CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TEC100	ADVANCED ENGINEERING MATHEMATICS	DISCIPLINE CORE	3	0	0	3

Preamble: The purpose of this course is to expose students to the basic theory of linear algebra and probability.

Course Outcomes: The COs shown are only indicative. For each course, there can be 4 to 6 COs. After the completion of the course the student will be able to

CO 1	To analyze distributions of random variables and make computations based on that
CO 2	evaluate average behaviour of random variables, and analyze their converging behviours
CO 3	To analyze behaviour of random processes and explain basis of vector spaces.
CO 4	To evaluate properties of linear transformations
CO 5	To evaluate if a linear tranformaion is diagonalizable and decompose it using spectral decomposition theorem.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7
CO 1	3		3		3	3	
CO 2	3		3		3	3	
CO 3	3		3		3	3	
CO 4	3		3		3	3	
CO 5	3		3		3	3	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	20
Evaluate	20
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

- Problem assignments including unsolved exercise problems from reference text books: 20 marks
- Quiz: 10 marks
- Test paper (1 number): 10 marks

Quiz shall include topics from at least 50% of the syllabus. Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

End Semester Examination: 60 marks

There will be two parts; Part A and Part B

- Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions.
- Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY
M.TECH DEGREE EXAMINATION
SEMESTER:
Branch:
ADVANCED ENGINEERING MATHEMATICS

Time: 2.5 Hours **Marks: 60**

Part A

Answer ALL Questions. Each question carries 5 marks

1. Given that $f(x) = \frac{k}{2^x}$ is a probability distribution of a random variable that can take on the values $x = 0,1,2,3,\wedge 4$. Find k. Find the cumulative distribution function.
2. State and prove weak law of large numbers.
3. Show that $(1,3,2,-2),(4,1,-1,3),(1,1,2,0),(0,0,0,1)$ is a basis for R^4.
4. Let $T: V \to W$be a linear transformation defined by $T(x,y,z) = (x+y, x-y, 2x+z)$. Find the range, null space, rank and nullity of T.
5. Describe an inner product space. If V is an inner product space, then for any vectors α, βin V prove that $\|\alpha+\beta\| \leq \|\alpha\| + \|\beta\|$.

Part B
Answer ANY FIVE Questions, one from each module
(5 x 7 marks = 35marks)

6. If the probability mass function of a RV X is given by $P(X = x) = kx^3, x = 1,2,3,4$. Find the value of k, $P\left[\left(\frac{1}{2} < X < \frac{3}{2}\right)/X > 1\right]$,mean and variance of X.
7. If the moment generating function of a uniform distribution for a random variable X is $\frac{1}{t}(e^{5t} - e^{4t})$.Find E(X).
8. Consider the Markov chain with three states, s={1,2,3} that has the following transition matrix $P = \begin{bmatrix} \frac{1}{2} & \frac{1}{4} & \frac{1}{4} \\ \frac{1}{3} & 0 & \frac{2}{3} \\ \frac{1}{2} & \frac{1}{2} & 0 \end{bmatrix}$ Draw the state diagram for the chain. If $P(X_1 = 1) = P(X_2 = 2) = \frac{1}{4}$, find $P(X_1 = 3, X_2 = 2, X_3 = 1)$.

9. Find the eigen values and eigen vectors of $A = \begin{bmatrix} 2 & 2 & 1 \\ 1 & 3 & 1 \\ 1 & 2 & 2 \end{bmatrix}$.

10. Find the least square solution to the equation $Ax = b$, where $A = \begin{bmatrix} 1 & 2 \\ 1 & 3 \\ 0 & 0 \end{bmatrix}$ and $b = \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix}$, Obtain the projection matrix P which projects b on to the column space of A.
11. Let T be the linear transformation from R^3 to R^2 defined by T(x,y,z) =(x+y, 2z-x). Let B_1, B_2 be standard ordered bases of R^3 and R^2 respectively. Compute the matrix of T relative to the pair B_1, B_2.
12. Let V be a finite-dimensional complex inner product space, and let T be any linear operator on V. Show that there is an orthonormal basis for V in which the matrix of T is upper triangular.

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Syllabus

Module 1 Axiomatic definition of probability. Independence. Bayes' theorem and applications. Random variables. Cumulative distribution function, Probability Mass Function, Probability Density function, Conditional and Joint Distributions and densities, Independence of random variables. Functions of Random Variables: Two functions of two random variables. Pdf of functions of random variables using Jacobian.

Module 2 Expectation, Fundamental theorem of expectation, Moment generating functions, Characteristic function. Conditional expectation. Covariance matrix. Uncorrelated random variables. Pdf of Jointly Gaussian random variables, Markov and Chebyshev inequalities, Chernoff bound. Central Limit theorem. Convergence of random variables. Weak law of large numbers, Strong law of large numbers.

Module 3 Random Processes. Poisson Process, Wiener Process, Markov Process, Birth-Death Markov Chains, Chapman- Kolmogorov Equations,

Groups, Rings, homomorphism of rings. Field. Vector Space. Subspaces. direct sum. Linear independence, span. Basis. Dimension. Finite dimensional vector spaces. Coordinate representation of vectors. Row spaces and column spaces of matrices.

Module 4 Linear Transformations. Four fundamental subspaces of a linear transformation. Rank and Rank-nullity theorem. Matrix representation of linear transformation. Change of basis transformation. System of linear equations. Existence and uniqueness of solutions. Linear functionals. Dual, double dual and transpose of a linear transformation.

Module 5 Eigen values, Eigen vectors, Diagonizability.

Inner product. Norm. Projection. Least-squares solution. Cauchy-Schwartz inequality. Orthonormal bases. Orthogonal complement. Spectral decomposition theorem.

Course Plan

No	Topic	No. of Lectures
	Module I	
1.1	Axiomatic definition of probability. Independence. Bayes' theorem and applications.	2
1.2	Random variables. Cumulative distribution function, Probability Mass Function,	1
1.3	Probability Density function, Conditional and Joint Distributions and densities, Independence of random variables.	2
1.4	Functions of Random Variables: Two functions of two random variables. Pdf of functions of random variables using jacobian.	2
	Module II	
2.1	Expectation, Fundamental theorem of expectation, Conditional expectation.	1
2.2	Moment generating functions, Charectristic function.	1
2.3	Covariance matrix. Uncorrelated random variables. Pdf of Jointly Guassian random variables,	2
2.4	Markov and Chebyshev inequalities, Chernoff bound. Central Limit theorem.	2
2.5	Convergence of random variables. Weak law of large numbers, Strong law of large numbers.	2
3	**Module III**	
3.1	Random Processes. Poisson Process, Wiener Process,	2
3.2	Markov Process, Birth-Death Markov Chains, Chapman-Kolmogorov Equations,	2
3.3	Groups, Rings, homomorphism of rings. Field. Vector Space. Subspaces. direct sum.	2
3.4	Linear independence, span. Basis. Dimension. Finite dimensional vector spaces.	2
3.5	Coordinate representation of vectors. Rowspaces and column spaces of matrices.	1
4	**Module IV**	
4.1	Linear Transformations. Four fundamental subspaces of a linear transformation. Rank and Rank-nullity theorem.	2
4.2	Matrix representation of linear transformation. Change of basis transformation.	1
4.3	System of linear equations. Existence and uniqueness of solutions.	2
4.4	Linear functionals. Dual, double dual and transpose of a linear transformation.	2

5	**Module V**	
5.1	Eigen values, Eigen vectors, Diagonizability.	2
5.2	Inner product. Norm. Projection. Least-squares solution. Cauchy-Schwartz inequality.	2
5.3	Orthonormal bases. Orthogonal complement. Spectral decomposition theorem.	2

Reference Books

1. Hoffman Kenneth and Kunze Ray, Linear Algebra, Prentice Hall of India.

2. Jimmie Gilbert and Linda Gilbert, Linear Algebra and Matrix Theory, Elsevier

3. Henry Stark and John W. Woods "Probability and Random Processes withApplications to Signal Processing", Pearson Education, Third edition.

4. Athanasios Papoulis and S. Unnikrishna Pillai. Probability, Random Variables and Stochastic Processes, TMH

CODE	COURSE	CATEGORY	L	T	P	CREDIT
221TEC003	ADVANCED DIGITAL SIGNAL PROCESSING	PROGRAM CORE 1	3	0	0	3

Preamble: The course is intended to impart comprehensive knowledge in the domain of advanced digital signal processing

Prerequisite: Digital Signal Processing

Course Outcomes: After the completion of the course the student will be able to

CO 1	Assimilate the Non-parametric and parametric methods for spectral estimation
CO 2	Distinguish between forward and backward linear prediction
CO 3	List the utilities of adaptive filters
CO 4	Illustrate the use of Levinson Durbin algorithm for the solution of normal equations
CO 5	Compare and contrast LMS algorithm and RLS Algorithm for Adaptive Direct form FIR filters
CO 6	Develop the efficient realization of QMF filter bank using polyphase decomposition and multirate identities

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	80%
Analyse	20%
Evaluate	-
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

CORE COURSES

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Micro project/Course based project: 20 marks

Course based task/Seminar/ Quiz: 10 marks

Test paper, 1 no: 10 marks The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

M.TECH DEGREE EXAM

221TEC003 ADVANCED DIGITAL SIGNAL PROCESSING

TIME :2.5 HRS **MAX MARKS:60**

PART A

ANSWER ALL QUESTIONS(5*5=25)

1.Prove that the energy density spectrum of a deterministic signal can be obtained from the Fourier transform of that signal?

2.Differentiate between the MDL criterion and CAT criterion towards the selection of an AR Model order?

3.Use the Levinson Durbin algorithm to solve the normal equations recursively for an m-step forward predictor?

4.In adaptive filtering ,iterative schemes are preferred over linear estimations. Justify?

5.Obtain the frequency domain characterization of a sampling rate converter of a rational factor 2 /3 ?

PART B

ANSWER ANY FIVE.EACH QUESTION CARRIES 7 MARKS(7*5=35)

6.With necessary equations ,substantiate the use of the Welch method-Averaging Modified Periodogram for spectrum estimation?

7.Ilustrate, the performance characteristics & Computational requirements of non-parametric methods for spectral estimation?

8.With necessary equations, explain the Yule-Walker method for AR model parameters in the context of parametric spectral estimation?

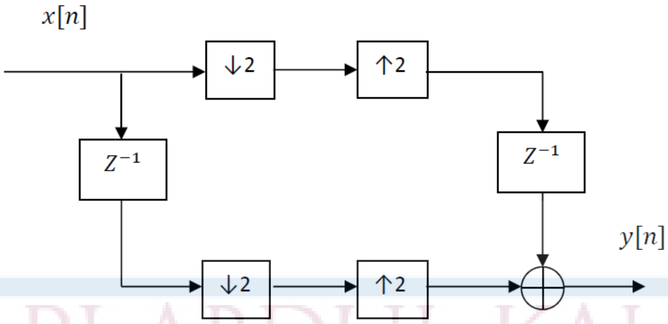
9.Illustrate how Schur Algorithm can be utilized for the Solution of the Normal Equations?

10.Describe an adaptive equalizer using RLS algorithm?

11.What is the PR condition for a filterbank? Design the analysis filter bank for a perfect reconstruction two channel Quadrature Mirror filterbank?

12.a.Realize a 3 band FIR filter of length N=15 using polyphase decomposition?

b.Express the output y[n] of the multirate system given below, as a function of the input x[n].



Syllabus and Course Plan(For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs)

Syllabus

Power spectrum estimation, Non-parametric methods for spectral estimation: Parametric spectral estimation, Linear Prediction and optimum linear filters, Adaptive filters for adaptive channel equalization,adaptive noise cancellation, Adaptive Direct form FIR filters: Multirate Signal Processing, The Polyphase decomposition-Applications to sub band coding, Fourier transform,Short-time(windowed) Fourier transform. The discrete wavelet transform.

Course Plan

No	Topic	No. of Lectures
1	**Power spectrum estimation**	
1.1	Estimation of spectra from finite duration observation of signals: Computation of Energy density spectrum-Estimation of the Autocorrelation and power spectrum of random signals -The periodogram,Use of DFT in power spectrum estimation -	2
1.2	Non-parametric methods for spectral estimation: Barlett method-Averaging Periodogram, Welch method-Averaging Modified Periodogram	3
1.3	Blackman and Tukey Method-Performance characteristics & Computational requirements of non-parametric methods for spectral estimation:	3
2	**Parametric spectral estimation**	
2.1	Parametric spectral estimation: Relationship between Autocorrelation and Model parameters	2
2.2	Yule-Walker method for AR model parameters, Burg method for AR model parameters	3
2.3	Selection of AR model order- MA and ARMA models for power spectrum estimation	4
3	**Linear Prediction and optimum linear filters**	

3.1	Linear Prediction : Forward and Backward Linear Prediction Optimum reflection coefficients for the Lattice Forward and Backward Predictors.	3
3.2	Solution of the Normal Equations: Levinson Durbin Algorithm, Schur Algorithm	3
3.3	Properties of Linear Prediction Filters	2
4	**Adaptive filters**	
4.1	Adaptive filters for adaptive channel equalization,adaptive noise cancellation and Linear Predictive Coding of Speech Signals	3
4.2	Adaptive Direct form FIR filters:Minimum mean square criteria,LMS algorithm	2
4.3	Adaptive Direct form filters:The RLS algorithm,Fast RLS Algorithm,Properties of Direct Form RLS algorithm	3
5	**Multirate Signal Processing**	
5.1	Mathematical description of sampling rate converters- Interpolator and Decimator,Multirate Identities	2
5.2	The Polyphase decomposition-Applications to sub band coding - Two Channel QMF filer bank-PR condition.	3
5.3	Fourier transform,Short-time(windowed) Fourier transform,The discrete wavelet transform-Wavelet- admissibility condition.MRA Axioms,scaling and wavelet function	3

Text books:

1. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing", Pearson Education,India, 2007

2. Monson H. Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley and Sons Inc., New York, 2006.

3. P. Vaidyanathan, "Multirate Systems and Filter Banks", Pearson Education

References:

1. Simon Haykin, "Adaptive Filter Theory", Prentice Hall, Englewood Cliffs, NJ1986.
2.Steven M Kay," Modern spectrum Estimation theory and application", Pearson India,January 2009
3.D.G. Manolakis, V.K. Ingle and S.M. Kogon: Statistical and Adaptive Signal Processing, McGraw Hill, 2000
4.Sophoncles J. Orfanidis, "Optimum Signal Processing ", McGraw-Hill, 2000
5. S K Mitra,"Digital Signal Processing: A computer based approach", Tata-McGraw Hill
4. C S Burrus, R A Gopinath, H. Guo, "Introduction to Wavelets and Wavelet Transforms: A primer", Prentice Hall.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC013	PATTERN ANALYSIS	PROGRAM ELECTIVE 1	3	0	0	3

Preamble : Pattern analysis is the use of machine learning algorithms to identify and categorise patterns. It classifies data based on statistical information or knowledge gained from patterns and their representation. The popular pattern analysis tasks are pattern recognition, classification, clustering and retrival. Students will be able to learn pattern analysis fundamentals, understand the different types of algorithms in pattern analysis, develop in-depth knowledge of pattern analysis tasks such as classification, clustering, matching, retrieval etc.

