Periodicity, Convergence, Markov-chain Monte Carlo, Descriptive statistics, Histogram, Sample mean and variance, Order statistics, Sample covariance, Sample covariance matrix	8
4.	• **Frequentist Statistics and Regression** Independent identically-distributed sampling, Mean square error, Consistency, Condence intervals, Nonparametric model estimation, Parametric model estimation, Linear Regression models, Least-squares estimation, Overtting, Global warming.	8
5.	• **Bayesian Statistics and Hypothesis Testing** Bayesian parametric models, Conjugate prior, Bayesian estimators, The hypothesis-testing framework, Parametric testing, Nonparametric testing: The permutation test, Multiple testing	8
	Total Lecture hours	42

15. Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief description of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

1. Probability and Statistics for Data Science, by Carlos Fernandez-Granda
2. Probability for Statistics and Machine Learning: Fundamentals and Advanced Topics, by Anirban Das Gupta
3. Probability, random variables, and stochastic processes, by Athanasios Papoulis.

Reference materials:

Supplementary reading material and other resources may be provided in class throughout the semester.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Any tool for computer programming and graphical representation of results
20.2	Hardware	NA

20.3	Teaching aids (videos, etc.)	Videos, Course Material, Handouts.
20.4	Laboratory	NA
20.5	Equipment	NA
20.6	Classroom infrastructure	NA
20.7	Site visits	NA
20.8	Others (please specify)	

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

21.1	Design-type problems	NA
21.2	Open-ended problems	NA
21.3	Project-type activity	Industry Oriented Projects (14 hrs)
21.4	Open-ended laboratory work	NA
21.5	Others (please specify)	

Date: 21 December 2021 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	**Center for Artificial Intelligence and Machine Learning (CAMeL)**		
2.	Course Title	**Artificial and Computational Intelligence**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Institute Core			

Institute Core for all UG programs	NA
Programme Linked Core for:	All UG/PG students
Departmental Core for:	NA
Departmental Elective for:	
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA
Programme Core for:	NA
Programme Elective for:	NA
Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of**	

	offering	
9.	**Faculty who will teach the course**:	

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): To develop semantic-based and context-aware systems to acquire, organize process, share and use the knowledge embedded in multimedia content. Research will aim to maximize automation of the complete knowledge lifecycle and achieve semantic interoperability between Web resources and services. The field of Robotics is a multi disciplinary as robots are amazingly complex system comprising mechanical, electrical, electronic H/W and S/W and issues germane to all these.

12.	**Course outcomes** (about 100 words): Upon successful completion of the course, the students will be able to • Solve basic AI based problems. • Define the concept of Artificial Intelligence. • Apply AI techniques to real-world problems to develop intelligent systems. • Select appropriately from a range of techniques when implementing intelligent systems.

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): ◆ Fundamentals on image processing ◆ Image Enhancement ◆ Image Restoration ◆ Image Segmentation ◆ Image Compression ◆ Digital Video Processing ◆ Motion Estimation ◆ Visual Scene Analysis

	Detailed Contents	
Module no.	**Topic**	**No. of hours**
1.	AI problems, foundation of AI and history of AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation.	6
2.	Searching- Searching for solutions, uniformed search strategies – Breadth first search, depth first Search. Search with partial information (Heuristic search) Hill climbing, A* ,AO* Algorithms, Problem reduction, Game Playing-Adversial search, Games, mini-max algorithm, optimal decisions in multiplayer games, Problem in Game playing, Alpha-Beta pruning, Evaluation functions.	8
3.	Knowledge representation issues, predicate logic- logic programming, semantic nets- frames and inheritance, constraint propagation, representing knowledge using rules, rules based deduction systems. Reasoning under uncertainty, review of probability, Baye's probabilistic interferences and dempstershafer theory.	8
4.	First order logic. Inference in first order logic, propositional vs. first order inference, unification & lifts forward chaining, Backward chaining, Resolution, Learning from observation Inductive learning, Decision trees, Explanation based learning, Statistical Learning methods , Reinforcement Learning.	8
5.	Expert systems:- Introduction, basic concepts, structure of expert systems, the human element in expert systems how expert systems works, problem areas addressed by expert systems, expert systems success factors, types of expert systems, expert systems and the internet interacts web, knowledge engineering, scope of knowledge, difficulties, in knowledge acquisition methods of knowledge acquisition, machine learning, intelligent agents, selecting an appropriate knowledge acquisition method, societal impacts reasoning in artificial intelligence, inference with rules, with frames: model based reasoning, case based reasoning, explanation & meta knowledge inference with uncertainty representing uncertainty.	10
6	Applications of AI	2
	Total Lecture hours	**42**

15. Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours

	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief description of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

1. S. Russel and P. Norvig, "Artificial Intelligence – A Modern Approach", SecondEdition, Pearson Education
2. David Poole, Alan Mackworth, Randy Goebel, "Computational Intelligence : a logical approach", Oxford University Press.
3. G. Luger, "Artificial Intelligence: Structures and Strategies for complex problemsolving", Fourth Edition, Pearson Education.
4. J. Nilsson, "Artificial Intelligence: A new Synthesis", Elsevier Publishers

Reference materials:

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Any tool for computer programming and graphical representation of results
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.

20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

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

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 21 December 2021 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/Scho	**Center for Artificial Intelligence and Machine**

	ol proposing the course	Learning (CAMeL)		
2.	Course Title	**Pattern Recognition**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Institute Core			

Institute Core for all UG programs	NA
Programme Linked Core for:	All UG/PG students
Departmental Core for:	NA
Departmental Elective for:	
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA
Programme Core for:	NA
Programme Elective for:	NA
Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	
9.	**Faculty who will teach the course**:	

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): This class deals with the fundamentals of characterizing and recognizing patterns and features of interest in numerical data. We also cover decision theory, statistical classification, maximum likelihood and Bayesian estimation, nonparametric methods, unsupervised learning and clustering. Additional topics on machine and human learning from active research are also talked about in the class

12.	**Course outcomes** (about 100 words): This course will study state-of-the-art techniques for analyzing data. The goal is to extract

	meaningful information from feature data. This includes statistical and information theoretic concepts relating to pattern recognition, with applications.