Prerequisite: A sound knowledge of the fundamentals and basics of probabilty, statistics and algorithms.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand and apply the fundamentals, concepts and terminologies in pattern analysis.
CO 2	Understand and analyse the principles of feature extraction and optimization and illustrate the functionalities of the feature extraction and optimization algorithms.
CO 3	Understand and analyse the principles of supervised models for pattern analysis and illustrate the functionalities of the supervised pattern analysis algorithms.
CO 4	Understand and analyse the principles of unsupervised models for pattern analysis and illustrate the functionalities of the unsupervised pattern analysis algorithms.
CO 5	Create and evaluate critically the domain specific applications of pattern analysis.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	3		3			
CO 2	2	2			2		
CO 3	3	2			2	3	3
CO 4					2	2	2
CO 5	3	3		2			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20 %
Analyse	40 %
Evaluate	20 %
Create	20 %

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed

Original publications (minimum 10 Publications shall be referred): 15 marks

Course based task/Seminar/Data Collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus. include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION, (**Model Question Paper)**

Discipline: ELECTRONICS & COMMUNICATION ENGINEERING

Stream: EC3 (Signal Processing, Signal Processing & Embedded Systems, Communication Engineering & Signal Processing)

Course Code: 221EEC013

Course Name: PATTERN ANALYSIS

Max. Marks: 60 Duration: 2.5Hours

PART A

Answer ALL Questions. Each Question Carries 5 marks.

1	Explain the concept of discriminant functions. Derive the discriminant function for a two class classification problem. Assume patterns are drawn from normal distribution	CO1	
2	Demonstrate dimensionality reduction of feature vectors using Fisher score based method.	CO2	
3	Illustrate with an example, the k- nearest neighbour algorithm for pattern classification. How do you compute the distance between two patterns ?	CO2	
4	With a suitable example demostrate the k-means clustering algorithm. Discuss the significance of silhoutte score to select optimal k.	CO2	
5	What do you mean by out lier detection? Explain an experimental set up for outlier detection from banking transaction data.	CO3	

PART – B

Answer any 5 full questions ; Each question carries 7 marks.

6. a)	The minimum error rate classification can be achieved by the use of discriminant functions $g_i(x) = \ln p(x\|w_i) + \ln P(w_i)$. The densities $p(x\|w_i)$ are assumed to be multivariate Gaussian. Determine the discriminant function for (i) $\Sigma_i = \sigma^2 I$ (ii) $\Sigma_i = \Sigma$ and $\Sigma_i =$ arbitrary. Discuss the nature of decision surface in each case.	5	CO4	

6. b)	Illustrate the working of LDA with a suitable toy dataset. Also explain how predictions are made.	2	CO3	
7.a)	Explain Bayes decision theory. Give expression for Bayes decision rule. Discuss the significance.	3	CO1	
7. b)	Give the expresion for Bayesian decision function. Use Bayes decision rule to find the answer to the following problem: Suppose a drug test is 99% sensitive and 99% specific. That is, the test will produce 99% true positive results for drug users and 99% true negative results for non-drug users. Suppose that 0.5% of people are users of the drug. If a randomly selected individual tests positive, what is the probability that they are a user?	4	CO5	
8.a)	Compare and contrast between the use of DFT and DCT for extracting transform based features from image data.	2	CO2	
8.b)	Discuss the significance of dimensionality reduction. Explain step-by step algorithm for PCA	5	CO4	
9. a)	Discuss gradient descent algorithm used in MLFFNN. Also comment on local and global minimum	3	CO4	
9.b)	Explain the concept of error back propagation learning used in MLFFNN. Obtain the weight updation equation for MLFFNN with one hidden layer.	3	CO1	
9.c)	Compare MLFFNN and perceptron based classifiers for pattern analysis. Comment on the stopping criterion for both.	1	CO2	
10.a)	Explain what do you mean by hard and soft margins. Derive the expression for the margin of separation for SVM.	2	CO1	
10.b)	State the dual problem of optimization for SVM for linearly non-separable patterns. Obtain the equation of optimal hyperplane and optimum weight vectors wo and optimum bias bo for linearly non-separable patterns. Give expression for finding the label of a test example xt.	5	CO3	
11.a)	Discuss the principles of fuzzy of k-means clustering	3	CO1	
11.b)	Illustrate hierarchical clustering for text classification of English sentences. Clearly explain the methodology used for generating feature vectors from sentences, similarity measures selected, formation of similarity matrix and formation of clusters. Also discuss the termination criteria.	4	CO3	
12.a)	List at least 3 pattern analysis tasks that we frequently encounter in our real world life.	3	CO5	

12.b)	Illustrate the functionality of Music Information Retrieval system with neat sketches. Design a MIR system. Explain the functionality of each module.	4	CO5	

Syllabus

Module - 1 (Introduction to Pattern Analysis) : Introduction - features, feature vectors and classifiers, Supervised versus unsupervised pattern recognition. Classifiers based on Bayes Decision theory- Review of Probability Theory, Conditional Probability and Bayes rule. Bayesian classification for normal distributions, Bayes classifier, Case I, Case II and Case III. Linear classifiers- Linear and quadratic discriminant functions and decision hyper planes.

Module -2 (Feature extraction and optimization)

Review of Linear Algebra. Linear Transformations-KLT, SVD, ICA, DFT, DCT, DST, Hadamard Transform, Wavelet Transform and transform based features. Feature engineering- Feature extraction- Global and local features, features for shape and characterization, typical features for object recognition in images, typical features for speech and audio classification, Feature reduction and optimization- Dimensionality reduction techniques, Principal component analysis.

Module 3 (Supervised Models for Pattern Classification)
K-Nearest-Neighbor Classification, selection criterion for k. The perceptron learning algorithm, classifier using perceptron. Multi layer perceptrons- Multilayer feed forward neural networks, Training neural networks, back propagation, gradient descent algorithm, activation functions and performance analysis of MLFFNN. Introduction to CNN. Support vector machines- SVM for linearly separable and nonlinearly separable patterns. Concept of maximum margin, kernels for SVM, kernel trick.

Module -4 (Unsupervised Models for pattern Classification)

Clustering - Vector Quantization, k-means clustering, Silhouette score, Cluster analysis, Proximity measures, Clustering Algorithms - Sequential algorithms, Hierarchical algorithms - Agglomerative algorithms, Divisive algorithms. Clustering Schemes - based on function optimization -Fuzzy clustering algorithms, Probabilistic clustering, Clustering algorithms based on graph theory.

Module- 5 (Applications of Pattern Analysis)
Application of pattern analysis in image classification, speech recognition, speaker identification, multimedia document recognition (MDR), automatic medical diagnosis. Outlier detection, novelty/anomaly detection using pattern analysis. Music and image/video retrieval systems.

Course Plan

No	Topic	No. of Lectures [40Hrs]
1	**Introduction to Pattern Analysis**	
1.1	Introduction - features, feature vectors and classifiers, Supervised versus unsupervised pattern recognition.	2
1.2	Classifiers based on Bayes Decision theory- Review of Probability Theory, Conditional Probability and Bayes rule.	2
1.3	Bayesian classification for normal distributions, Bayes classifier, Case I, Case II and Case III.	3
1.4	Linear classifiers- Linear and quadratic discriminant functions and decision hyper planes.	2
2	**Feature extraction and optimization**	
2.1	Review of Linear Algebra. Linear Transformations-KLT, SVD, ICA, DFT, DCT, DST, Hadamard Transform, Wavelet Transform and transform based features.	2
2.2	Feature engineering- Feature extraction- Global and local features, features for shape and characterization.	3
2.3	Typical features for object recognition in images, typical features for speech and audio classification.	2
2.4	Feature reduction and optimization- Dimensionality reduction techniques.	3
2.5	Principal component analysis.	2
3	**Supervised Models for Pattern Classification**	
3.1	K-Nearest-Neighbor Classification, selection criterion for k. The perceptron learning algorithm, classifier using perceptron.	3
3.2	Multi layer perceptrons- Multilayer feed forward neural networks, Training neural networks, back propagation, gradient descent algorithm, activation functions and performance analysis of MLFFNN. Introduction to CNN.	
3.3	Support vector machines- SVM for linearly separable and nonlinearly separable patterns. Concept of maximum margin, kernels for SVM, kernel trick.	3
4	**Unsupervised Models for pattern Classification**	
4.1	Clustering - Vector Quantization, K-means clustering, Silhouette score.	3
4.2	Cluster analysis, Proximity measures, Clustering Algorithms - Sequential algorithms, Hierarchical algorithms - Agglomerative	

	algorithms, Divisive algorithms.	
4.3	Clustering Schemes based on function optimization-Fuzzy clustering algorithms, Probabilistic clustering,	2
4.4	Clustering algorithms based on graph theory.	3
5	**Applications of Pattern Analysis**	
5.1	Application of pattern analysis in image classification, speech recognition, speaker identification.	2
5.2	Multimedia document recognition (MDR), automatic medical diagnosis.	2
5.3	Outlier detection, novelty/anomaly detection using pattern analysis.	1
5.4	Music and image/video retrieval systems.	2

Text Books

1. Pattern classification , Richard O. Duda and Hart P.E, and David G Stork, , 2nd Edn., John Wiley & Sons Inc., 2001

2. Neural Networks and Learning Machines, Simon S. Haykin, 3rd Edition, Pearson-Prectice Hall, ISBN-10: 0-13-147139-2, 2009.

3. Pattern Recognition, Sergios Theodoridis, Konstantinos Koutroumbas , Academic Press, 2006.

Reference Books

1. Pattern Recognition and Classification- An Introduction, Geoff Dougherty, ISBN: 978-1-4614-5323-9, Springer, 2013.

2. Advances in Fuzzy Clustering and its Applications, Jose Valente de Olliveira (Editor), Witold Pedrycz (Editor), ISBN: 978-0-470-02760-8, Wiley 2017.

3. Digital Pattern Recognition, King Sun Fu, ISBN: 978-3-642-96303-2, Springer, 1976

4. Pattern Recognition and Image Analysis Earl Gose, Richard Johnsonbaugh, and Steve Jost,, PHI Pvt. Ltd., NewDelhi-1, 1999.

5. Statistical Pattern Recognition, 2nd Edition, Andrew R. Webb, ISBN:9780470845134, John Wiley & Sons, 2002

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC016	INFORMATION HIDING AND DATA ENCRYPTION	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: The course is designed to provide an insight to various data encryption and information hiding techniques and applying these techniques in various security applications. The course also aims to develop skills in analysing the strengths and weakness of various techniques used for information security.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply various techniques for data encryption and analyse the performance (K3).
CO 2	Identify and apply information hiding and digital watermarking techniques for given problems in security systems (K3).
CO 3	Analyse publications related to encryption and information hiding in journals and conferences and submit report (K4).
CO 4	Choose and solve a research problem in the area of data encryption /and information hiding (K5).

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3					2	
CO 2	3		3			2	
CO 3	3	3	3			2	
CO 4	3	3	3	3	3	2	2

Assessment Pattern

Bloom's Category	End Semester Examination	Continuous Internal Evaluation
Understand	10	
Apply	40	10
Analyse	10	15
Evaluate		15
Create		

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred):	15 marks
Course based task/Seminar/Data Collection and interpretation:	15 marks
Test paper, 1 no.: (Test paper shall include minimum 80% of the syllabus.)	10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

CO level Assessment Questions

CO1: Apply various techniques for data encryption and analyse the performance

1. Distinguish between a synchronous and a nonsynchronous stream cipher.
2. In the DSS scheme, if Eve can find the value of r (random secret), can she forge a message? Explain.
3. Prove that $(x^3 + x^2 + 1)$ is an irreducible polynomial of degree 3.

CO2: Identify and apply information hiding and digital watermarking techniques for given problems in secure communication systems

1. Choose a digital watermarking technique for protecting an image and justify
2. Derive a method to hide an image in a video with optimal bandwidth.
3. Describe the hiding techniques in spatial and temporal transform domains and their applications.

CO3: Analyse publications related to encryption and information hiding in journals and conferences and submit report.

1. Review any 10 conference papers on digital watermarking techniques, analyse and prepare a report.
2. Analyse at least 10 journal papers on video steganography and present.

CO4: Choose and solve a research problem in the area of data encryption /and information hiding.

1. Encrypt any text data using symmetric and asymmetric methods of encryption and compare the performance.
2. Protect an audio file which has to be protected and transmitted through a vulnerable and noisy channel using image steganography.
3. Hide an image using any one of the conventional steganographic techniques and also using network steganography (Protocol) and compare your results.

Model Question Paper

Course Code: 221EEC016

Course Name: INFORMATION HIDING AND DATA ENCRYPTION

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all Questions. Each question carries 5 marks

Sl. No.	Question	CO
1.	Find the remainder when 16^{53} is divided by 7	1
2.	Describe the parameters used for measuring the capability of hiding techniques	1
3.	Identify the techniques used for tamper detection in image and audio and explain how the detection is carried out.	1
4.	Suggest a mathematical model for protecting the bio-medical signals and justify.	2
5.	Explain detection theoretic approach for steganalysis.	2

PART B

Answer any one full question from each module. Each question carries 7 marks

6.	Derive a general formula to calculate the number of each kind of transformation (SubBytes, ShiftRows, MixColumns, and AddRoundKey) and the number of total transformations for AES192 and AES256. The formula should be parametrized on the number of rounds.	1
7.	Write down algorithm for embedding and retrieval of text data using spread spectrum technique.	2
8.	Derive a mathematical model for hiding an image and explain.	2
9.	Differentiate between adaptive and non-adaptive techniques for information hiding. Which are the adaptive techniques used for hiding audio?	2
10.	Write down the encoding and decoding process for image hiding in the DCT domain and explain.	2
11.	Discuss temporal and transform domain techniques used in video using relevant examples.	2
12.	Illustrate SVM method for steg-analysis	2

Syllabus

Module1:

Review of Number Theory: Elementary Number theory, Algebraic Structures- Groups, Rings and Finite Fields, Polynomials over Finite Fields (F_q), Introduction to Complexity theory.

Data Encryption Methods: Introduction to Cryptography, Classical Cryptography, Stream Ciphers, Public Key Cryptography based on Knapsack problem, AES. Digital Signature, Zero Knowledge Proofs.

Module2:

Introduction to Information Hiding: Steganography. Objectives, difference, requirements, Types – Fragile, Robust. Parameters and metrics - BER, PSNR, WPSNR, Correlation coefficient, MSE, and Bit per pixel.

Information Hiding Approaches: LSB, additive and spread spectrum methods.

Module3:

Digital Watermarking: Algorithms, Types of Digital Watermarks, Applications, Audio Watermarking

Applications of Information Hiding: Authentication, annotation, tamper detection and Digital rights management. Hiding text and image data, mathematical formulations.

Module4:

Information Hiding in 1D signals: Time and transform techniques, hiding in Audio, biomedical signals, HAS Adaptive techniques.

Information Hiding in 2D signals: Spatial and transform techniques-hiding in images, ROI images.

Module5:

Information Hiding in video: Temporal and transform domain techniques, Bandwidth requirements, HVS Adaptive techniques.

Steg analysis: Statistical Methods, HVS based methods, SVM method, Detection theoretic approach.

Course Plan

No	Topic	No. of Lectures
1	**Review of Number Theory and Data Encryption Methods:**	
1.1	Elementary Number theory	1
1.2	Algebraic Structures- Groups, Rings and Finite Fields, Polynomials over Finite Fields (F_q)	2
1.3	Introduction to Complexity theory.	1
1.4	Introduction to Cryptography, Classical Cryptography, Stream Ciphers	2
1.5	Public Key Cryptography based on Knapsack problem	2
1.6	AES. Digital Signature, Zero Knowledge Proofs.	2
2	**Information Hiding**:	
2.1	Steganography. Objectives, difference, requirements	2
2.2	Types – Fragile, Robust. Parameters and metrics - BER, PSNR, WPSNR, Correlation coefficient, MSE, and Bit per pixel.	3
2.3	Information Hiding Approaches: LSB, additive and spread spectrum methods.	3
3	**Digital Watermarking and applications of Image Hiding:**	
3.1	Digital Watermarking Algorithms	2
3.2	Types of Digital Watermarks and Applications	1
3.3	Audio Watermarking	1
3.4	Applications of Information Hiding: Authentication, annotation, tamper detection and Digital rights management	2
3.5	Hiding text and image data, mathematical formulations.	2
4	**Information Hiding in 1D and 2D signals:**	
4.1	Information Hiding in 1D signals: Time and transform techniques, hiding in Audio, biomedical signals, HAS Adaptive techniques.	3
4.2	Information Hiding in 2D signals: Spatial and transform techniques-hiding in images, ROI images, HVS Adaptive techniques.	4
5	**Information Hiding in video and Steg analysis:**	
5.1	Information Hiding in video: Temporal and transform domain techniques, Bandwidth requirements.	3
5.2	Steg analysis: Statistical Methods, HVS based methods, SVM method, Detection theoretic approach.	4

Reference Books

1. Neal Koblitz, A Course in Number Theory and Cryptography, 2nd Edition, Springer
2. Stefan Katzenbeisser, Fabien A. P. Petitcolas, Information Hiding Techniques for Steganography and Digital Watermarking, Artech House Publishers, 2000.
3. Neil F Johnson et al Kluwer, Information hiding: Steganography and Watermarking - Attacks and Countermeasures,Springer, 2001.

4. Ingemar J Cox, Digital Watermarking, The Morgan Kaufman Series in Multimedia Information and Systems, 2001
5. Ira S Moskowits, Information Hiding, Proceedings, 4th International Workshop, IH 2001, Pittsburg, USA, April 2001, Eds:2. AVISPA package homepage, http:/www.avispaproject.org/
6. Handbook of Applied Cryptography, AJ Menezes, CRC Press, 2001.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC017	PROGRAMMING TOOLS FOR MODELING AND SIMULATION	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: This course is about learning the programming languages used in the development of embedded systems. Learners can use the concepts learned in this course for the development of processor based systems.

Course Prerequisites: Basic knowledge in programming, and embedded systems. Knowledge on ARM processors or any other processors and their architecture is a requirement.

Course Outcomes After the completion of the course the student will be able to

CO 1	To understand the Linux system and command level programming
CO 2	To understand the c programming basics
CO 3	To apply the c programming language in ARM programming
CO 4	To understand the basics of python language and its constructs
CO 5	To apply the python language in embedded applications

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3		3	3	3		
CO 2	3		3	3	3		
CO 3	3		3	3	3		
CO 4	3		3	3	3		
CO 5	3		3	3	3		

Assessment Pattern

Bloom's Category	End Semester Examination (Marks)
Apply	20
Analyse	20
Evaluate	
Create	20

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Evaluation shall only be based on application, analysis or design based questions(for both internal and end semester examinations).

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

All course based assignments/tasks shall be of programming examples/ programming implementations of embedded systems. Review article can be prepared on embedded application implementations, embedded processors,

End Semester Examination Pattern:
The end semester examination will be conducted by the respective College. Therewill be two parts; Part A and Part B.
Part A will contain 5 numerical/short answerquestions with 1 question from each module; having 5 marks for each question (suchquestions shall be useful in the testing of knowledge, skills, comprehension,application, analysis, synthesis, evaluation and understanding of the students).Students should answer all questions.
Part B will contain 7 questions (such questionsshall be useful in the testing of overall achievement and maturity of the students in acourse, through long answer questions relating to theoretical/practical knowledge,derivations, problem solving and quantitative evaluation), with minimum one questionfrom each module of which student should answer any five. Each question can carry7 marks.
Note: The marks obtained for the ESE for an elective course shall not exceed20% over the average ESE mark % for the core courses. ESE marks awarded to astudent for each elective course shall be normalized accordingly. For example if theaverage end semester mark % for a core course is 40, then the maximum eligiblemark % for an elective course is 40+20 = 60 %.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M. TECH DEGREE EXAMINATION, (Model Question Paper)

Program: M.Tech. in EC3 (Signal Processing, Signal Processing & Embedded Systems, Communication Engineering & Signal Processing)

Course Code: 22EEC017

Course Name: PROGRAMMING TOOLS FOR MODELING AND SIMULATION

Max. Marks: 60 **Duration: 150 Minutes**

PART A

Answer ALL Questions. Each Carries 5 mark.

1. Write a C program to read an English Alphabet through keyboard and display whether the given Alphabet is in upper case or lower case.
2. With a suitable example, explain how pointers can help in changing the content of a single dimensionally array passed as an argument to a function in C.
3. Write a python program to print odd numbers from 1 to N.
4. How will you plot magnitude spectrum in Matplotlin in Python?
5. Explain virtual desktop. How do you share a program across different virtual desktops under Linux?

PART – B

Answer any 5 questions; each question carries 7 marks.

6. Write a Linux X window program to create a window with a little black square in it and exits on a key press.
7. Explain the features of the Linux system? Why Linux is regarded as a more secure operating system than other operating systems?
8. Write a C program to find the transpose of a matrix.
9. Write an embedded C ARM I/O program to display a message on the LCD using 8-bit mode and delay.
10. Write Python code to multiply two matrices using nested loops and also perform transpose of the resultant matrix.
11. Write a note on the image processing function in Python.
12. Write a NumPy program to create an element-wise comparison (equal, equal within a tolerance) of two given arrays

Syllabus

Module I (8 Hrs.)

Linux: Introduction, The shell, Shell script and programming, Shell configuration, Linux files, directories and archives. The X window system, Xorg, and Display managers, Gnome, KDE, Linux software management.

Module II (8 Hrs.)

Embedded Programming: C programming, Constants, variables and data types, operators and Expressions, I/O operations, Control flow statements (if else, switch, loops), Arrays and strings, Functions, structures and unions, Pointers, file management, Dynamic memory allocation and Linked lists.

Module III (8 Hrs.)

Embedded C Programming using embedded IDE. ARM I/O programming, LED, LCD, Keypad interfacing, UART,SPI,I2C programming, Timer programming, Interrupt and Exception programming, ADC, DAC, Sensor interfacing.

Module IV (8 Hrs.)

Python Programming basics: variables, Input, Output, Basic operations, String manipulation, Loops, functions, Lists, Dictionary.

Module V (8 Hrs.)

Python programming- Advanced python, Formatting, class, files, exceptions.

Course Plan

No	Topic	No. of Lectures
1	Linux: Introduction, The shell, Shell script and programming, Shell configuration, Linux files, directories and archives. The X window system, Xorg, and Display managers, Gnome, KDE, Linux software management.	
1.1	Linux : Introduction, distributions, accessing linux system, deskop and command line interface	3
1.2	The shell, Shell script and programming, Shell configuration, Linux files, directories and archives.	3
1.3	The X window system, Xorg, and Display managers, Gnome, KDE, Linux software management.	2
2	Embedded Programming: C programming, Constants, variables and data types, operators and Expressions, I/O operations, Control flow statements (if else, switch,	

	loops), Arrays and strings, Functions, structures and unions, Pointers, file management, Dynamic memory allocation and Linked lists.	
2.1	Embedded Programming: C programming, Constants, variables and data types, operators and Expressions, I/O operations,	3
2.2	Control flow statements (if else, switch, loops), Arrays and strings, Functions, structures and unions,	3
2.3	Pointers, file management, Dynamic memory allocation and Linked lists.	2
3	Embedded C Programming using embedded IDE. ARM I/O programming, LED, LCD, Keypad interfacing, UART,SPI,I2C programming, Timer programming, Interrupt and Exception programming, ADC, DAC, Sensor interfacing	
3.1	Embedded C Programming using embedded IDE. ARM I/O programming, LED, LCD, Keypad interfacing	3
3.2	UART,SPI,I2C programming, Timer programming,	3
3.3	Interrupt and Exception programming, ADC, DAC, Sensor interfacing	2
4	Python Programming basics : variables, Input, Output, Basic operations, String manipulation, Loops, functions, Lists, Dictionary	
4.1	Python Programming basics : variables, Input, Output, Basic operations,	3
4.2	String manipulation, Conditional instructions, Loops, functions,	3
4.3		2
5	Python programming- Advanced python, Formatting, class, files, exceptions, linux commands, web server, Signal plotting and processing (numpy and matplotlib), Graphics, Computer vision. Programming examples of systems.	
5.1	Python programming- Advanced python, Formatting, class, files, exceptions	3
5.2	linux commands, web server, Signal plotting and processing (numpy and matplotlib),	3
5.3	Graphics, Computer vision. Programming examples of systems.	2

Text Books

1. E. Balagurusamy, Programming in ANSI C, Tata McGraw-Hill, 6th Edition 2012
2. Muhammad Ali Mazidi, Shujen Chen, Sarmad Naimi, SepehrNaimi, “Freescale ARM Cortex-M Embedded Programming using C language”, Mazidi and Naimi,2014
3. Simon Monk, “Raspberry Cook Book Software and Hardware Problems and Solutions”, 2nd Edition, O’ Reilly Media Inc., 2016.
4. Richard Petersen, "Linux: The Complete Reference", 2017, Sixth Edition, McGraw Hill Education

Reference Books

1. David Russell, "Introduction to Embedded systems Using ANSI C and the Arduino development Environment", 2010, 1rd edition, Morgan & Claypool Publishers.
2. E.I. Horvath, E.A. Horvath, "Learning IoT with Python and Raspberry Pi", Learning IoT LLC, 2019.
3. Sarmad Naimi, Muhammad Ali Mazidi, SepehrNaimi, "The STM32F103 Arm Microcontroller and Embedded Systems: Using Assembly and C", MicroDigitalEd, 2020

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TEC004	TOPICS IN MACHINE LEARNING	PROGRAM CORE 2	3	0	0	3

Preamble: Machine learning is a subfield of artificial intelligence, which is broadly defined as the capability of a machine to imitate intelligent human behavior. Artificial intelligence systems are used to perform complex tasks in a way that is similar to how humans solve problems. Machine learning allows software applications to become more accurate at predicting outcomes without being explicitly programmed to do so. Machine learning algorithms use historical data as input to predict new output values. Students will be able to learn machine learning fundamentals, understand the different types of algorithms in machine learning, develop in-depth knowledge of machine learning tasks such as regression, classification, clustering etc.

Prerequisite: A sound knowledge of the fundamentals and basics of probabilty, statistics and algorithms.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand and apply the fundamentals, concepts and terminologies in machine learning, Deep learning and artificial intelligence.
CO 2	Understand and analyse the principles of supervised and unsupervised learning and illustrate the functionalities of the supervised and unsupervised learning algorithms.
CO 3	Understand and analyse the principles of semi-supervised and reinforcement learning and illustrate the functionalities of the semi-supervised and reinforcement learning learning algorithms.
CO 4	Analyze and evaluate the performance of artificial neural networks and deep learning neural architectures.
CO 5	Create and evaluate critically the domain specific applications of Machine learning.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	3		2			
CO 2	2	3			2		
CO 3	3	2			2	2	3
CO 4					2	2	3
CO 5	3	3		2			

Assessment Pattern

Bloom's Category	End Semester Examination %
Apply	10
Analyse	40
Evaluate	30
Create	20

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Evaluation:	**40 marks**
Micro project/Course based project:	20 marks
Course based task/Seminar/Quiz:	10 marks
Test paper, 1 no:	10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer question relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION, (**Model Question Paper)**

Discipline: ELECTRONICS & COMMUNICATION ENGINEERING

Stream: EC3 (Signal Processing, Signal Processing & Embedded Systems, Communication Engineering & Signal Processing)

Course Code: 221TEC004

Course Name: TOPICS IN MACHINE LEARNING

Max. Marks: 60 Duration: 2.5Hours

PART A

Answer ALL Questions. Each Question Carries 5 marks.

1	A sample x1, ..., xn has been obtained from a probability model specified by mass or density function fX (x; θ) depending on parameter(s) θ lying in parameter space Θ. Estimate the maximum likelihood.	CO1	
2	Illustrate with an example, the k- nearest neighbour algorithm for pattern classification. How do you compute the distance between two patterns ?	CO2	
3	Explain how semi-supervised learning is different from supervised learning. Illustrate self learning.	CO2	
4	Demonstrate gradient descent algorithm for error back propagation in ANNs.	CO2	
5	Suggest a strategy based on machine learning techniques for sentiment analysis in social networks. Explain with neat schematics.	CO3	

PART – B

Answer any 5 full questions ; each question carries 7 marks.

6. a)	With neat schematics, explain machine learning process flow. Explain the process involved in model building and validation, interpretaion of model and data visualization.	5	CO4	

6. b)	What do you mean by hyperparameters ? Explain the process of fine tuning the hyper parameters.	2	CO3	
7.a)	Discuss the principles of density based clustering and explain the basic algorithm. What do you mean by ε -neighbourhood ?	3	CO1	
7. b)	With the help of relevant equation explain how do you compute cosine similarity between two feature vectors.	4	CO5	
8.a)	State the dual problem of optimization for SVM for linearly non-separable patterns. Obtain the equation of optimal hyperplane and optimum weight vectors wo and optimum bias bo for linearly non-separable patterns. Give expression for finding the label of a test example xt.	2	CO2	
8.b)	Explain what do you mean by hard and soft margins. Derive the expression for the margin of separation for SVM.	5	CO4	
9. a)	Explain the concept of error back propagation learning used in MLFFNN. Obtain the weight updation equation for MLFFNN with one hidden layer.	3	CO4	
9.b)	Discuss the significance of activation functions. With the help of a neat sketch explain sigmoidal activation function. Explain how spread factor (β) value is selected	3	CO1	
9.c)	Discuss the functionalities of different layers in a CNN.	1	CO2	
10.a)	Compare and contrast between agglomerative and divisive techniques for clustering. Give the step-by-step algorithm for agglomerative clustering. What are the proximity measures between clusters ?	2	CO1	
10.b)	With the help of suitable illustrations explain the selection of number of clusters using silhouette analysis.	5	CO3	
11.a)	Discuss the basic concepts of deep learning. With a neat schematic explain the principles of convolutional neural networks.	3	CO1	
11.b)	Discuss the need for pooling layer in a CNN architecture. Distinguish between max pooling and average pooling.	4	CO3	
12.a)	Illustrate the use of machine learning algorithms in medical image segmentation for brain tumor detection. Draw neat schematics for the system and expalin the functionality of each module.	3	CO5	
12.b)	Explain the use of machine learning algorithms and tools for rain forecasting in Kerala. Explain the data collection process, data refinement and models used for prediction. How do you validate the model?	4	CO5	

Syllabus

Module - 1 (Basics of Machine Learning)

Introduction to machine learning, artificial intelligence and deeplearning. Learning algorithms - over fitting and under fitting, hyperparameters and validation sets, estimators, bias and variance, Maximum Likelihood Estimation. Machine learning process flow- define problem, objective, data acquisition and preprocessing, feature engineering, model building and validation.

Module -2 (Supervised and Unsupervised Learning)

Supervised Learning- Basic principles of linear regression, logistic regression. Classification- Supervised algorithms-Decision trees, k-Nearest Neighbour, Naive Bayes, support vector machines, ensemble learning techniques. Unsupervised Learning- Basic principles of clustering, clustering algorithms-hierarchical algorithms-agglomerative, divisive algorithms. Partitioning algorithms- k-means, k medoids algorithms, density based algoritms.

Module -3 (Semi-supervised and Reinforcement Learning)

Semi-supervised learning – Types of semi-supervised learning- Self learning, graph based SSL-label propagation. Reinforcement Learning-Taxonomy, Reinforcement Learning Algorithms-Value based, Policy based and model based algorithms. Characteristics and types of reinforcement learning. Reinforcement learning models- Markov decision process, Q-learning.

Module -4 (Artificial Neural Networks and Deep Learning)

Artificial neural networks- Basic principles of Back propagation, Gradient Descent, Training Neural Network, Initialisation and actvation functions. Deep learning principles and achitectures-Dropout, Batch normalisation, Ensemble learning, Data augmentation, Transfer learning, Convolutional Neural Networks, Recurrent Neural Networks, LSTM, Data augmentation-GAN.