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): ◆ **Bayes Decision Theory** ◆ **Parameter Estimation Methods** ◆ **Unsupervised learning and clustering** ◆ **Nonparametric techniques for density estimation** ◆ **Dimensionality reduction** ◆ **Linear discriminant functions** ◆ **Non-metric methods for pattern classification**

14.	Detailed Contents	
Module no.	**Topic**	**No. of hours**
1.	**Bayes Decision Theory:** Minimum-error-rate classification, Classifiers, Discriminant functions, Decision surfaces, Normal density and discriminant functions, discrete features	6
2.	**Parameter Estimation Methods:** Maximum-Likelihood estimation: Gaussian case; Maximum a Posteriori estimation; Bayesian estimation: Gaussian case	6
3.	**Unsupervised learning and clustering:** Criterion functions for clustering; Algorithms for clustering: K-Means, Hierarchical and other methods; Cluster validation; Gaussian mixture models; Expectation-Maximization method for parameter estimation; Maximum entropy estimation	8
4.	**Nonparametric techniques for density estimation:** Parzen-window method; K-Nearest Neighbour method	6
5.	**Dimensionality reduction:** Fisher discriminant analysis; Principal component analysis;	6
6.	**Linear discriminant functions:** Gradient descent procedures; Perceptron; Support vector machines	5
7.	**Non-metric methods for pattern classification :** Non-numeric data or nominal data. Decision trees: Classification and Regression Trees (CART)	5
	Total Lecture hours	**42**

15. Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief description of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

- S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009
- R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001

Reference materials:

- C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Any tool for computer programming and graphical representation of results
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.

20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

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

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 21 December 2021 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Center for Artificial Intelligence and Machine Learning (CAMeL)		
2.	Course Title	**Image and Video Processing**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Institute Core			

Institute Core for all UG programs	NA
Programme Linked Core for:	All UG/PG students
Departmental Core for:	NA
Departmental Elective for:	
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA
Programme Core for:	NA
Programme Elective for:	NA

Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	
9.	**Faculty who will teach the course**:	

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): • To provide the basic concepts on image formation model and visualization. • To provide the conceptual relationships between spatial and frequency. • To provide an idea of image and video processing. • To provide an exposure to various image and video compression standards.

12.	**Course outcomes** (about 100 words): 1. Defining the digital image, representation of digital image, importance of image resolution, applications in image processing. 2. Know the advantages of representation of digital images in transform domain, application of various image transforms. 3. Know how an image can be enhanced by using histogram techniques, filtering techniques etc 4. Understand image degradation, image restoration techniques using spatial filters and frequency domain 7. Know the video technology from analog color TV systems to digital video systems, how video signal is sampled and filtering operations in video processing. 8. Know the general methodologies for 2D motion estimation; various coding used in video processing. Evaluate model parameters using parameter estimation techniques.

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): ◆ Fundamentals on image processing

	• Image Enhancement • Image Restoration • Image Segmentation • Image Compression • Digital Video Processing • Motion Estimation • Visual Scene Analysis

14.	Detailed Contents	
Module no.	**Topic**	**No. of hours**
1.	**Fundamentals of Image Processing:** Introduction, Image sampling, Quantization, Resolution, Image file formats, Elements of image processing system, Applications of Digital image processing.	3
2.	**Image Enhancement:** Spatial domain methods: Histogram processing, Fundamentals of Spatial filtering, Smoothingspatial filters, Sharpening spatial filters. Frequency domain methods: Basics of filtering in frequency domain, image smoothing, image sharpening, Selective filtering.	6
3.	**Image Restoration:** Introduction to Image restoration, Image degradation, Types of image blur, Classification of image restoration techniques, Image restoration model, Linear and Nonlinear image restoration techniques.	5
4.	**Image Segmentation:** Introduction to image segmentation, Point, Line and Edge Detection, Region based segmentation., Classification of segmentation techniques, Region approach to image segmentation, clustering techniques, Image segmentation based on thresholding, Edge based segmentation	6
5.	**Image Compression:** Introduction, Need for image compression, Redundancy in images, Classification of redundancy in images, image compression scheme, Classification of image compression schemes, Image compression standard, JPEG Standards.	5
6.	**Basic Steps of Video Processing:** Analog Video, Digital Video. Time-Varying Image Formation models: Three-Dimensional Motion Models, Geometric Image Formation, Photometric Image Formation, Sampling of Videosignals, Filtering operations	6
7.	**2-D Motion Estimation:** Optical flow, General Methodologies, Pixel Based Motion Estimation, Block Matching Algorithm, Mesh based Motion Estimation, Global	6

	Motion Estimation, Region based Motion Estimation.	
8.	**Visual scene analysis:** Basics of background modeling and foreground detection connected component labeling, shot boundary detection	5
	Total Lecture hours	**42**

15. Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief description of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

- Digital Image Processing – Gonzaleze and Woods, 3rdEd., Pearson.
- Digital Video Processing – M. Tekalp, Prentice Hall International.
- S. Jayaraman, S. Esakkirajan and T. VeeraKumar, "Digital Image processing, TataMcGraw Hill publishers, 2009

Reference materials:

- Digital Image Processing (3rd Edition) by Willam K. Pratt, John Willey & Sons

- Anil K. Jain, Fundamentals of Digital Image Processing", Pearson Education, Inc., 2002.
- Alan C. Bovik, "Handbook of image and video processing" Elsevier Academic press, 2005.
- Thomas. B. Moeslund, "Introduction to Video and Image Processing", Springer, 2012

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Any tool for computer programming and graphical representation of results
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

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

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 21 December 2021 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Center for Artificial Intelligence and Machine Learning		
2.	Course Title	**Machine Learning**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Institute Core			

Institute Core for all UG programs	NA
Programme Linked Core for:	All PG Executive Students
Departmental Core for:	NA
Departmental Elective for:	
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA
Programme Core for:	NA
Programme Elective for:	NA
Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	Once in every year
9.	**Faculty who will teach the course**: TBD	

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): Machine learning is a field of scientific study concerned with algorithmic techniques that enable machines to learn performance on a given task via the discovery of patterns or regularities in exemplary data. Consequently, its methods commonly draw upon a statistical basis in conjunction with the computational capabilities of modern computing hardware. This course aims to acquaint the student with the main branches of machine learning and provide a thorough introduction to the most widely used approaches and methods in this field.

12.	**Course outcomes** (about 100 words): By the end of this course, students should: ● Know different machine learning model classes. ● Comprehend the difference between supervised, unsupervised, and reinforcement learning methods. ● Understand common machine learning models. ● Analyze trade-offs in the application of different models. ● Appropriately choose machine learning models according to a given task.

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): ● Introduction to Machine Learning ● Clustering ● Regression ● Support Vector Machines ● Decision Trees ● Genetic Algorithms

	Detailed Contents	
Module no.	Topic	No. of hours
	Introduction to Machine Learning ● Learning Hypothesis ● Data Representation and Pre-processing ● Types of Learning: Supervised, Unsupervised Learning, Semi-supervised ● Reinforcement Learning ● Regression, Classification, Clustering ● Metrics for accuracy: Precision, Recall, F1-score, total accuracy, MSE, MAPE etc. ● Data Split and Data Pre-processing, cross-validation and parameter tuning	6
	Challenges in Learning ● PAC - learning ● Bias and Variance ● Data Representation and Pre-processing	4
	Supervised Learning ● Linear Regression, Non-Linear Regression, Regularization, Quantile and multivariate, Optimization (Gradient Descent (GD)) and Closed form solutions ● Logistic Regression (LogReg), LogReg with Regularization ● Bayesian and Naive Bayes Classification ● Support Vector Machine (linear, non-linear (kernel)) and Support Vector Regression (linear, non-linear (kernel)), Various optimisation schemes (SMO, GD etc) ● Decision Tree, Random Forest ● Neural Network	20
	Unsupervised Clustering ● Introduction to clustering ● K-Means ● Expectation Maximization ● DBScan ● Hierarchical Clustering	10

	Hyper-parameter optimisation ● Grid search ● Random Search	2
	Total Lecture hours	42

Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief description of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

1.Patterson D.W, Introduction to AI and Expert Systems, Mc GrawHill (1998).
2. Bishop C., Pattern Recognition and Machine Learning, Springer-Verlag (2006).

Reference materials:

Supplementary reading material and other resources may be provided in class throughout the semester.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Any tool for computer programming and graphical representation of results
20.2	Hardware	NA
20.3	Teaching aids (videos, etc.)	Videos, Course Material, Handouts.
20.4	Laboratory	NA
20.5	Equipment	NA
20.6	Classroom infrastructure	NA
20.7	Site visits	NA
20.8	Others (please specify)	

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

21.1	Design-type problems	NA
21.2	Open-ended problems	NA
21.3	Project-type activity	Industry Oriented Projects (14 hrs)
21.4	Open-ended laboratory work	NA
21.5	Others (please specify)	

Date: 21 December 2021 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Center for Artificial Intelligence and Machine Learning		
2.	Course Title	**Deep Learning**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Institute Core			

Institute Core for all UG programs	NA
Programme Linked Core for:	All PG Executive Students
Departmental Core for:	NA
Departmental Elective for:	
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA
Programme Core for:	NA
Programme Elective for:	NA
Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	
9.	**Faculty who will teach the course**: TBD	

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): Neural networks and deep learning approaches have revolutionized the fields of data science and artificial intelligence in recent years, and applications built on these techniques have reached or surpassed human performance in many specialized applications. After a short review of the origins of neural networks and deep learning, this course will cover the most common neural network architectures and discuss in detail how neural networks are trained using dedicated data samples, avoiding common pitfalls such as overtraining. The course includes a detailed overview of alternative methods to train neural networks and further network architectures which are relevant in a wide range of specialized application scenarios.

12.	**Course outcomes** (about 100 words): By the end of this course, students should: • Comprehend the fundamental building blocks of neural networks. • Understand concepts in deep learning. • Analyze the relevant deep learning architecture in a wide range of application scenarios. • Create deep learning models. • Utilize alternative methods to train deep learning models.

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): • Introduction to Deep Learning and Neural Networks • Perceptron and Multi-Layer Perceptrons

	• Multi-layered Neural Networks • Artificial Neural Networks • Restricted Boltzmann Machines (RBM) • Different Training Methods • Deep learning libraries • Deploying Machine Learning Models on Cloud (MLOps)

	Detailed Contents	
Module no.	Topic	No. of hours
	Introduction to Deep Learning and Neural Networks • Introduction to Machine Learning ○ Supervised Machine Learning ○ Unsupervised Machine Learning ○ Reinforcement Learning ○ Learning Concepts (PAC) ○ Bias & Variance • Applications and History of Deep Learning	4
	Perceptron and Multi-Layer Perceptron • ANN(Multi-layer perceptron) • Neurons • Weights • Connectivity and Logic Gates • Activation Function • NN Model building • Loss Function • NN Architecture • Perceptron Model and Optimization using Gradient Descent	6

	• Regularization	
	Multi-layered Neural Networks (Architecture & Training) • Feed Forward and Backpropagation NN • Dense Neural Networks • Convolution Networks • Recurrent Networks • Memory Cells • LSTMs • GRUs • Basics for Weight Initialization and Transfer Function, Batch Normalization, Gradient Checking	12
	Popular and State-of-the-art Models • Working of RBM and Implementation • AlexNet, VGG16, Inception, Xception etc. • Auto-encoders (AE), Variational AE • Generative Adversarial Networks	6
	Deep learning libraries (Usage and Applications) • Tensorflow and Keras • PyTorch	10
	Deploying Machine Learning Models on Cloud (MLOps) • Introduction to MLOPS • Process of MLOPS • Why Mlops? • AZURE Machine Learning	4
	Total Lecture hours	**42**

Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief dDescription of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

1.Ian Goodfellow and Yoshua Bengio and Aaron Courville, "Deep Learning", MIT Press, 2016.

2.François Chollet, Deep Learning with Python, Manning Publications, 2017.