Module- 5 (Applications of Machine Learning)

Machine learning applications for prediction-weather, sales of a store, eligibility of loan. Medical diagnoses, Financial industry and trading, image classification, recognition and segmentation, speech recognition, automatic language translation and auto corrections, recommendation engines.

Course Plan

No	Topic	No. of Lectures [40Hrs]
1	**Basics of machine learning.**	
1.1	Introduction to machine learning.	1
1.2	Artificial intelligence and deeplearning.	1
1.3	Learning algorithms-over fitting and under fitting, hyperparameters and validation sets.	2
1.4	Estimators, bias and variance, Maximum Likelihood Estimation.	1
	Machine learning process flow- define problem, objective, data acquisition and preprocessing, feature engineering, model building and validation.	2
2	**Semi-supervised and Reinforcement Learning**	
2.1	Supervised Learning- Basic principles of linear regression, logistic regression.	2
2.2	Classification-Supervised algorithms-Decision trees, k-Nearest Neighbour, Naive Bayes.	2
2.3	Support vector machines, ensemble learning techniques.	2
2.4	Unsupervised Learning- Basic principles of clustering.	1
2.5	Clustering algorithms-hierarchical algorithms-agglomerative, divisive algorithms. Partitioning algorithms- k-means, k medoids algorithms, density based algoritms.	2
2.6	Partitioning algorithms- k-means, k medoids algorithms, density based algoritms. Case study in clustering- Medical image segmentation.	2
3	**Semi-supervised and Reinforcement Learning**	
3.1	Semi-supervised learning – Types of semi-supervised learning- Self learning, graph based SSL-label propagation.	2
3.2	Reinforcement Learning-Taxonomy, Reinforcement Learning Algorithms-Value based, Policy based and model based algorithms. Characteristics and types of reinforcement learning. Reinforcement learning models- Markov decision process, Q-learning.	3
3.3	Characteristics and types of reinforcement learning. Reinforcement learning models- Markov decision process, Q-learning.	3
4	**Artificial Neural Networks and Deep Learning**	

4.1	Artificial neural networks- Basic principles of Back propagation, Gradient Descent.	2
4.2	Training Neural Network, Initialisation and actvation functions.	
4.3	Deep learning principles and achitectures-Dropout, Batch normalisation, Ensemble learning, Data augmentation, Transferlearning.	2
4.4	Convolutional Neural Networks, Recurrent Neural Networks, LSTM, Data augmentation-GAN.	3
5	**Applications of Machine Learning**	
5.1	Machine learning applications for prediction-weather, sales of a store, eligibility of loan.	2
5.2	Medical diagnoses, Financial industry and trading.	2
5.3	Image recognition, classification and segmentation.	1
5.4	Speech recognition, automatic language translation and auto corrections, recommendation engines.	2

Text Books

1. Machine Learning: The Art and Science of Algorithms that Make Sense of Data, Peter A Flach, Cambridge University Press, ISBN-10 1107422221, 2012.

2. Applied Machine Learning, 2nd Edition, M. Gopal, Mc Graw Hill Education, ISBN-10 : 9789353160258, 2018.

3. Neural Networks and Learning Machines, Simon S. Haykin, 3rd Edition, Pearson-Prectice Hall, ISBN-10: 0-13-147139-2, 2009.

Reference Books

1. An Introduction to Machine Learning, Miroslov Kubat, Springer, ISBN-10 3030819345, 2021.

2. Machine Learning, 1st Edition, Saika Dutt, Subramanian Chandramouli, Amit Kumar Das, Pearson Education, ISBN-10 9353066697, 2018.

3. Machine Learning: A First Course for Engineers and Scientists, Andreas Lindholm, Niklas Wahlstom, Fredrik Lindsten et al., Cambridge University Press, ISBN-10 1108843603, 2022.

4. Handbook of Reinforcement Learning and Control, Kyriakos G. Vamvoudakis, Yan Wan, et al., ISBN-10 3030609898, Sprimger, 2021.

5. Neural Networks and Deep Learning, Charu C. Aggarwal, Springer, ISBN: 978-3-319-94463-0, 2018.

CODE	COURSE	CATEGORY	L	T	P	CREDIT
221EEC014	SPEECH SIGNAL PROCESSING	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: This course aims to develop in-depth understanding of fundamentals of speech analysis, parametric representations and models of speech and speech processing applications enabling the students to explore into research and development of speech processing systems.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the basic concepts of speech production and apply time domain analysis methods for classification of speech sounds
CO 2	Analyse speech segments using frequency domain techniques - STFT and Cepstral analysis
CO 3	Apply LPC Analysis to speech signals
CO 4	Analyse and apply speech coding techniques for speech compression, storage and transmission
CO 5	Understand the fundamentals of speech processing applications

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3		3	3	3		
CO 2	3		3	3	3		
CO 3	3		3	3	3		
CO 4	3		3	3	3		
CO 5	3		3	3	3		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	40%
Evaluate	20%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed Original publications (minimum10 Publications shall be referred):**15 marks**

Course based task/Seminar/Data Collection and interpretation: **15 marks**

Test paper (Shall include minimum of 80% of the syllabus)1 no.: **10 marks**

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

No. of Pages: 2 **D**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION

Branch: Electronics and Communication Engineering

Stream(s): Signal Processing

*Course Code & Name: **221EEC014 - SPEECH SIGNAL PROCESSING***

Max. Marks: 60 Duration: 2.5 hours

PART A

Answer all questions. Each question carries 5 marks.

1. How do you differentiate voiced and unvoiced speech segments using short time zero crossing rate and short time energy?
2. Why do we do short time analysis in the case of speech signals? Distinguish between narrow band and wide band spectrograms.
3. Explore the use of AR models in the analysis of speech signals.
4. How is perceptual irrelevancy removal used in speech compression?
5. Investigate the challenges in speech segmentation?

PART B

Answer any five questions. Each question carries 7 marks.

6. The waveforms and autocorrelation plots of two phonemes segmented from continuous speech are given in Fig.1(a) and Fig.1(b). Analyze the figures and state your inferences.

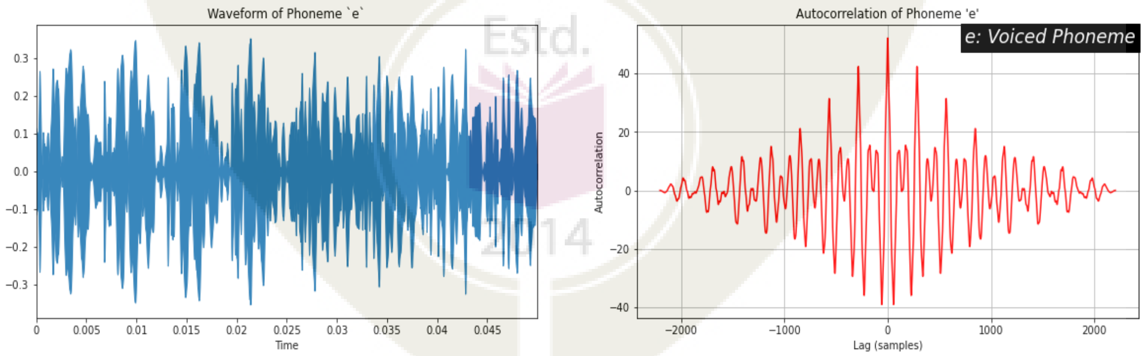


Fig.1(a)

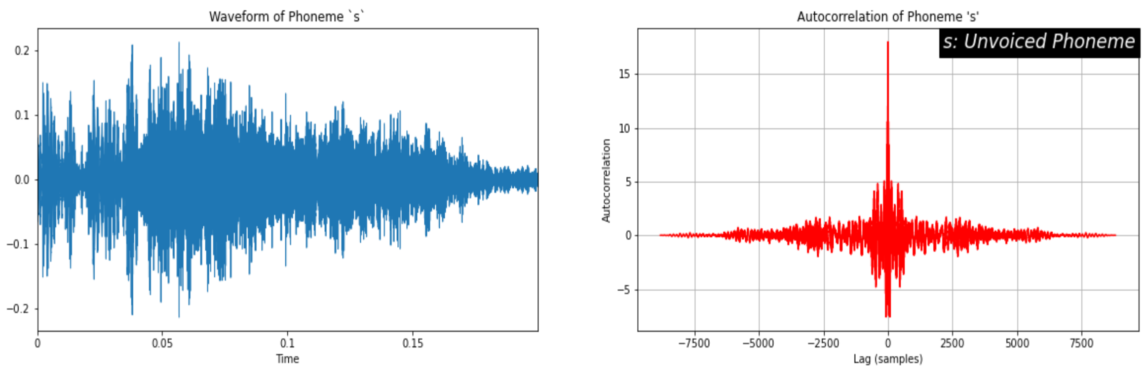


Fig.1(b)

7. How can we use cepstral analysis to separate source and filter characteristics of a speech signal? Derive the steps involved in obtaining cepstral coefficients.
8. Formulate the Filter Bank Summation (FBS) method of STFT synthesis. Derive the FBS constraint.
9. How can we use Levinson Durbin algorithm to find the LPC coefficients?
10. How can we use sub band coding for speech compression?
11. How can we convert any given text to speech ?
12. How can we automatically verify the identity of a given speaker?
13.

Syllabus

MODULE I
Speech Production and Short-Time Speech Analysis:Acoustic theory of speech production, Excitation, Vocal tract model for speech analysis, Formant structure, Pitch, Articulatory Phonetics, and Acoustic Phonetics, Time domain analysis (Short time energy, short time zero crossing Rate, ACF),

MODULE II
Frequency domain analysis: Filter Banks, STFT, Spectrogram, Formant Estimation & Analysis, Cepstral Analysis, MFCC,

MODULE III
Parametric representation of speech: AR model, ARMA model, LPC model, Autocorrelation method, Covariance method, Levinson-Durbin Algorithm, Lattice form, Sinusoidal Model, GMM, Hidden Markov Model,

MODULE IV
Speech coding: Phase Vocoder, LPC, Sub-band coding, Adaptive Transform Coding, Harmonic Coding, Vector Quantization based Coders, CELP

MODULE V
Applications of speech processing: Fundamentals of Speech recognition, Speech segmentation, Text-to-speech conversion, speech enhancement, Speaker Verification, Language Identification

Course Plan

No	Topic	No. of Lectures
1	**MODULE I**	
1.1	Acoustic theory of speech production, Excitation, Vocal tract model for speech analysis	2
1.2	Formant structure, Pitch, Articulatory Phonetics, and Acoustic Phonetics	2
1.3	Time domain analysis (Short time energy, short time zero crossing Rate, ACF).	2
2	**MODULE II**	
2.1	Filter Banks, STFT	3
2.2	Spectrogram, Formant Estimation & Analysis	2
2.3	Cepstral Analysis, MFCC	2
3	**MODULE III**	
3.1	AR model, ARMA model, LPC Analysis - LPC model, Autocorrelation method	3
3.2	Covariance method, Levinson-Durbin Algorithm, Lattice form	3
3.3	Sinusoidal Model, GMM, Hidden Markov Model	3
4	**MODULE IV**	
4.1	Phase Vocoder, LPC, Sub-band coding	3
4.2	Adaptive Transform Coding, Harmonic Coding	3
4.3	Vector Quantization based Coders, CELP	3
5	**MODULE V**	
5.1	Fundamentals of Speech recognition, Speech segmentation.	3
5.2	Text-to-speech conversion, speech enhancement	3
5.3	Speaker Verification, Language Identification	3

Reference Books

1. Thomas F. Quatieri, Discrete-Time Speech Signal Processing: Principles and Practice, Prentice Hall; ISBN: 013242942X; 1st edition
2. Rabiner and Juang, Fundamentals of Speech Recognition, Prentice Hall, ISBN: 0130151572.
3. Douglas O'Shaughnessy, Speech Communications: Human & Machine, IEEE Press, Hardcover 2nd edition, 1999; ISBN: 0780334493.
4. Digital Processing of Speech Signals, 1st edition, ISBN: 97881317051314.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC015	ADVANCED EMBEDDED PROCESSORS	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: This course is intended to impart thorough knowledge in embedded processors. It also helps to develop skills in designing complex systems using different processor architectures.

Course Prerequisites: Basic knowledge in digital electronics and Microprocessors at UG level.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the basics of an embedded system
CO 2	Familiarize ARM Architecture
CO 3	Understand and analyse the structure and design of an Embedded System
CO 4	Analyse Product Enclosure, Design and Development
CO 5	Compare standard I/O interfaces.
CO 6	Design an Embedded System

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3		2	2			
CO 2	3		2	2	3		
CO 3	3		3	2	2		
CO 4	3		3	3	2		
CO 5	3		2	3	3		
CO 6	3		3	3	3	3	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20%
Analyse	50%
Evaluate	
Create	30%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	15 marks
Course based task/Seminar/Data collection and interpretation	15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.)	10 marks
TOTAL	**40 marks**

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M. TECH DEGREE EXAMINATION

Program: M.Tech.in EC3 (Signal Processing, Signal Processing & Embedded Systems, Communication Engineering & Signal Processing)

Course Code: 221EEC015

Course Name: ADVANCED EMBEDDED PROCESSORS

Max. Marks: 60 Duration: 150 Minutes

Part A

Answer All Questions. Each Carries 5 mark.

1. Mention two application of embedded system in health care and how can it be used for monitoring purpose.
2. Discuss about some of the deviation of ARM architecture from pure RISC nature.
3. Explain the linear waterfall model of EDLC.
4. Discuss any two product enclosure development techniques
5. What is cross compilation? What are the files generated on cross compilation?

Part B

Answer any five questions: Each question carries 7 marks.

6. With a neat diagram explain the parts or elements of an embedded system.
7. Explain the 5-stage pipeline ARM organization with the help of a neat diagram.
8. Discuss the different phases of EDLC with the help of classic Embedded Product Development Life Cycle Model
9. Discuss and describe the communication interfacing technique used in USB and IEEE 1394.
10. Explain the external communication interfaces in detail.
11. Describe the boundary scan technique for testing the interconnection among the various chips in a complex hardware board.
12. Explain the SPI bus architecture with the help of a neat bus architecture diagram

Syllabus

Module 1: 8 hours

Introduction to Embedded systems: Embedded system examples, Parts of Embedded System, Typical Processor architecture, Power supply, clock, memory interface, interrupt, I/O ports, Buffers, Programmable Devices, ASIC, etc. Simple interfacing examples, Memory Technologies, EPROM, Flash, OTP, SRAM, DRAM, SDRAM etc

Module 2: 11 hours

ARM architecture: ARM organization and Implementation, Memory Hierarchy, ARM Instruction Set and Thumb Instruction set.High- Level Language Programming, System Development using ARM. Digital Signal Processing on ARM, Peripheral Programming and system design for a specific ARM processor (ARM7/9).

Module 3: 7 hours

Embedded System product Development: Embedded System product Development Life cycle (EDLC). Specifications, Component selection, Schematic Design, PCB layout, fabrication and assembly.

Module 4: 6 hours

Product enclosure design and development: Concept of firmware, operating system and application programs. Power supply Design, External Interfaces.

Module 5: 8 hours

Embedded System Development Environment: IDE, Cross compilation, Simulators/Emulators. Hardware Debugging. Hardware testing methods like Boundary Scan, In Circuit Testing (ICT) etc., Serial EEPROM, PWM, Analog to digital converter Bus architecture like I2 C, SPI, AMBA, CAN etc.