Reference materials:

1. https://www.coursera.org/specializations/deep-learning

Journals/Coneferences:

AAAI, ICML, ICDM, KDD, IJCAI, UAI, NIPS, JMLR, ACL, PRL, JoML etc. tensorflow.org, sk-learn, eras, NLTK, Mallet, mathworks.com , LaTex, Caffe, PyTorch

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	NA
20.2	Hardware	NA
20.3	Teaching aids (videos, etc.)	Videos, course material, handouts.
20.4	Laboratory	NA
20.5	Equipment	NA
20.6	Classroom infrastructure	NA
20.7	Site visits	NA
20.8	Others (please specify)	

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

21.1	Design-type problems	NA
21.2	Open-ended problems	Industry Oriented Projects (14 hrs)
21.3	Project-type activity	NA
21.4	Open-ended laboratory work	NA
21.5	Others (please specify)	

Date: 15th Jan 2022 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Center for Artificial Intelligence and Machine Learning		
2.	Course Title	**Internet of Things**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Elective			

Institute Core for all UG programs	NA
Programme Linked Core for:	All PG Executive Students
Departmental Core for:	NA
Departmental Elective for:	MS for Working Professionals in Artificial Intelligence and Machine Learning
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA
Programme Core for:	NA
Programme Elective for:	NA
Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	
9.	**Faculty who will teach the course**:	

10.	**Will the course require any visiting faculty?**	No

11.	**Course objectives** (Why should one study this course?) (about 100 words): The course will provide an introduction to internet of things (IoT), system architecture, and related terminologies. The course also introduces hardware boards for developing prototypes. Towards the end, case studies will be presented.

12.	**Course outcomes** (about 100 words): By the end of this course, students should: • Be able to describe IoT elements and architecture • Be able to choose appropriate protocol and method for IoT communication • Be able to apply the protocols for application development

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): • Introduction to IoT • IoT Architecture • Communication Protocols for IoT • Cloud and Security for IoT • Case studies

14.	Detailed Contents	
Module	Topic	No. of hours
1.	Introduction to IoT components: Characteristics IoT sensor nodes, Edge computer, cloud and peripheral cloud, single board computers, open source hardwares, Examples of IoT infrastructure	10
2.	Point-to-point Communication: IoT Communication Pattern, IoT protocol Architecture, Wireless technologies: 6LoWPAN, Zigbee, WIFI, BT, BLE, SIG, NFC, LORA, Lifi.	8
3.	Towards Cloud: IoT Evolution of Cloud Computation, Commercial clouds and their features, open source IoT platforms, cloud dashboards, IoT Server Client Setup	8
4.	IoT Security: Need for encryption, standard encryption protocol, lightweight cryptography, Quadruple Trust Model for IoT	8
5.	Case Studies: IoT for smart cities, health care, agriculture, Smart Grid, Web of things, Cellular IoT, Industrial IoT, Current Trends.	8
	Total Lecture hours	42

15. Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief description of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

Suggested texts and reference materials:

1. Alessandro Bassi, Martin Bauer, Martin Fiedler, Thorsten Kramp, Rob van Kranenburg, Sebastian Lange, Stefan Meissner, "Enabling things to talk – Designing IoT solutions with the IoT Architecture Reference Model", Springer Open, 2016 2.
2. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, "From Machine to Machine to Internet of Things", Elsevier Publications, 2014.

Reference materials:

1. LuYan, Yan Zhang, Laurence T. Yang, Huansheng Ning, The Internet of Things: From RFID to the Next-Generation Pervasive Network, Aurbach publications, March,2008.
2. Vijay Madisetti , Arshdeep Bahga, Adrian McEwen (Author), Hakim Cassimally "Internet of Things A Hands-on-Approach" Arshdeep Bahga & Vijay Madisetti, 2014.
3. Asoke K Talukder and Roopa R Yavagal, "Mobile Computing," Tata McGraw Hill, 2010. 4 Barrie Sosinsky, "Cloud Computing Bible", Wiley-India, 2010.
4.

Supplementary reading material and other resources may be provided in class throughout the semester.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Any tool for computer programming and graphical representation of results
20.2	Hardware	Ardunio, Raspberry Pi, PHYCOM Boards,
20.3	Teaching aids (videos, etc.)	Videos, Course Material, Handouts.
20.4	Laboratory	NA
20.5	Equipment	NA
20.6	Classroom infrastructure	NA
20.7	Site visits	NA
20.8	Others (please specify)	

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

21.1	Design-type problems	NA
21.2	Open-ended problems	NA
21.3	Project-type activity	Industry Oriented Projects (14 hrs)
21.4	Open-ended laboratory work	NA
21.5	Others (please specify)	

Date: 21 December 2021 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Center for Artificial Intelligence and Machine Learning		
2.	Course Title	**Databases & SQL Scripting**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Elective			

Institute Core for all UG programs	NA
Programme Linked Core for:	All PG Executive Students
Departmental Core for:	NA
Departmental Elective for:	
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA
Programme Core for:	NA
Programme Elective for:	NA
Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	Once in every year
9.	**Faculty who will teach the course**: TBD	

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): As data collection has increased exponentially, so has the need for people skilled at using and interacting with data; to be able to think critically, and provide insights to make better decisions and optimize their businesses. To work with data, we need to extract it from the database. This is where SQL comes into the picture. Relational Database Management is a crucial part of Data Science. This course is designed to give you a primer in the fundamentals of SQL and working with data so that you can begin analyzing it for data science purposes. You will begin to ask the right questions and come up with good answers to deliver valuable insights for your organization. This course starts with the basics and assumes you do not have any knowledge or skills in SQL. It will build on that foundation and gradually have you write both simple and complex queries to help you select data from tables. You'll start to work with different types of data like strings and numbers and discuss methods to filter and pare down your results.