COURSE PLAN

No	Topic	No. of Lectures
1	**Introduction to Embedded systems**	
1.1	Embedded system examples, Parts of Embedded System, Typical Processor architecture, Power supply, clock, memory interface, interrupt, I/O ports, Buffers, Programmable Devices, ASIC, etc	4
1.2	Simple interfacing examples, Memory Technologies, EPROM, Flash, OTP, SRAM, DRAM, SDRAM etc	4
2	**ARM architecture**	
2.1	ARM organization and Implementation, Memory Hierarchy, ARM Instruction Set and Thumb Instruction set	4
2.2	High- Level Language Programming, System Development using ARM	4
2.3	Digital Signal Processing on ARM, Peripheral Programming and system design for a specific ARM processor (ARM7/9).	3
3	**Embedded System product Development**	
3.1	Embedded System product Development Life cycle (EDLC)	3
3.2	Specifications, Component selection, Schematic Design, PCB layout, fabrication and assembly.	4
4	**Product enclosure design and development**	
4.1	Concept of firmware, operating system and application programs	3
4.2	Power supply Design, External Interfaces.	3
5	**Embedded System Development Environment**	
5.1	IDE, Cross compilation, Simulators/Emulators	3
5.2	Hardware Debugging. Hardware testing methods like Boundary Scan, In Circuit Testing (ICT) etc.,	2
5.3	Serial EEPROM, PWM, Analog to digital converter, Bus architecture like I2C, SPI, UART, AMBA, CAN etc.	3

Text Books

1. Shibu K.V. Introduction to Embedded Systems, Tata McGraw Hill, 2009.
2. Steve Furber, ARM System-on-chip Architecture, Second Edition Pearson Education, 2007.

Reference Books

1. Van Ess, Currie and Doboli, Laboratory Manual for Introduction to Mixed-Signal, Embedded Design, Alphagraphics, USA
2. William Hohl, ARM Assembly Language Programming, CRC Press, 2009.
3. Andrew Sloss, Dominic Symes, Christ Wright, ARM System Developer's guide – Designing and optimizing software, Elsevier Publishers, 2008.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC022	INTERNET OF THINGS	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: The core modules of this elective course include introduction to Internet of Things (IoT), IoT protocol and software, IoT point to point communication technologies, IoT security and IoT Platform. This course aims to teach the student to understand the concepts of IoT and its applications.

Prerequisites: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify the IoT networking components with respect to OSI layer.
CO 2	Understand the communication networks and protocols used in IoT
CO 3	Understand the cloud resources, data analysis and applications.
CO 4	Understand IoT security and threat models analysis.
CO 5	Understand various IoT applications and its variants.
CO 6	Design and develop prototype models for various IoT applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3		3	3	3		
CO 2	3		3	3	3		
CO 3	3		3	3	3		
CO 4	3		3	3	3		
CO 5	3		3	3	3		
CO 6	3		3	3	3		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	20
Evaluate	
Create	20

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module; having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M. TECH DEGREE EXAMINATION, (Model Qtn Paper)

Program: M.Tech. in EC3 (Signal Processing, Signal Processing & Embedded Systems, Communication Engineering & Signal Processing)

Course Code: 221EEC022

Course Name: INTERNET OF THINGS

Max. Marks: 60 Duration: 150 Minutes

PART A

Answer All Questions. Each Carries 5 marks.

1. How is data link addressing different from network addressing?
2. Explain the CoAP message format.
3. Discuss the components in the open source cloud platform OpenStack..
4. List the standard encryption protocols used in IoT. Explain any one algorithm with example.
5. With the help of block diagram explain the IoT application in healthcare. Explain each modules of the network.

PART B

Answer any 5 questions: Each question carries 7 marks.

6. What is internet protocol suit? How is it differ from th ISO-OSI model?
7. Design an IoT based water quality monitoring system using MQTT protocol. Explain the publish subscribe model in detail.
8. Design a LoRa based smart street lighting system for smart cities (block diagram only). Discuss the security features of LoRaWAN.
9. Explain the requirements of privacy and security, vulnerabilities from threats, and need of threat-analysis in IoT
10. Discuss on the cryptographic functions and their security services.
11. How IoT is related to big data analytics? Explain with an example.
12. Design an M2M Smart meter which allow you to track energy consumption in real-time. Draw the block diagram of the network and explain each modules

SYLLABUS

Module 1: 8 hours

Introduction to IoT: Basics of Networking- network types,layered network models, addressing,TCP/IP Transport layer, Emergence of IoT- evolution of IoT, IoT networking components ,IoT network architecture and design-comparing IoT architectures, simplified IoT architecture,Smart objects: the things in IoT-sensors, actuators and smart objects, sensor networks

Module 2: 8 hours

IoT protocols and Software: Connecting smart objects: communications criteria, IoT connectivity technologies(IEEE 802.15.4, Zigbee,Sigfox,LoRA,NB-IoT,Wi-Fi,Bluetooth),IoT communication technologies: infrastructure protocols (Ipv6,6LoWPAN), Data protocols (MQTT,CoAp, AMQP, XMPP, SOAP, REST, WebSocket)

Module 3: 8 hours

Introduction to Cloud computation and Big data analytics: cloud computing: introduction, cloud models, cloud implementation-cloud simulation,open source cloud (OpenStack),commercial cloud:AWS,introduction to data analytics for IoT, machine learning, Big data analytics tools and technology – Hadoop,Edge streaming analytics,Network analytics.

Module 4: 8 hours

IoT security: common challenges in IoT security,fundamentals of cryptography: cryptographic algorithms and their security services, the lightweight features of cryptographic algorithms, Quadruple Trust Model for IoT-A – Threat Analysis and model for IoT-A, Cloud security.

Module 5: 8 hours

IoT application and its Variants: Case studies: IoT for smart cities, health care, agriculture, smart meters.M2M, Web of things, Cellular IoT, Industrial IoT, Industry 4.0, IoT standards.

Course Plan

No	Topic	No. of Lectures
1	**Introduction to IoT:**	
1.1	Basics of Networking- network types,layered network models, addressing,TCP/IP Transport layer	2
1.2	Emergence of IoT- evolution of IoT,IoT networking components	3
1.3	IoT network architecture and design-comparing IoT architectures,simplified IoT architecture.	2
1.4	Smart objects: the things in IoT-sensors, actuators and smart objects,sensor networks	1
2	**IoT protocols and Softwares:**	
2.1	Connecting smart objects: communications criteria	2
2.2	IoT connectivity technologies(IEEE 802.15.4,Zigbee,Sigfox,LoRA,NB-IoT,Wi-Fi,Bluetooth)	3
2.3	IoT communication technologies: infrastructure protocols(IPv6,6LoWPAN),Data protocols(MQTT,CoAp,AMQP,XMPP,SOAP,REST,WebSocket)	3
3	**Introduction to Cloud computation and Big data analytics:**	
3.1	cloud computing: introduction, cloud models	1
3.2	cloud implementation-cloud simulation,open-source cloud(OpenStack), commercial cloud:AWS	2
3.3	introduction to data analytics for IoT, machine learning	1
3.4	Big data analytics tools and technology - Hadoop	2
3.5	Edge streaming analytics, Network analytics	2
4	**IoT security:**	
4.1	common challenges in Iot security	1
4.2	fundamentals of cryptography: cryptographic algorithms and their security services, the lightweight features of cryptographic algorithms	2
4.3	Quadruple Trust Model for IoT-A – Threat Analysis and model for IoT-A,	2
4.4	Cloud security	3
5	**IoT application and its Variants:**	

5.1	Case studies: IoT for smart cities, health care, agriculture, smart meters.	3
5.2	M2M, Web of things, Cellular IoT	3
5.3	Industrial IoT, Industry 4.0, IoT standards.	2

Text Books

1. S.Misra, A. Mukherjee, and A.Roy, 2020. Introduction to IoT. Cambridge University Press.
2. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, ―IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017.
3. Rajkamal, "Internet of Things : Architecture and Design Principles", McGraw Hill (India) Private Limited
4. Chuan Kun Wn,"Internet of Things Security: Architectures and Security Measures",Springer 2021.
5. 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

Reference Books

1. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, "From Machine to Machine to Internet of Things", Elsevier Publications, 2014.
2. LuYan, Yan Zhang, Laurence T. Yang, Huansheng Ning, The Internet of Things: From RFID to the Next-Generation Pervasive Network, Aurbach publications, March,2008.
3. Vijay Madisetti , Arshdeep Bahga, Adrian McEwen (Author), Hakim Cassimally "Internet of Things A Hands-on-Approach" Arshdeep Bahga & Vijay Madisetti, 2014.
4. Asoke K Talukder and Roopa R Yavagal, "Mobile Computing," Tata McGraw Hill, 2010.
5. Barrie Sosinsky, "Cloud Computing Bible", Wiley-India, 2010
6. RonaldL. Krutz, Russell Dean Vines,Cloud Security: A Comprehensive Guide to Secure Cloud Computing,Wiley-India, 2010

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC012	ADVANCED DIGITAL COMMUNICATION	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: Digital communications is a broad term that incorporates all procedures and forms of transmission of data or information. This course imparts mathematical modelling about various modulation schemes, channels and multipath mitigation techniques.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Represent digitally modulated signals in signal space.
CO 2	Design of Optimum receiver for AWGN channel.
CO 3	Design of Equalizers for optimum detection in presence of ISI
CO 4	Analyse Multi Channel and Multi Carrier Systems
CO 5	Evaluate Digital Communication through Fading Multipath Channels
CO 6	Analysis of CDMA systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	2	3		3	
CO 2	3	3	2	3	3	3	2
CO 3	3	2	2	3		3	
CO 4	3	2	2	3	3	3	2
CO 5	3	2	2	3	3	3	2
CO 6	3	3	2	3	3	3	2

Assessment Pattern

Bloom's Category	End Semester Examination %
Apply	20
Analyse	50
Evaluate	30
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 Hrs

Evaluation of Elective Courses

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
M.TECH DEGREE EXAMINATION
First Semester

Branch:

ADVANCED DIGITAL COMMUNICATION

Time: 2.5 Hours **Marks: 60**

Part A

Answer ALL Questions. Each question carries 5 marks

1. Represent 8-PSK as a linear combination of two orthonormal signal waveforms. Using Gray encoding label the corresponding signal points
2. Derive the impulse response of a matched filter.
3. Explain Nyquist criteria for zero ISI. Illustrate the pulse shape for zero ISI.
4. Design a 4 bit PN sequence generator with shift registers.
5. Explain RAKE receiver.

Part B

Answer ANY FIVE Questions. Each question carries 7 marks

6. Three messages are transmitted over an AWGN channel with noise power spectral density $N_0/2$ The messages are

$$S1(t) = \begin{cases} 1\ ;\ 0 \le t \le T \\ 0\ ;\ other\ wise \end{cases}$$

$$S_2(t) = -S_3(t) = \begin{cases} 1\ ;\ 0 \le t \le T/2 \\ -1;\ \frac{T}{2} \le t \le T \\ 0;\ otherwise \end{cases}$$

   i. Find the dimensionality of the signal space.
   ii. Find and draw an appropriate basis for the signal space.

7. Derive the expression for error probability of binary QPSK modulation scheme in AWGN channel.
8. In an un-equalized linear filter channel the noise free output of the demodulator when a '1' is transmitted is

$$x_m = \begin{cases} 0.3; & m = 1 \\ 0.9; & m = 0 \\ 0.3; & m = -1 \\ 0 & otherwise \end{cases}$$

   Design a three tap zero forcing equalizer so that the output is $q_m = \begin{cases} 1; & m = 0 \\ 0; & m = \pm 1 \end{cases}$

9. Explain an FFT based multi-carrier System.

10. Explain the Delay locked loop for tracking DS spread spectrum signal.
11. A multipath fading channel has a multipath spread of Tm=1 sec and a Doppler spread Bd = 0.01 Hz. The total channel bandwidth at band-pass available for signal transmission is W=5 Hz. To reduce ISI the selected pulse duration is T= 10 sec.
(i)Determine the coherence Bandwidth and Coherence Time?
(ii)Is the channel is frequency selective?
12. Explain the ALOHA system and protocols in multiuser communication system.

Syllabus

Module I

Characterization of Communication Signals and Systems: Overview of Digital Communication systems,Communication Channels and Mathematical models,Representation of band pass signals and systems, Signal spacerepresentation,Representation of digitally modulated signals, Spectral Characteristics of Digitally Modulated Signals.

Module II

Optimum receiver for AWGN channel:Correlationdemodulator, matched filter demodulator, optimum detector,Performance of optimum receiver for memoryless modulationtechniques, Probability of error for binary modulation and M-ary orthogonal signals, Probability of errorQPSK, QAM.

Module III

Communication through Band-Limited Linear Filter channelsOptimum receiver for channels with ISI andAWGN,Equalization techniques: Linear equalization, Decisionfeedback equalization,Adaptive equalization Algorithms(ZF and LMS).

Module IV

Multi Channel and Multi Carrier Systems: Multichannel Digital communication in AWGN channels,Multicarrier communication- Discrete implementation of multicarrier modulation. FFT based multi carrier system,Spread spectrum principles, Generation of PN sequences, DSSS & FHSS, Synchronization of Spread Spectrum signals.

Module V

Digital Communication through Fading Multipath Channels: Characterisation of fading multipath channel,Frequency-nonselective slowly fading channel, Diversity techniques,Digital signalling over a frequencyselectiveslowly fading channel, RAKE receiver,Multiple access techniques- CDMA signal and channel models.

Course Plan

No	Topic	No. of Lectures
1	**Characterization of Communication Signals and Systems:**	
1.1	Overview of Digital Communication systems.	1
1.2	Communication Channels and Mathematical models	2
1.3	Representation of band pass signals and systems, Signal spacerepresentation.	2
1.4	Representation of digitally modulated signals	2
1.5	Spectral Characteristics of Digitally Modulated Signals.	2
2	**Optimum receiver for AWGN channel:**	
2.1	Correlationdemodulator, matched filter demodulator, optimum detector.	3
2.2	Performance of optimum receiver for memoryless modulationtechniques: probability of error for binary modulation and M-aryorthogonal signals	3
2.3	Probability of errorQPSK, QAM.	2
3	**Communication through Band-Limited Linear Filter channels**	
3.1	Optimum receiver for channels with ISI and AWGN.	3
3.2	Equalization techniques: Linear equalization, Decision feedback equalization,	3
3.3	Adaptive equalization: Algorithms(ZF and LMS)	2
4	**Multi Channel and Multi Carrier Systems**	
4.1	Multichannel Digital communication in AWGN channels	2
4.2	Multicarrier communication: Discrete implementation of multicarrier modulation. FFT based multi carrier system	2
4.3	Spread spectrum principles, Generation of PN sequences,	2
4.4	Direct sequence spread spectrum (DSSS), Frequency Hopping SpreadSpectrum (FHSS), Synchronization of Spread Spectrum signals.	3
5	**Digital Communication through Fading Multipath Channels**	
5.1	Characterisation of fading multipath channel	1
5.2	Frequency-nonselective slowly fading channel	2
5.3	Diversity techniques for Fading Multipath channels	2
5.4	Digital signalling over a frequencyselectiveslowly fading channel. RAKE receiver	2
5.5	Multiple access techniques- CDMA signal and channel models, Random access Methods	3

Text Books

1. John G.Proakis, Digital Communications, 4/e, McGraw-Hill

Reference Books

1. Edward. A. Lee and David. G. Messerschmitt, “Digital Communication”, Allied Publishers (second edition).
2. Viterbi, A. J., and J. K. Omura. Principles of Digital Communication and Coding. NY: McGraw-Hill, 1979. ISBN: 0070675163.
3. Marvin K Simon, Sami M Hinedi, William C Lindsey - Digital Communication - Techniques –Signal Design & Detection, PHI.
4. Bernard Sklar,” Digital Communications: Fundamentals and applications “, Prentice Hall 2001.
5. Andrea Goldsmith,” Wireless Communications”, Cambridge University Press 2005.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC020	MULTIRATE SIGNAL PROCESSING AND WAVELETS	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: Multirate systems play a central role in many areas of signal processing, such as filter bank theory and multiresolution theory. This course imparts a comprehensive knowledge of topics in multirate signal processing and wavelets, essential in some of the standard signal processing techniques such as signal analysis, denoising and other applications.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply sampling rate conversions, decimation and interpolation as part of Signal Processing techniques
CO 2	Design a perfect reconstruction filter bank system
CO 3	Analyze the signal decomposition and reconstruction using tree structured filter banks
CO 4	Design an orthogonal/biorthogonal wavelet system according to the application.
CO 5	Implement the wavelet based decomposition using appropriate filter bank structure
CO 6	Apply wavelets for signal analysis and other applications

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1				3			
CO 2	3					2	
CO 3				3			
CO 4	3						
CO 5				3			
CO 6	3			2			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	20
Evaluate	10
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred):	15 marks
Course based task/Seminar/Data Collection and interpretation:	15 marks
Test paper, 1 no.: (Test paper shall include minimum 80% of the syllabus.)	10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

Name:

Reg. No:

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY **E**

FIRST SEMESTER M.TECH DEGREE EXAMINATION

MULTIRATE SIGNAL PROCESSING AND WAVELETS

Subject: 221EEC020

Time: 2.5 Hours Maximum: 60 Marks

Part A

Answer all questions. Each question carries 5 marks (5x5=25 Marks)

1. Obtain the type-I polyphase decomposition of decimation filter with transfer function $H(z) = 1 + 5z^{-1} + 10z^{-2} + 10z^{-3} + 5z^{-4} + z^{-5}$.