12.	**Course outcomes** (about 100 words): By the end of this course, students should: • Identify SQL architecture, client/server relation, and database types • Deploy several functions, operators, etc. for designing relational databases • Modify data using T-SQL, views, and stored procedures • Understand concept of triggers and their creation • Utilize records for searching, sorting, indexing, and grouping • Implement Database administration, types, and SQL Server tools and services • Backup and restore databases

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): • Introduction to SQL & RDBMS • Database normalization and entity-relationship model • SQL operators • Working with SQL: Join, tables, and variables • Deep dive into SQL • Functions

	• Working with Sub-queries • SQL views, functions, and stored procedures

	Detailed Contents	
Module no.	Topic	No. of hours
	Introduction to SQL & RDBMS and Installation • Various types of databases • Introduction to Structured Query Language • Distinction between client server and file server databases • Understanding SQL Server Management Studio • SQL Table basics • Data types and functions • Transaction-SQL • Authentication for Windows • Data control language • Identification of the keywords in T-SQL (such as Drop Table)	5
	Database normalization and entity-relationship model • Entity-Relationship Model • Entity and Entity Set • Attributes and types of Attributes • Entity Sets • Relationship Sets • Degree of Relationship • Mapping Cardinalities, One-to-One, One-to-Many, Many-to-one, Many-to-many • Symbols used in E-R Notation • Normalization and functional Dependencies: 1NF, 2NF, 3NF, boyce codd NF, 4NF and 5NF	8
	SQL operators • Introduction to relational databases • Fundamental concepts of relational rows, tables, and columns • Several operators (such as logical and relational), constraints, domains,	3

	indexes, stored procedures, primary, foreign and unique keys • Understanding group functions	
	Working with SQL: Join, tables, and variables • Advanced concepts of SQL tables • SQL functions • Operators & queries • Table creation • Data retrieval from tables • Combining rows from tables using inner, outer, cross, and self joins • Deploying operators such as 'intersect,' 'except,' 'union,' • Temporary table creation • Set operator rules • Table variables	4
	Functions/Procedures in SQL • Understanding SQL functions – what do they do? • Scalar functions • Aggregate functions • Functions that can be used on different datasets, such as numbers, characters, strings, and dates • Inline SQL functions • General functions • Duplicate functions	4
	Sub-queries in SQL • Understanding SQL subqueries, their rules • Statements and operators with which subqueries can be used • Using the set clause to modify subqueries • Understanding different types of subqueries, such as where, select, insert, update, delete, etc. • Methods to create and view subqueries	4
	SQL views, functions, and stored procedures • Learning SQL views • Methods of creating, using, altering, renaming, dropping, and modifying views • Understanding stored procedures and their key benefits • Working with stored procedures	3

	• Studying user-defined functions • Error handling	
	User-defined Functions (UDF) and Triggers • User-defined functions and rank • Types of UDFs, such as scalar • Inline table value • Multi-statement table • Stored procedures and when to deploy them • Triggers and usage	3
	SQL Optimization and Performance • Records grouping, advantages, searching, sorting, modifying data • Clustered indexes creation • Use of indexes to cover queries • Common table expressions • Index guidelines	3
	SQL interfacing with Python • Python as front end • Examples	3
	No-SQL Concepts and Usage • Large datasets • Querying using No-SQL	2
	Total Lecture hours	**42**

Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0

Total Tutorial hours (0 times 'T')	

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief description of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

1. Database Systems Design, Implementation, & Management by Carlos Coronel Steven Morris
2. Database Management Systems by Raghu Ramakrishnan, Johannes Gehrke

3. An Introduction to Database Systems By C. J. Date

Reference materials:

Supplementary reading material and other resources may be provided in class throughout the semester.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	MS-SQL
20.2	Hardware	NA

20.3	Teaching aids (videos, etc.)	Videos, course material, handouts.
20.4	Laboratory	NA
20.5	Equipment	NA
20.6	Classroom infrastructure	NA
20.7	Site visits	NA
20.8	Others (please specify)	

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

21.1	Design-type problems	NA
21.2	Open-ended problems	NA
21.3	Project-type activity	Industry Oriented Projects (14 hrs)
21.4	Open-ended laboratory work	NA
21.5	Others (please specify)	

Date: 21 December 2021 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Center for Artificial Intelligence and Machine Learning		
2.	Course Title	**Speech & Audio Processing**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Elective			

Institute Core for all UG programs	NA
Programme Linked Core for:	All PG Executive students
Departmental Core for:	NA
Departmental Elective for:	
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA
Programme Core for:	NA
Programme Elective for:	NA
Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	Once in every Quarter
9.	**Faculty who will teach the course**: TBD	

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): You will become familiar with sequence models and their exciting applications such as speech recognition, music synthesis, chatbots, machine translation, natural language processing (NLP), and more. You will learn to build and train Recurrent Neural Networks (RNNs) and commonly-used variants such as GRUs and LSTMs;

12.	**Course outcomes** (about 100 words): By the end of this course, students should: ◆ Able to learn Natural Language Processing, Long Short Term Memory (LSTM), Gated Recurrent Unit (GRU), Recurrent Neural Network, Attention Models ◆ How to apply RNNs to Character-level Language Modeling; ◆ gain experience with natural language processing and Word Embeddings

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): ◆ **Introduction to Audio Signal Processing** ◆ **Recurrent Neural Networks** ◆ **Natural Language Processing & Word Embeddings** ◆ **Sequence Models & Attention Mechanism**

14.	Detailed Contents	
Module no.	Topic	No. of hours
◆	**Introduction to Tools for Audio Signal Processing** ◆ Basic mathematics	2

	• Introduction to Audacity • Introduction to SonicVisualizer • Introduction to sms-tools • Introduction to Python • Python and sounds • sms-tools software	
	Speech Production Mechanism & Features Computation via Short Time Fourier Transfrom, DCT, Wavelet Transform	5
	LPC Modeling and Coding : Pitch computation from LPC modeling and Speech Coding. Frequency Domain Pitch detection algorithms	8
	Time Frequency Analysis : Detail Analysis of STFT and its relationship with Bank of Modulators and Low Pass Filters, Frequency Resolution Analysis for various Wndows, Detailed Analysis of Wavelet Transform and its relationship with STFT.	6
•	**Segmental and Supra-segmental features of speech Signal : Cepstral Transform co-efficients parameter extraction, Mel frequency Cepstral Coefficients, Mel feature vectors,**	7
•	**Statistical Modeling of speech signal : GMM Modeling, HMM Modeling, Expectation and Maximization Approach for parameter estimation**	6
•	**Text to Speech Synthesis, Automatic Speech Recognition (Speech to Text) using HMM, Sphinx etc, Speech based technology development for e-learning (Application of Speech Processings)**	8
	Total Lecture hours	**42**

15. Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief description of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

Reference materials:

Supplementary reading material and other resources may be provided in class throughout the semester.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	NA
20.2	Hardware	NA
20.3	Teaching aids (videos, etc.)	Videos, course material, handouts.
20.4	Laboratory	NA
20.5	Equipment	NA
20.6	Classroom infrastructure	NA
20.7	Site visits	NA
20.8	Others (please specify)	

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

21.1	Design-type problems	NA
21.2	Open-ended problems	NA
21.3	Project-type activity	Industry Oriented Projects (14 hrs.)
21.4	Open-ended laboratory work	NA

21.5	Others (please specify)	

Date: 13 January 2022 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Center for Artificial Intelligence and Machine Learning		
2.	Course Title	**Computer Vision**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Elective			

Institute Core for all UG programs	NA
Programme Linked Core for:	All PG Executive students
Departmental Core for:	NA
Departmental Elective for:	
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA
Programme Core for:	NA
Programme Elective for:	NA
Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Image and Video Processing

8.	**Frequency of offering**	Once in every Quarter
9.	**Faculty who will teach the course**: TBD	

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): To introduce the student to computer vision algorithms, methods and concepts which will enable the student to implement computer vision systems with emphasis on applications and problem solving.