2. The prototype filter of a 2 channel QMF is given as $H_0(z) = a + bz^{-1} + cz^{-2} + dz^{-3} - ez^{-5}$. Design the remaining filtersof the filter bank.

3. Obtain the time frequency variation of the function$(t) = e^{-a|t|}$.

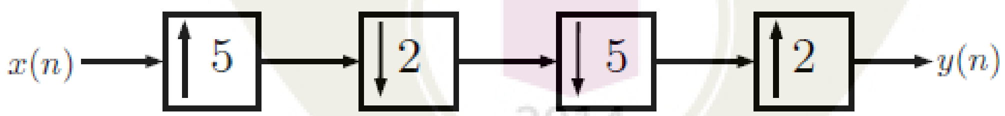
4. Differentiate the concepts of orthogonality and biorthogonality.

5.Explain how wavelets can be used for facial recognition.

Part B

Answer any FIVE full questions; each question carries 7 marks. (5x7=35)

6 a) Consider the following multirate system. Obtain the expression for its output. (3 Marks)



b) Derive the frequency domain input-output relation of a decimator. (4 Marks)

7. a) Design a sampling rate converter to convert a digital audio signal of 48kHz sampling rate to 32kHz sampling rate. (4 Marks)

b) Develop a computationally efficient realization of a factor of 3 interpolator employing a length 15 linear phase FIR filter. (3 Marks)

8. a) Design a 3 channel perfect reconstruction filter bank given its polyphase components as

$$E(z) = \begin{bmatrix} 1 & 2 & 3 \\ 0 & 1 & 4 \\ 5 & 6 & 0 \end{bmatrix}$$

(4 Marks)

b) For a two channel QMF, let the analysis filter $H_0(z) = 2 + 5z^{-1} + 3z^{-2} - 8z^{-3} + 8z^{-4}$.
Design remaining analysis filters and synthesis filters which result in perfect reconstruction. Calculate the alias component matrix for the filter bank. (3 Marks)

9 a) Derive the constraint equations for the design of a Daubechies 6-tap orthogonal wavelet system. (7 Marks)

10 a) Explain B-spline scaling functions. Derive the B-spline scaling function of order 2 from Haar scaling function. (3 Marks)

b) Derive the filter bank structure to obtain the fine scale coefficients $s_{j+1}(k)$ of any signal f(t) from its smooth (s_j (k)) and detail coefficients (d_j (k)) at coarse resolution, and hence explain it with the required block diagram. (4 Marks)

11 a) Derive the analysis and synthesis side equations for a biorthogonal wavelet system. (7 Marks)

12. Deduce the method of decomposing a given sequence into wavelet packets using Haar wavelets and draw the decomposition tree with an example. (7 marks)

Syllabus

Module 1:Multi-rate System Fundamentals

Review of basic multi-rate operations: up sampling and down sampling, time domain and frequency domain analysis, Need for antialiasing and anti-imaging filters.Interpolator and decimator design, Noble identities.Type 1 and Type 2 polyphase decomposition, 2-channel and N-channelpolyphase decomposition .Efficient structures for decimation and interpolation filters, efficient structures for fractional sampling rate conversion.

Module 2:Multi-rate Filter Banks

Overview of Maximally decimated filter banks and non-maximally decimated filter bank. Uniform DFT filter banks - design, polyphase implementation.Two-channel critically sampled filter banks.Amplitude-Complementary 2-Channel Filter Bank
Example - Two channel Haar Filter bank and its polyphase decomposition, Quadrature mirror filter (QMF) bank, Errors in the QMF bank, conditions for perfect reconstruction, polyphase implementation. Design of perfect reconstruction M- channel Filter Banks, Overview of Uniform and non-uniform tree structured filter banks, Dyadic filter bank.

Module 3:Continuous and Discrete Wavelet Transform

Short Time Fourier Transform (STFT), STFT as a bank of filters, Choice of window function and time frequency trade-off.The Uncertainty Principle and Time Frequency Tiling,Continuous wavelet transform (CWT) and inverse CWT,Properties of Wavelets used in CWT, Admissibility condition.Concept of orthogonal and orthonormal basis functions, function spaces. Discrete Wavelet Transform.Haar Scaling Function, Nested Spaces, Haar Wavelet Function, Orthogonality of scaling and translate functions, Normalization of Haar Bases at different Scales, Refinement Relation with respect to normalized bases.Support of a Wavelet System, Daubechies Wavelets.

Module 4:Design of Orthogonal & Biorthogonal wavelets systems

Designing Orthogonal Wavelet systems - a direct approach, Frequency domain approach for designing wavelets. Implementation using tree structured QMF bank and equivalent M-channel filter bank.Designing Biorthogonal Wavelet systems: Biorthogonality in Vector Space, Biorthogonal Wavelet Systems.Signal Representation Using Biorthogonal Wavelet System,Biorthogonal Analysis and Biorthogonal Synthesis.Construction of Biorthogonal Wavelet Systems-B-splines,Computation of the discrete wavelet transform using Mallat Algorithm and Lifting Scheme

Module 5:Wavelet Packet Analysis and applications of wavelets

Wavelet Packet Transform – Signal representation using wavelet packet analysis
Applications of Wavelets and Wavelet Packets in Signal and Image compression
Wavelet based signal denoising.

Course Plan

No	Topic	No. of Lectures
1	**Multi-rate System Fundamentals:**	
1.1	Review of basic multi-rate operations: up sampling and down sampling, time domain and frequency domain analysis, Need for antialiasing and anti-imaging filters. Interpolator and decimator design, Noble identities.	3
1.2	Type 1 and Type 2 polyphase decomposition, 2-channel and N-channelpolyphase decomposition	2
1.3	Efficient structures for decimation and interpolation filters, efficient structures for fractional sampling rate conversion.	3
2	**Multi-rate Filter Banks**	
2.1	Overview of Maximally decimated filter banks and non-maximally decimated filter bank. Uniform DFT filter banks - design, polyphase implementation. Two-channel critically sampled filter banks Amplitude-Complementary 2-Channel Filter Bank Example - Two channel Haar Filter bank and its polyphase decomposition.	3

2.2	Quadrature mirror filter (QMF) bank , Errors in the QMF bank, conditions for perfect reconstruction, polyphase implementation	2
2.3	Design of perfect reconstruction M- channel Filter Banks	2
2.4	Overview of Uniform and non-uniform tree structured filter banks. Dyadic filter bank.	1
3	**Continuous and Discrete Wavelet Transform**	
3.1	Short Time Fourier Transform (STFT), STFT as a bank of filters, Choice of window function and time frequency trade-off.	2
3.2	The Uncertainty Principle and Time Frequency Tiling	1
3.3	Continuous wavelet transform (CWT) and inverse CWT. Properties of Wavelets Used in CWT, Admissibility condition.	2
3.4	Concept of orthogonal and orthonormal basis functions, function spaces. Discrete Wavelet Transform. Haar Scaling Function, Nested Spaces. Haar Wavelet Function, Orthogonality of scaling and translate functions, Normalization of Haar Bases at different Scales, Refinement Relation with respect to normalized bases. Support of a Wavelet System, Daubechies Wavelets.	4
4	**Design of Orthogonal & Biorthogonal wavelets systems**	
4.1	Designing Orthogonal Wavelet systems - a direct approach, Frequency domain approach for designing wavelets. Implementation using tree structured QMF bank and equivalent M-channel filter bank.	3
4.2	Designing Biorthogonal Wavelet systems: Biorthogonality in Vector Space, Biorthogonal Wavelet Systems. Signal Representation Using Biorthogonal Wavelet System, Biorthogonal Analysis and Biorthogonal Synthesis. Construction of Biorthogonal Wavelet Systems-B-splines	3
4.3	Computation of the discrete wavelet transform using Mallat Algorithm and Lifting Scheme	3
5	**Wavelet Packet Analysis and applications of wavelets**	
5.1	Wavelet Packet Transform – Signal representation using wavelet packet analysis	2
5.2	Applications of Wavelets and Wavelet Packets in Signal and Image compression	3
5.3	Wavelet based signal denoising.	2

Reference Books

1.P. P. Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education, 2006.

2.Fredric J Harris, Multirate Signal Processing for Communication Systems, 1st Edition, Pearson Education, 2007

3.Sanjit K. Mitra, Digital Signal Processing: A Computer based Approach, Special Indian Edition,McGraw Hill, 2013.

4. Spectral Audio Signal Processing, Julius O. Smith III, W3K Publishing, 2011.

5. N.J. Fliege, Multirate Digital Signal Processing, John Wiley, 1994.

6. K. P. Soman, K. I. Ramachandran, N. G. Resmi, PHI, Insight into wavelets :From theory topractice

7. G.Strang& T. Nguyen , Wavelets and Filter bank, Wellesly-Cambridge

8. M. Vetterli& J. Kovacevic, Wavelets and sub band coding, Prentice Hall

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC021	ADAPTIVE SIGNAL PROCESSING	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: This course introduces the design and analysis of signal processing algorithms which can automatically change the system parameters to get a desired output, when a stationary random signal is applied to it.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyse stationary random signals and adaptive systems.
CO 2	Analyse performance of the gradient search algorithms.
CO 3	Evaluate the effect of gradient noise in weight vector solution.
CO 4	Analyse LMS algorithms, adaptive recursive filters and Kalman filters.
CO 5	Apply the adaptive systems for applications in system modelling and inverse adaptive modelling.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1						
CO 2	2		2		2		
CO 3	2		2		2		
CO 4	2		2	3	2		
CO 5	2		2	3	3	2	

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	20%
Apply	70%
Analyse	10%
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred):	15 marks
Course based task/Seminar/Data Collection and interpretation:	15 marks
Test paper, 1 no.: (Test paper shall include minimum 80% of the syllabus.)	10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper Subject: 221EEC021

Name:
Reg. No: **E**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M. TECH DEGREE EXAMINATION

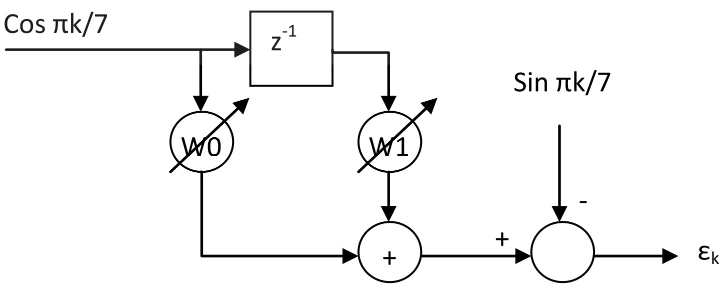
ADAPTIVE SIGNAL PROCESSING

Time: 2.5 Hours Maximum: 60 Marks

PART A (Answer all questions)

1	Prove that the autocorrelation of a non-zero wide sense stationary random sequence is positive definite. Compute the 2x2 auto correlation matrix of $x(n) = a + N(0,\sigma)$, where a and σ are constants, *N(.)* refers to normal distribution.	5 marks
2	Compare and contrast various configurations of adaptive systems. Give one example for each.	5 marks
3.	Evaluate the expression for MSE performance surface of a system with $R = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$, $P = \begin{bmatrix} 5 \\ 6 \end{bmatrix}$, $E(d_k{}^2) = 11$ at the weight vector $w = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$. Calculate ξ_{min}.	5 marks
4.	Obtain the expression for weight updation in the LMS algorithm. What is the condition for convergence in the LMS algorithm?	5 marks
5.	Illustrate the method for adaptive modelling of earth's impulse response for geophysical exploration	5 marks

PART B (Answer any five question)

6	Compute the most significant two Eigen vectors of the correlation matrix $R = \begin{bmatrix} 4 & 3 & 0 \\ 3 & 6 & 2 \\ 0 & 2 & 4 \end{bmatrix}$	7 marks
7.	 Consider the adaptive system given in figure. Write an expression for the	7 marks

performance surface. Determine a range for the adaptive gain constant. Calculate W* and ξ_{min}.

Module 2

8.	Determine the autocorrelation matrix, performance penalty and perturbation of a two-weight system with performance surface $\xi = 16w_0^2 + 16w_1^2 + 6w_0 + 4w_1 + 16w_0 w_1 + 42$ and δ=1/4.	7 marks
9.	Derive the prediction and correction equations of the discrete Kalman Filter.	7 marks
10 a.	Derive the expressions for the weight updating in adaptive recursive filter.	5 marks
10 b.	Identify major challenges in adaptive recursive filter implementation.	2 marks
11.	Explain in detail about the adaptive modelling of multipath communication channels.	7marks
12	Derive the expression for the covariance of noise in the gradient estimation in the case of steepest descent method?	7marks

Syllabus

(For 3 credit courses, the content can be for 40 hrs)

Review of discrete time stochastic process and auto correlation matrix - Introduction to adaptive systems - performance functions - Gradient search methods -Gradient estimation and its effects on the adaptation - LMS algorithm - Adaptive recursive filters - discrete Kalman filter- application of adaptive filtering.