12.	**Course outcomes** (about 100 words): By the end of this course, students should:

	◆ Understand the mission of making computers see and interpret the world as humans do ◆ Understand what computer vision is and its goals ◆ Identify some of the key application areas of computer vision ◆ Understand the digital imaging process ◆ Apply mathematical techniques to complete computer vision tasks

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): This course is a broad introduction to computer vision. Topics include camera models, multi-view geometry, reconstruction, some low-level image processing, and high-level vision tasks like image classification and object detection

14.	Detailed Contents	
Module no.	Topic	No. of hours
1	**Introduction to Computer Vision:** Overview and State-of-the-art, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing.	6
2	**Camera Geometry and Depth View:** Perspective, Binocular Stereopsis: Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration.	8
3	**Visual Features:** Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, GLCM, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT.	8
4	**Segmentation:** Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection.	6
5	**Motion Analysis:** Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.	8
6	**Recognition:** Patterns & pattern classification, Recognition based on decision theoretic methods, Structural methods	4

7	**Application of Computer Vision**	2
	Total Lecture hours	**42**

15. Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief description of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

Text Book:

Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011.

D. A. Forsyth, J. Ponce, Computer Vision: A Modern Approach, Pearson Education, 2003.

Reference materials:

R.C. Gonzalez and R.E. Woods, Digital Image Processing, Addison- Wesley, 1992.

A. Zisserman and R. Hartley, Multiple View Geometry in Computer Vision, 2/e, Cambridge University Press, 2004.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	NA
20.2	Hardware	NA
20.3	Teaching aids (videos, etc.)	Videos, course material, handouts.
20.4	Laboratory	NA
20.5	Equipment	NA
20.6	Classroom infrastructure	NA
20.7	Site visits	NA
20.8	Others (please specify)	

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

21.1	Design-type problems	NA
21.2	Open-ended problems	NA
21.3	Project-type activity	Industry Oriented Projects (14 hrs.)
21.4	Open-ended laboratory work	NA
21.5	Others (please specify)	

Date: 13 January 2022 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Center for Artificial Intelligence and Machine Learning		
2.	Course Title	**Big Data Engineering using Apache Spark**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Elective			

Institute Core for all UG programs	NA
Programme Linked Core for:	All PG Executive students
Departmental Core for:	NA
Departmental Elective for:	
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA

Programme Core for:	NA
Programme Elective for:	NA
Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	Once in every Quarter
9.	**Faculty who will teach the course**: TBD	

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): Data are often considered the “new oil”, the raw material from which value is created. To harness the power of data, the data need to be stored and processed on a technical level. This course introduces the four “Vs” of data, as well as typical data sources and types, storing of data in HDFS & no-sql. Particular focus is given to database structures and different types of databases, e.g., relational, Nosql. Learn how the modern frameworks like Apache Spark & HDFS helps in solving complex problems like high volume data processing and high volume data storage. How to work with live streaming of huge data (Twitter or any other API) for data processing in real time. Learn how to use Apache spark in machine learning applications using MLlib.

12.	**Course outcomes** (about 100 words): By the end of this course, students should:

	• **Identify different types and sources of data.** • **Understand different database concepts.** • **Learn to build new database structures.** • **Evaluate various data storage frameworks w.r.t. Project requirements.** • **Analyze which data format to use for a given project.** • **Understand what roles you could take in such projects.** • **Create a distributed computing environment for a given project.** • **Understand the ethical impact of big data technology choices.**

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): • **Working with Big Data Tools and technology** • **Introduction to Spark** • **Spark Basics** • **Working with RDDs in Spark** • **Aggregating Data with Pair RDDs** • **Writing and Deploying Spark Applications** • **Parallel Processing** • **Spark RDD Persistence** • **Spark MLlib** • **Integrating Apache Flume and Apache Kafka** • **Spark Streaming** • **Improving Spark Performance** • **Spark SQL and Data Frames** • **Scheduling/Partitioning**

	Detailed Contents	
Modu		

le no.	Topic	No. of hours
	Working with Big Data Tools and technology • 4 V's of Big Data • Different data types, HDFS, • MapReduce Brief • Architecture.Working with Apache Spark	2
	Hadoop Framework • Hadoop Framework (Installation single/multi-node) • Data format and movement • Map-Reduce for Hadoop • Applications	4
	Introduction to Spark • Introduction to Spark • Spark overcomes the drawbacks of working on MapReduce • Understanding in-memory MapReduce • Interactive operations on MapReduce • Spark stack, fine vs. coarse-grained update, Spark Hadoop YARN, HDFS • Revision, and YARN Revision • The overview of Spark and how it is better than Hadoop • Deploying Spark without Hadoop • Spark history server and Cloudera distribution	2
	Spark Basics • Spark installation guide • Spark configuration • Memory management • Executor memory vs. driver memory • Working with Spark Shell • The concept of resilient distributed datasets (RDD)	3

	• Learning to do functional programming in Spark • The architecture of Spark	
	Working with RDDs in Spark • Spark RDD • Creating RDDs • RDD partitioning • Operations and transformation I • Deep dive into Spark RDDs • The RDD general operations • Read-only partitioned collection of records • Using the concept of RDD for faster and efficient data processing • RDD action for the collect, count, collects map, save-as-text-files, and pair RDD functions	4
	Aggregating Data with Pair RDDs • Understanding the concept of key-value pair in RDDs • Learning how Spark makes MapReduce operations faster • Various operations of RDD • MapReduce interactive operations • Fine and coarse-grained update • Spark stack	3
	Writing and Deploying Spark Applications • Comparing the Spark applications with Spark Shell • Creating a Spark application using Scala or Java • Deploying a Spark application • Scala built application	3