Course Plan

No	Topic	No. of Lectures
1	**Review of discrete time stochastic process and auto correlation matrix**	
1.1	Univariate and Multivariate random sequences, Gaussian noise	3
1.2	Autocorrelation matrix of stationary process and its properties	2
1.3	Eigen decomposition, properties of Eigen vectors, whitening	3
2	**Introduction to adaptive systems**	
2.1	Introduction to adaptive systems – definitions– characteristics– configurations – applications	2
2.2	Adaptive linear combiner – MSE performance function – Wiener-Hopf equation	2
2.3	Searching the MSE performance function – Newton's method for searching the performance function, stability and convergence	2
2.4	Steepest descent algorithm – Stability and convergence – Learning curve	2
3	**Gradient estimation and its effects on adaptation**	
3.1	Performance penalty and perturbation	2
3.2	Effects on weight vector solution, covariance of weight vector	3
3.3	Excess MSE, mis adjustment and time constants	2
4	Adaptive algorithms and structures	
4.1	LMS algorithm, Convergence of weight vector and learning curve	2
4.2	Adaptive recursive filters	2
4.3	Discrete Kalman Filter, filtering example	4
5	**Applications of adaptive filtering**	
5.1	Adaptive modelling of multipath communication channel	2
5.2	Adaptive modelling for FIR filter synthesis	2
5.3	Adaptive equalization of telephone channels	2
5.4	Adapting poles and zeros for IIR digital filter synthesis	2

Reference Books

1. Bernard Widrow and Samuel D. Stearns, Adaptive signal processing, Pearson education.
2. Simon Hykins, Adaptive filter theory, Fifth edition, Pearson education.
3. A. Papaulis and U. Pillai, Probability Random Variables and Stochastic Processes, 4th Edition, McGraw Hill Education.
4. S. Thomas Alexander, Adaptive Signal Processing – Theory and Applications, SpringerVerlag

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC023	**OPTIMIZATION TECHNIQUES**	**PROGRAM ELECTIVE 2**	**3**	**0**	**0**	**3**

Preamble: This course aims to enable the students to apply suitable optimization techniques for various applications.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO1	Outline the mathematical building blocks of optimization
CO2	Model and solve linear programming problems
CO3	Apply principles and techniques for solving nonlinear programming models
CO4	Investigate and assess constrained convex optimization problems
CO5	Appreciate prominent heuristic optimization algorithms
CO 6	Solve optimization problem through optimization software

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3		2	3	3	1	
CO2	3	1	2	3	3	1	1
CO3	3	1	2	3	3	1	1
CO4	3	1	2	3	3	1	1
CO5	3		2	3	3	1	1
CO 6	3	1	2	3	3	1	1

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyze	20
Evaluate	10
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	**40**	**60**	**2.5hours**

Continuous Internal Evaluation Pattern:

- Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): *15 marks*
- Course based Task/ Seminar/ Data: *15 marks*
- Test paper 1 no. (Test paper shall include minimum 80% of syllabus):*10marks*

End Semester Examination Pattern:

The end semester examination will be conducted by respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: *The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.*

SYLLABUS

Module 1:

Mathematical Background:

Vector norm, Matrix norm, Inner product, Norm ball, Interior point, Closure and boundary, Complement, scaled sets, and sum of sets, Supremum and infimum, Vector subspace, Function, Continuity of function, Derivative and gradient, Hessian, Convex sets and convex functions. Introduction to optimization - Optimal problem formulation, Engineering applications of optimization, Optimization techniques - Classification.

Module 2:

Linear Programming:

Linear Programming **-** Formulation of the problem, Graphical method, Simplex method, Artificial variable techniques, Duality Principle, Dual simplex method.

Module 3:

Non-linear programming:

Unimodal Function, Elimination methods – Fibonacci method, Golden section method, Direct search methods – Random walk, Grid search method, Indirect search methods – Steepest descent method, Newton’s method.

Module 4:

Convex optimization:

Standard form of convex optimization problems, Global optimality, An optimality criterion for differentiable convex function, Lagrange dual function and conjugate function, Lagrange dual problem, Karush–Kuhn–Tucker (KKT) optimality conditions, Lagrange dual optimization.

Module 5:

Optimization algorithms:

Genetic algorithm, Neural network-based optimization, Ant colony optimization, Particle swarm optimization. Optimization Libraries in Python: scipy.optimize, CVXPY, CVXOPT.

Text Books

1. Chong-Yung-Chi, Wei-Chiang Li, Chia-Hsiang Lin, Convex Optimization for Signal Processing and Communications – From fundamentals to applications, CRC press.
2. Sukanta Nayak, Fundamentals of Optimization Techniques with Algorithms, Academic press.
3. Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley and Sons.

Reference Books

1. Igor Griva, ArielaSofer, Stephen G Nash,Linear and Nonlinear Optimization, Second edition, SIAM.
2. Kalyanmoy Deb,Optimization for Engineering: Design Algorithms and Examples, Second edition,Prentice Hall.
3. David G Luenberger, Linear and Nonlinear Programming, Second edition, Addison-Wesley.

No	Topic	No. ofLectures
1	**Mathematical Background:**	
1.1	Vector norm, Matrix norm, Inner product, Norm ball	1
1.2	Interior point, Closure and boundary	1
1.3	Complement, scaled sets, and sum of sets, Supremum and infimum	1
1.4	Vector subspace, Function, Continuity of function,	1
1.5	Derivative, gradient and Hessian	1
1.6	Convex sets and convex functions	1
1.7	Introduction to optimization - Optimal problem formulation	1
1.8	Engineering applications of optimization, Optimization techniques Classification	1
2	**Linear Programming:**	
2.1	Linear Programming **-** Formulation of the problem, Graphical method	2
2.2	Simplex method	2
2.3	Artificial variable techniques, Duality Principle	2
2.4	Dual simplex method	2
3	**Non-linear programming:**	

3.1	Uni-modal Function	1
3.2	Elimination Methods: (1) Fibonacci Method	1
3.3	Elimination Methods: (2) Golden Section Method	1
3.4	Direct Search Methods: (1) Random Walk	1
3.5	Direct Search Methods: (2) Grid Search Method	1
3.6	Indirect Search Method: (1) Steepest Descent Method	1
3.7	Indirect Search Method: (2) Newton's Method	2
4	**Convex optimization:**	
4.1	Standard form of convex optimization problems	1
4.2	Global optimality, An optimality criterion for differentiable convex function	2
4.3	Lagrange dual function and conjugate function	1
4.4	Lagrange dual problem	2
4.5	Karush–Kuhn–Tucker (KKT) optimality conditions	2
5	**Optimization algorithms:**	
5.1	Genetic algorithm	1
5.2	Neural network-based optimization	2
5.3	Ant colony optimization	2
5.4	Particle swarm optimization.	1
5.5	Optimization Libraries in Python: scipy.optimize, CVXPY, CVXOPT	2

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M. TECH DEGREE EXAMINATION

Electronics and Communication Engineering

Streams: Signal Processing, Signal Processing and Embedded Systems, Communication Engineering & Signal Processing

Course Code and Course Name: 221EEC023 Optimization Techniques

Max.Marks: 60 Duration:2.5 Hours

PARTA

Answer ALL Questions. Each Carries 5 marks.

1. Define the gradient of the function. Demonstrate its importance in the multi-variable optimization

2 State and prove complementary slackness theorem.

3 Using Newton's method minimize $f=(3x_1-1)^3 + 4x_1x_2 + 2x_2^2$ by taking initial point as (1,2)

4 State and prove Kuhn – Tucker conditions in non-linear programming

5 Differentiate supervised and supervised learning.

PART–B

Answer any FIVE full questions; each question carries 7 marks.

6.a) Given, $\Psi_1^{-1}=\begin{bmatrix}0.5000 & 0.5000 & 0.5000 & 0.5000\\ 0.6533 & 0.2706 & -0.2706 & -0.6533\\ 0.5000 & -0.5000 & -0.5000 & 0.5000\\ 0.2706 & -0.6533 & 0.6533 & -0.2706\end{bmatrix}$,

$\Psi_2^{-1}=\begin{bmatrix}1 & 1 & 1 & 1\\ 1 & -j & -1 & j\\ 1 & -1 & 1 & -1\\ 1 & j & -1 & -j\end{bmatrix}$ and $x=\begin{bmatrix}4\\5\\5\\4\end{bmatrix}$ 4 marks

Let Ψ_1 and Ψ_2 be two change of basis matrices. Obtain the representation of the given vector x in terms of Ψ_1 and Ψ_2. Calculate l_0, l_1 and l_∞ norms of the representation.

6.b) Discuss the convexity and concavity of the following functions

a) $f(x) = (x_1 + x_2)e^{(x_1+x_2)} x_1 > 0, x_2 > 0$

b) $f(x) = x_1 f_1(x) + x_2 f_2(x) x_1 \geq 0, x_2 \geq 0$ and both $f_1(x)$ and $f_2(x)$ are convex functions 3 marks

7.a) Congratulations! Upon graduating from college, you have immediately been offered a high-paying position as president of the Lego Furniture Company. Your company produces chairs (each requiring 2 square blocks and 1 rectangular block) as well as tables (each requiring 2 square blocks and 2 rectangular blocks) and has available resources consisting of 8 rectangular 3 marks blocks and 6 square ones. Assume chairs and tables each sell for 5 and 7 respectively, and that your company sells all of what it produces.

(i) Set up an LP whose objective is to maximize your company's revenue.

(ii) Represent it in the standard form and matrix form.

7.b) Solve the following LPP using dual simplex method — 4 marks

$$\min z = 3x_1+2x_2$$

subject to
$$2x_1+3x_2 \geq 30$$
$$-x_1+2x_2 \leq 6$$
$$x_1+3x_2 > 20$$
$$x_1, x_2 \geq 0$$

8a) Solve the following optimization problem using Simplex algorithm. — 3 marks

$$\max_{x_1,\, x_2,\, x_3} \; 15x_1 + 4x_2 - 5x_3$$
$$s.\,t. \quad x_1 + x_2 - x_3 \leq 21$$
$$3x_1 + 2x_2 + 2x_3 \leq 42$$
$$2x_1 + 3x_3 \leq 42$$
$$x_1 \geq 0,\; x_2 \geq 0, x_3 \geq 0$$

8 b) Consider an LPP — 4 marks

$$\max z = -x_1 - x_2$$

subject to
$$-x_1+ x_2 \geq 1$$
$$2x_1- x_2 \leq 2$$
$$x_1, x_2 \geq 0$$

Find the dual to the problem. Solve the primal and the dual graphically, and verify that the results of the strong duality theorem hold.

9a) Prove that in Fibonacci search algorithm, at the end of (n-1) iterations, the length of the interval of uncertainty is reduced from (b_1-a_1) to $(b_1-a_1) / F_n$. Moreover, show that Fibonacci method is more efficient than Golden section search algorithm. — 4 marks

9 b) Use Newton's method to solve, — 3 marks

minimize $f(x_1,x_2) = 5x_1^4+6x_2^4-6x_1^2+2x_1x_2+5x_2^2+15x_1-7x_2+13$

Use the initial guess $(1, 1)^T$.

10a) Use the steepest descent method to solve — 4 marks

minimize $f(x_1,x_2) = 4x_1^2+4x_1x_2+2x_2^2-3x_1$, starting from the point $(2, 2)^T$.

Perform three iterations.

10 b) Describe Grid search method with a suitable example. — 3 marks

11a) Consider the problem — 4 marks

$$\min\ f(x_1,x_2,x_3,x_4) = x_1^2+x_2^2+x_3^2+x_4^2$$

subject to $g_1(x_1,x_2,x_3,x_4) = x_1+2x_2+3x_3+5x_4-10 = 0$

$g_2(x_1,x_2,x_3,x_4) = x_1+2x_2+5x_3+6x_4-15 = 0$

Solve the problem using Lagrangian method and compute the Lagrange multipliers.

11 b) Formulate the Karush-Kuhn-Tucker (KKT) necessary conditions for the following optimization problem — 3 marks

min $z = x_1 + x_2$

subject to $g_1(x_1,x_2) = x_1^3-x_2 \geq 0$

$g_2(x_1,x_2) = x_1 \geq 0$

$g_3(x_1,x_2) = x_2 \geq 0$

12 a) Explain Ant Colony Optimization algorithm in detail. — 4 marks

12 b) Describe Particle Swam Optimization algorithm. List out its advantages, disadvantages and applications. — 3 marks

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC019	CODING THEORY	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: This course aims at a rigorous analysis of various error correction codes starting from the earliest Hamming code to the latest polar codes used in 5G

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyse block codes and various bounds governing their construction
CO 2	Analyse LDPC coding and hard decision/soft decision decoding
CO 3	Illustrate coding and decoding of BCH/RS codes
CO 4	Review convolutional encoding and decoding them using BCJR algorithm
CO 5	Illustrate coding and decoding of Turbo codes
CO 6	Discuss polar codes and their applications in 5G

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	2				
CO 2	3	2	2				
CO 3	3	3	3				
CO 4	3	2	3				
CO 5	3	3	2				
CO 6	3	3	3				

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	10
Analyse	25
Evaluate	20
Create	5

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

- Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
- Course based task/Seminar/Data collection and interpretation:15 marks
- Test paper, 1 no. :10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B

- Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions.
- Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY
M.TECH DEGREE EXAMINATION
FIRST SEMESTER
CODING THEORY

Time: 2.5 Hours **Max. Marks: 60**

PART A

Answer All Questions **5 x 5 marks = 25 marks**

1. Explain Hamming bound and Gilbert-Varshamov bound
2. Analyse the effect of short-cycles in the decoding of LDPC codes
3. Show that the dual of an RS code is also an RS code (and hence MDS)
4. Construct the Generator matrix of a RM(1,3) code
5. Discuss the encoding of Turbo codes

PART B

Answer any 5 questions **5 x 7 marks = 35marks**

6.The parity check bits of a (8,4) block code are generated by, $p_0 = m_0 + m_1 + m_3$, $p_1 = m_0 + m_1 + m_2$,$p_2 = m_0 + m_2 + m_3$, $p_3 = m_1 + m_2 + m_3$ where m_0 , m_1, m_2 and m_3 are the message digits.

a) Find the generator matrix and the parity check matrix for this code in the form $G=[P:I_k]$

b) Find the minimum weight of this code.

c) Find the error-detecting capabilities of this code.

d) Check whether 11101000 and 11100000 are valid codewords using H matrix.

7. a)Explain hard decision decoding of LDPC codes using Bit-flipping algorithm in BSC.
   b) .Explain BCJR decoding of convolutional codes

8. For a binary, narrow sense, triple error correcting BCH code of length 15, constructed using the polynomial x^4+x+1

(a) Compute a generator polynomial for this code

(b) Determine the rate of the code

(c) Construct the parity check matrix and generator matrix for this code

9. Form the generator matrix of the first order RM code RM (1,3) of length 8. What is the minimum distance of the code? Determine its parity check sums and devise a majority logic decoder for the code. Decode the received vector r = (01000101)

10. Describe the basic ideas of polarization. Analyse mathematically channel polarisation for N=2 channel

11.Analyze the iterative soft decoding of Turbo codes

12. Differentiate between the BCH Viewpoint and Vandermonde viewpoints of Reed Solomon Codes

Syllabus

Module 1 Linear Block Codes and Bounds: Course Overview-Relevance of Error correction schemes in communication systems, Repetition coding, concepts of Code rate, Hamming Distance, Minimum Distance, Error detecting and correcting capability, Review of Group, ring, fields and vectorspaces, Hamming bound, Singleton bound, Plotkin bound, Gilbert-Varshamov bound

Module 2 LDPC Codes Regular and Irregular Low Density Parity Check Codes-Tanner graph, Message Passing decoding-Hard decision and Soft decision, Bit flipping algorithm for decoding, Bit flipping algorithm for decoding, Belief Propagation decoding: Sum Product algorithm

Module 3 BCH and RS codes Galois Fields -- Irreducible and Primitive Polynomials- BCH Codes - Design, BCH Bound, Decoding BCH codes – Decoding BCH – the general outline, computation of the syndrome, error locator polynomial, Chien Search algorithm, Finding the error locator polynomial. Berlekamp Massey Algorithm. Burst-error correction capability of BCH codes. Reed Solomon Codes – BCH code viewpoint. Vandermonde matrix view point

Module 4 Convolutional Codes and Turbo codes Review of convolutional codes : Encoding, state diagram, trellis diagram , Viterbi Decoding, BCJR algorithm, Turbo Codes: Turbo encoder, Parallel concatenation decoding

Module 5 Reed-Muller Codes and Polar Codes Reed Muller Codes, Encoding and decoding of RM (1, m) codes. Majority-logic decoding of Reed-Muller codes. Polar Codes – Introduction, polarization of BEC channels, Polar transform and frozen bits.