	• Creation of the mutable list, set and set operations, list, tuple, and concatenating list • Creating an application using SBT • Deploying an application using Maven • The web user interface of Spark application • A real-world example of Spark • Configuring of Spark	
	Parallel Processing • Learning about Spark parallel processing • Deploying on a cluster • Introduction to Spark partitions • File-based partitioning of RDDs • Understanding of HDFS and data locality • Mastering the technique of parallel operations • Comparing repartition and coalesce • RDD actions	3
	Spark RDD Persistence • The execution flow in Spark • Understanding the RDD persistence overview • Spark execution flow, and Spark terminology • Distribution shared memory vs. RDD • RDD limitations • Spark shell arguments • Distributed persistence	3

	• RDD lineage • Key-value pair for sorting implicit conversions like CountByKey, ReduceByKey, SortByKey, and AggregateByKey	
	Spark Mllib • Introduction to Machine Learning • Types of Machine Learning • Introduction to Mllib • Various ML algorithms supported by Mllib • Linear regression, logistic regression, decision tree, random forest, and K-means clustering techniques	5
	Integrating Apache Flume and Apache Kafka • Why Kafka and what is Kafka? • Kafka architecture • Kafka workflow • Configuring Kafka cluster • Operations • Kafka monitoring tools • Integrating Apache Flume and Apache Kafka	2
	Spark Streaming • Introduction to Spark Streaming • Features of Spark Streaming • Spark Streaming workflow • Initializing StreamingContext, discretized Streams (DStreams), input DStreams and Receivers • Transformations on DStreams, output operations on DStreams, windowed	2

	operators and why it is useful • Important windowed operators and stateful operators	
	Spark SQL and Data Frames • Learning about Spark SQL • The context of SQL in Spark for providing structured data processing • JSON support in Spark SQL • Working with XML data • Parquet files • Creating Hive context • Writing data frame to Hive • Reading JDBC files • Understanding the data frames in Spark • Creating Data Frames • Manual inferring of schema • Working with CSV files • Reading JDBC tables • Data frame to JDBC • User-defined functions in Spark SQL • Shared variables and accumulators • Learning to query and transform data in data frames • Data frame provides the benefit of both Spark RDD and Spark SQL • Deploying Hive on Spark as the execution engine	6
	Total Lecture hours	**42**

Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief description of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

1. Donald Miner and Adam Shook: MapReduce Design Patterns, O'Reilly Media

2. Tom White: Hadoop Definitive Guide, O'Reilly Media

3.Holden Karau, Andy Konwinski, Patrick Wendell, Matei Zaharia: Learning Spark: Lightning-Fast Big Data Analysis

Reference materials:

Supplementary reading material and other resources may be provided in class throughout the semester.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Apache Spark,
20.2	Hardware	NA
20.3	Teaching aids (videos, etc.)	Videos, course material, handouts.
20.4	Laboratory	NA
20.5	Equipment	NA
20.6	Classroom infrastructure	NA
20.7	Site visits	NA
20.8	Others (please specify)	

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

21.1	Design-type problems	NA
21.2	Open-ended problems	NA
21.3	Project-type activity	Industry Oriented Projects (14 hrs.)
21.4	Open-ended laboratory work	NA
21.5	Others (please specify)	

Date: 13 January 2022 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Center for Artificial Intelligence and Machine Learning		
2.	Course Title	**Artificial Intelligence for Biomedicals**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		
6.	Course Status (Course Category for Program): Elective			

Institute Core for all UG programs	NA
Programme Linked Core for:	All PG Executive Students
Departmental Core for:	NA

Departmental Elective for:	
Minor Area / Interdisciplinary Specialization Core for:	
Minor Area / Interdisciplinary Specialization Elective for:	NA
Programme Core for:	NA
Programme Elective for:	NA
Open category Elective for all other programs (No if Institute Core)	

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	
9.	**Faculty who will teach the course**: TBD	

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): Artificial intelligence (AI) has transformed industries around the world, and has the potential to radically alter the field of healthcare. Imagine being able to analyse data on patient visits to the clinic, medications prescribed, lab tests, and procedures performed, as well as data outside the health system -- such as social media, purchases made using credit cards, census records, Internet search activity logs that contain valuable health information, and you'll get a sense of how AI could transform patient care and diagnoses. In this course, we'll discuss the current and future applications of AI in healthcare with the goal of learning to bring AI technologies into the clinic safely and ethically.

12.	**Course outcomes** (about 100 words): By the end of this course, student should be able to: • Understand how AI can be used to innovate and improve the Medical related applications. • Implement Model Building. • Implement different Machine Learning Techniques and Algorithms. • Image classification and segmentation models to make diagnoses of lung and brain disorders.

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): • **Problems and challenges in Biomedical** • **Introduction to Artificial Intelligence** • **Basics of Learning** • **Disease detection** • **Applications of AI in solving Medical problems.**

	Detailed Contents	
Module no.	Topic	No. of hours
	Problems in Bio-Medical • Disease Diagnosis • Disease Progression Inferencing/Montoring • Gene Expression data analysis • Protein Structure Prediction • Learning Rules For Biological Data • Inferencing using Mining Biological Data	4

	• Image Data analysis (X-ray/MRI/CT-scan etc.):Classification and Segmentation	
	Challenges in Bio-Medical Domain • Availability of data • Class imbalance, missing values • Privacy and ethics (Anonymization) • Bias and Inequality (data) • Real-time deployment	3
	Introduction to Artificial Intelligence • Introduction and problem representation • Searching and fuzziness (with Application) • Learning strategies (objectives and constraints) • Supervised, Unsupervised and Semi-supervised • Vector Space representation • Feature extraction and understanding	6
	Problem Representation for AI • Pre-processing: Noise Removal, Normalization • Feature extraction • Vector representation	3
	Learning Methods for Bio-medical problems • Loss functions, Accuracy metrics • Classification: Bayesian, Hidden Markov Model, Logistic Reg with Regularization, Support Vector Machine (linear & non-linear), Decision Tree, Random Forest, Neural Network (NN) • Regression: Linear Regression and Variants, Support Vector Regressor, NN based models • Clustering • Applications of Deep layered NN in problem solving □ Dense Layer NN (Fully Connected)	16

	▫ Recurrent NN and Variants (for Sequence data) ▫ Convolutional NN (for Image data)	
	Problem solving using the learning Methods (Experiments) • Medical Image Diagnosis: classification, segmentation • Clinical data analysis • Eye Disease and Cancer Diagnosis • Protein Structure Prediction • Analysis of Gene Expression Data	10
	Total Lecture hours	**42**

Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief dDescription of module-wise activities pertaining to self-learning component
(if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

1. Lei Xing, Maryellen L. Giger, James K. Min: Artificial Intelligence in Medicine Technical Basis and Clinical Applications, Elsevier (2020)

2. Janmenjoy Nayak, Bighnaraj Naik, Danilo Pelusi, Asit Kumar Das: Handbook of Computational Intelligence in Biomedical Engineering and Healthcare, Elsevier, 2021

Reference materials:

Supplementary reading material and other resources may be provided in class throughout the semester.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	NA
20.2	Hardware	NA
20.3	Teaching aids (videos, etc.)	Videos, course material, handouts.
20.4	Laboratory	NA
20.5	Equipment	NA
20.6	Classroom infrastructure	NA
20.7	Site visits	NA
20.8	Others (please specify)	

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

21.1	Design-type problems	NA

21.2	Open-ended problems	NA
21.3	Project-type activity	Industry Oriented Projects (14 hrs)
21.4	Open-ended laboratory work	NA
21.5	Others (please specify)	

Date: 21 December 2021 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Center for Artificial Intelligence and Machine Learning		
2.	Course Title	**Advanced Digital Signal Processing**		
3.	L-D-P structure	3-0-0		
4.	Credits	3	Non-graded Units	NA
5.	Course number	To be allotted		

6.	Course Status (Course Category for Program): Elective	
Institute Core for all UG programs		NA
Programme Linked Core for:		All PG Executive Students
Departmental Core for:		NA
Departmental Elective for:		
Minor Area / Interdisciplinary Specialization Core for:		
Minor Area / Interdisciplinary Specialization Elective for:		NA
Programme Core for:		NA
Programme Elective for:		NA
Open category Elective for all other programs (No if Institute Core)		

7.	**Pre-requisite(s)**	Nil

8.	**Frequency of offering**	Once in every year
9.	**Faculty who will teach the course**: TBD	

10.	**Will the course require any visiting faculty?**	Yes

11.	**Course objectives** (Why should one study this course?) (about 100 words): The course will briefly provide the review of signals and systems. It explains about digital filtering which involves design and quantization effects of digital filters. Multirate filterings, Cyclostationarity and LPTV filters and wavelet transform are covered in the course.

12.	**Course outcomes** (about 100 words): By the end of this course, students should: • Analyze the signal in spectral domain • Comprehend the difference between various Digital Domain Transforms like FFT and Z Transforms. • Apply DSP in real time applications like speech and image processing

13.	**Course contents:** (Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):

	• Review of Signal & Systems • design and quantization effects of digital filters • Multirate signal processing • Filter Design • wavelet transforms

14.	Detailed Contents	
Module no.	Topic	No. of hours
1.	○ **Review of Signals and Systems**: This module includes Band Pass Sampling and data reconstruction processes. Z Transform, Definition of Z Transform, Importance of Z transform over Fourier Transform, Properties of Z Transform and Inverse Z Transform. Discrete linear systems.	8
2.	• **Frequency domain design of Digital filters**: This module includes design of FIR and IIR filters in frequency domain.	6
3.	• **Quantization effects in Digital Filters :** This module includes Distribution of Truncation Errors, Quantization of Filter Coefficients and Quantization of Pole Locations. • **Discrete Fourier transform and FFT algorithms**: This module includes definition of DFT and its properties. It also describes the fast computation of DFT which is FFT.	8
4.	• **High speed convolution and its application to digital filtering :** This module includes Theory of Convolution Filters, Approximation to the Filters and Accuracy of the Approximation Filters.	4
5.	◆ **Introduction to Multirate signal processing**: This module deals with decimation and interpolation concepts of sampling theorem. ◆ **Multirate filtering and Filter banks**: This module presents Polyphase decomposition and perfect reconstruction.	4
6.	**Cyclostationarity and LPTV filters :** This module describes Cyclostationary and Linear Periodically Time Varying (LPTV) filters.	4

7.	**Introduction to Speech Signal Processing :** Speech Production Mechanism, LPC Analysis, Speech Features Computation, Short Time Fourier Transform. **Introduction to Wavelet Transform :** This module deals with Wavelet transform, its similarities and differences over Fourier Transform. It also explains its application in speech and audio processing.	6
	Total Lecture hours	42

15. Brief description of tutorial activities (if applicable):

Module no.	Description	No. of hours
	NA	0
Total Tutorial hours (0 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	Hours

18. Brief description of module-wise activities pertaining to self-learning component (if any -Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
1.	

19. Suggested texts and reference materials

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

Suggested texts and reference materials:

1. Discrete-Time Signal Processing, 3/E, Alan V. Oppenheim and Ronald W. Schafer
2. Digital Signal Processing, 3/e, Sanjit K Mitra

Reference materials:

Supplementary reading material and other resources may be provided in class throughout the semester.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Any tool for computer programming and graphical representation of results
20.2	Hardware	NA
20.3	Teaching aids (videos, etc.)	Videos, Course Material, Handouts.
20.4	Laboratory	NA
20.5	Equipment	NA
20.6	Classroom infrastructure	NA
20.7	Site visits	NA
20.8	Others (please specify)	

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

21.1	Design-type problems	NA
21.2	Open-ended problems	NA
21.3	Project-type activity	Industry Oriented Projects (14 hrs)
21.4	Open-ended laboratory work	NA
21.5	Others (please specify)	

Date: 21 December 2021 (Signature of the Head of the Department)

Date of Approval of Template by Senate	

The information on this template is as on the date of its approval, and is likely to evolve with time.