Course Plan

No	Topic	No. of Lectures
1	**Linear Block Codes and Bounds**	
1.1	Course Overview-Relevance of Error correction schemes in communication systems	1
1.2	Repetition coding, concepts of Code rate, Hamming Distance, Minimum Distance, Error detecting and correcting capability.	1

1.3	Review of Group,ring, fields and vector spaces	2
1.4	Linear Block codes-Generator and parity check matrices,encoding, standard array and syndrome decoding, Hamming codes	2
1.5	Maximum Distance Separable (MDS) codes	1
1.6	Bounds on size of codes: Hamming bound, Singleton bound, Plotkin bound, Gilbert-Varshamov bound	2
2	**LDPC Codes**	
2.1	Regular and Irregular Low Density Parity Check Codes-Tanner graph	1
2.2	Message Passing decoding-Hard decision and Soft decision	1
2.3	Message passing decoding in a BEC	1
2.4	Bit flipping algorithm for decoding	1
2.5	Belief Propagation decoding: Sum Product algorithm	2
3	**BCH and RS codes**	
3.1	Galois Fields -- Irreducible and Primitive Polynomials, Primitive elements, Field extension, Conjugate elements and Minimal Polynomials. Cyclotomiccosets.	2
3.2	BCH Codes - Design, BCH Bound, Decoding BCH codes – Decoding BCH – the general outline, computation of the syndrome, error locator polynomial, Chien Search algorithm, Finding the error locator polynomial. Berlekamp Massey Algorithm. Burst-error correction capability of BCH codes.	4
3.3	Reed Solomon Codes – BCH code viewpoint. Vandermonde matrix view point. MDS property. Generalized Reed-Solomon codes. Application of BCH decoding algorithms to Reed-Solomon decoding. Sudan's algorithm for decoding. Use of RS codes in disks and cloud storage.	4
4	**Convolutional Codes and Turbo codes**	
4.1	Review of convolutional codes: Encoding, state diagram, trellis diagram	1
4.2	Review of convolutional codes: Viterbi Decoding	1
4.3	Decoding of convolutional codes: BCJR algorithm	2
4.4	Turbo Codes: Turbo encoder, Parallel concatenation decoding	3
5	**Reed-Muller Codes and Polar Codes**	
5.1	Reed Muller Codes, Encoding and decoding of RM (1, m) codes. Majority-logic decoding of Reed-Muller codes.	4
5.2	Polar Codes – Introduction, polarization of BEC channels, Polar transform and frozen bits.	4

Text Books

1. Shu Lin, D. J Costello Jr. Error Control Coding: Fundaments and Applications, Prentice Hall

Reference Books:

1. Ron M Roth, Introduction to Coding Theory, Cambridge University Press

2. T. Richardson, R. Urbanke, Modern Coding Theory, Cambridge University Press

3. A. Thangaraj, LDPC and Polar Codes in 5G Standard, NPTEL

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC018	DSP PROCESSORS AND ARCHITECTURE	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: The aim of the course is to give an overview of the commonly used DSPalgorithms, their applications and various techniques for the algorithmic and architecturelevel optimisations through various algorithm to architecture mapping which can lead to efficient hardware implementations. The course also introduces the basic features in DigitalSignal Processors,Micro controllers with DSP extensions, DSP Architecture with case studies, the latest architectural trends in DSPsand their programming tools.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyse the basic resource constraints in a practical DSP system and solve them using various techniques/transformations that map the DSP algorithms to efficient architectures.
CO 2	Apply the knowledge of various single core and multicore Digital Signal Processor architectures in identifying the optimal processor for solving real life signal processing problems.
CO 3	Evaluate the DSP algorithms implemented in dedicated DSP processors and the micro controllers with DSP extensions
CO 4	Create algorithms to solve signal processing problems using the latest hardware platforms and software tools.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1		3	3	3	1	
CO 2	1		3	3	3	1	
CO 3	1		3	3	3	1	
CO 4	2		3	3	3	2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	15
Evaluate	15
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10) Publications shall be referred): 15 marks

Course based task/Seminar/Data Collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination question paper consists of two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus

Module 1: Basics of DSP Algorithm Representation to Architecture Mapping

DSP Algorithm representations –Block Diagram, Signal Flow Graph, Data Flow Graph, Dependence Graph;

Introduction to Filter structures- Recursive, Non-recursive and Lattice structures;

Fundamentals of DSP algorithm to architecture mapping - Loop bound, Iteration Bound, Critical Path;

Algorithms for computing Iteration Bound – Longest Path Matrix Algorithm, Minimum Cycle Mean Algorithm.

Module 2: Transformations for Improved DSP Architectures

VLSI performance measures - area, power, and speed;
Pipelining - Pipelining of FIR filters, Concept of Fine Grain Pipelining;
Parallel Processing – Designing Parallel FIR systems;
Pipelining and Parallel Processing for low power;
Folding and Unfolding Transformations and its applications.

Module 3: Single Core DSP Architectures

Introduction to General Purpose Processors (GPP), Microcontroller Units (MCU), Digital Signal Processors (DSP) - comparison and Applications;
The key features of a Digital Signal Processors – Dedicated hardware units, Circular Buffers, Modified bus structures and Memory access schemes;
Introduction to Harvard, Super Harvard DSP architectures, Concept of Instruction Level Parallelism, VLIW Architecture and Single Instruction Multiple Data (SIMD) processor architecture;
Case Study 1: Introduction to a popular DSP from Texas Instruments, The TMS320C67xx Series Processor- CPU Architecture - CPU Data Paths and Control - Timers – Multichannel Buffered Serial Ports (McBSPs)- Internal Data/ Program Memory - External Memory Interface.

Case Study 2: Introduction to ARM Cortex-M Based Microcontrollers with DSP extensions - ARMv7E-M architecture

Module 4: Homogeneous Multicore DSPs

Introduction to multicore processors and their applications, A brief comparison between DSP SoCs, Field-Programmable Gate Arrays (FPGAs), Graphic Processors and CPUs;
Introduction to Multicore DSP Architectures: The TMS320C66x
architecture: The CPU, Overview of the peripherals, Overview of the memory organization.

Module 5: Programming the DSPs

Introduction to Code Composer Studio (CCS) software development tool and the TMS320C6XX EVM kit. Introduction to Keil Development tool, CMSIS DSP software library and ARM Cortex-M4 development board;
Introduction to Open MP Application Programming Interface (API) and Open Computing Language (OpenCL);
Implementation of simple DSP algorithms;
Latest architectural trends in digital signal processing: Introduction to Heterogeneous Multicore DSP Architecture and FPGA SoCs.

Course Plan

No	Topic	No. of Lectures
1	**Basics of DSP Algorithm Representation to Architecture Mapping**	
1.1	DSP Algorithm representations –Block Diagram, Signal Flow Graph,Data Flow Graph, Dependence Graph.	2
1.2	Introduction to Filter structures- Recursive, Non-recursive and Lattice structures.	1
1.3	Fundamentals of DSP algorithm to architecture mapping - Loop bound,Iteration Bound, Critical Path.	2
1.4	Algorithms for computing Iteration Bound – Longest Path Matrix Algorithm, Minimum Cycle Mean Algorithm.	2
2	**Transformations for Improved DSP Architectures**	
2.1	VLSI performance measures - area, power, and speed	1
2.2	Pipelining - Pipelining of FIR filters, Concept of Fine Grain Pipelining.	2
2.3	Parallel Processing – Designing Parallel FIR systems.	2
2.4	Pipelining and Parallel Processing for low power.	1
2.5	Folding and Unfolding Transformations and its applications.	2
3	**Single Core DSP Architectures**	
3.1	Introduction to General Purpose Processors (GPP), Microcontroller Units (MCU), Digital Signal Processors (DSP) - comparison and Applications.	1
3.2	The key features of a Digital Signal Processors – Dedicated hardware units, Circular Buffers, Modified bus structures and Memory access schemes.	1
3.3	Introduction to Harvard, Super Harvard DSP architectures, Concept of Instruction Level Parallelism, VLIW Architecture and Single Instruction Multiple Data (SIMD) processor architecture.	1
3.4	Case Study 1: Introduction to a popular DSP from Texas Instruments, The TMS320C67xx Series Processor- CPU Architecture - CPU Data Paths and Control - Timers – Multichannel Buffered Serial Ports (McBSPs)- Internal Data/ Program Memory - External Memory Interface.	3
3.5	Case Study 2: Introduction to ARM Cortex-M Based Microcontrollers with DSP extensions - ARMv7E-M architecture	3
4	**Homogeneous Multicore DSPs**	
4.1	Introduction to multicore processors and their applications, A brief comparison between DSP SoCs, Field-Programmable Gate Arrays (FPGAs), Graphic Processors and CPUs.	1

4.2	Introduction to Multicore DSP Architectures: The TMS320C66x architecture: The CPU, Overview of the peripherals, Overview of the memory organization.	4
5	**Programming the DSPs**	
5.1	Introduction to Code Composer Studio (CCS) software development tool and the TMS320C6XX EVM kit Introduction to Keil Development tool, CMSIS DSP software library and ARM Cortex-M4 development board	3
5.2	Introduction to Open MP Application Programming Interface (API) and Open Computing Language (OpenCL).	2
5.3	Implementation of simple DSP algorithms	2
5.4	Latest architectural trends in digital signal processing: Introduction to Heterogeneous Multicore DSP Architecture and FPGA SoCs.	1

Text Books

1. Keshab K. Parhi, "VLSI Signal Processing Systems, Design and Implementation", John Wiley &Sons,1999
2. NaimDahnoun, "Multicore DSP: from algorithms to real-time implementation on the TMS320C66x SoC". John Wiley & Sons, 2018.
3. Steven W. Smith, "The Scientist and Engineer's Guide to Digital Signal Processing" Second Edition, California Technical Publishing , 1999.
4. Reference Link for Overview of Latest Processor Architectures– Digital signal processors (DSPs) | Overview | Processors | TI.com, https://training.ti.com/system/files/docs/c66x-corepac-instruction-set-referenceguide.pdf
5. Joseph Yiu "The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors", Elsevier, 2014

Reference Books

1.RulphChassaing, "Digital Signal Processing and Applications with the C6713 and C6416 DSK", John Wiley & Sons, 2005.

2.Sen M. Kuo, Woon-Seng S. Gan, Digal Signal Processors: Architectures, Implementations, and Applications, Prentice Hall, 2004.

3.Lars Wanhammar, DSP Integrated Circuits, Academic Press, 1999.

4.B Venkataramani, M Bhaskar, "Digital Signal Processors: Architecture, Programming and Applications", 2nd Ed., Tata McGraw-Hill Education, 2002.

5. A. Kharin, S. Vityazev and V. Vityazev, "Teaching multi-core DSP implementation on EVM C6678 board," 2017 25th European Signal Processing Conference (EUSIPCO), 2017, pp. 2359-2363, doi: 10.23919/EUSIPCO.2017.8081632

6.Donald S. Reay.. "Digital Signal Processing Using the ARM Cortex M4", (1st. ed.). Wiley Publishing, 2015

7.CemÜnsalan, M. ErkinYücel, H. DenizGürhan, "Digital Signal Processing Using Arm Cortex-M Based Microcontrollers: Theory and Practice", ARM Education Media, 2018.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M. TECH DEGREE EXAMINATION, (**Model Question Paper)**

Course Code: 221EEC018

Course Name: DSP PROCESSORS AND ARCHITECTURE

Max. Marks: 60 Duration: 2.5 Hours

PART A

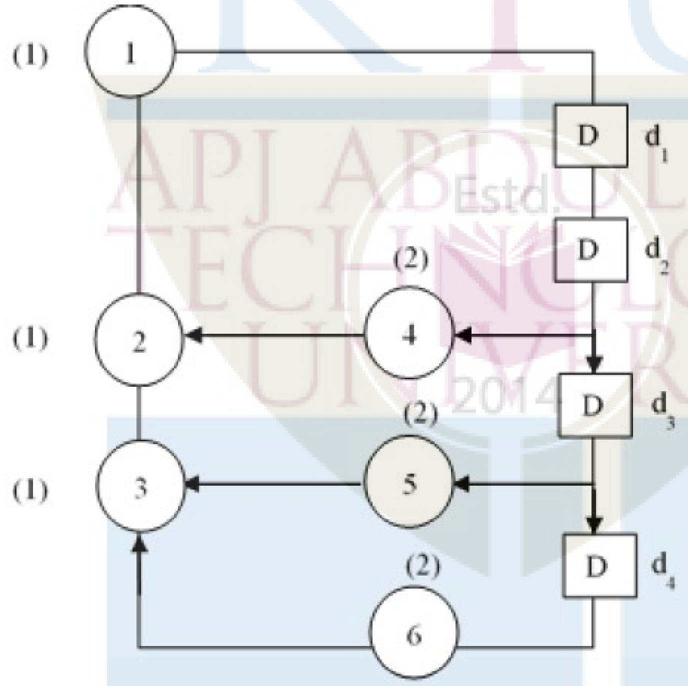
Answer all Questions. Each Carries 5 mark.

1	Differentiate between Signal Flow Graph (SFG) and Data Flow Graph (DFG) with example.
2	What is pipelining? Explain with an example, how it helps in reducing the critical path delay in implementing the DSP systems.
3	In what way the Super Harvard architecture-based DSPs differs from the normal microprocessors?
4	What is the concept of Heterogeneous Multicore DSP Architecture? Quote an example processor?
5	Quoting a suitable example, explain the architectural advantages of an FPGA SoC.

PART – B

(Answer any five questions, each carries 7 mark.)

6	Explain the Longest Path Matrix (LPM) Algorithm for computing the iteration bound of a DFG. For the DFG shown in figure below, the computation times of the nodes are shown in parentheses. Compute the iteration bound of this DFG using the LPM algorithm.



7	For the following transfer function given, Derive the basic lattice filter and draw its structure

	$H(z)=\frac{3.9+2.3z^{-1}+z^{-2}}{1+0.3z^{-1}+0.5z^{-2}}$ $H(z)=\frac{-3+5.192z^{-1}-3.56z^{-2}+2z^{-1}}{1+0.28z^{-1}+0.056z^{-2}+0.4z^{-3}}$
8	Consider a direct-form implementation of the FIR filter y(n) = ax(n) + bx(n-2) +cx(n-3) Assume that the time required for 1 multiply-add operation is T i. Pipeline this filter such that the clock period is approximately T ii. Draw block filter architecture for a block size of three. Pipeline this block filter such that clock period is about T. What is the system sample
9	The TMS320C6713 processor is used for an application where, it has to read the audio data inputted through the codec and has to send the data which is band limited to 1 KHz, to another external device for further processing. If the processor is connected to the audio codec through the McBSPs of the TMS320C6713 processor. a)Draw the interconnection diagram showing all the necessary signals, for inputting an analog signal to the processor for the processing and to send the result there after, with the entire data transfer initiated through the McBSPs. b)What are the various registers need to be programmed in order to affect the data transfer? Explain the role and functionality of each.
10	Draw a neat block schematic of the architecture of TMS320C66x series of processor. Briefly explain the role of each block.
11	Give an overview of the memory organisation in TMS320C66xx series of processors. Explain the role of various memory controllers and interfaces in relieving the CPU load.
12	Give an overview of the latest architectural trends for implementing DSP algorithms. How will you compare FPGA SoCs and DSP SoCs?.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221LEC001	SIGNAL PROCESSING LAB 1	LABORATORY 1	0	0	2	1

Preamble: To experiment the concepts introduced in the topics : Linear Algebra, Random processes, Advanced Signal Processing and Machine Learning

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply knowledge of Linear algebra, Random processes,Advanced Signal Processing and Machine Learning in various signal processing applications.
CO 2	Develop the student's ability on analysing observations of experiments/ simulations, interpreting them and preparing reports
CO 3	Apply the fundamental principles of linear algebra and random processes
CO 4	Familiarize the basic operations of filter banks through simulations
CO 5	Implement the basic algorithms learned in Machine learning
CO 6	Implement a mini project pertaining to an application of Signal Processing in real life

Assessment Pattern

Bloom's Category	CIE
Apply	40
Analyse	30
Evaluate	15
Create	15

Mark distribution

Total Marks	CIE	ESE
100	100	--

Continuous Internal Evaluation Pattern:

Tools :

Numerical Computing Environment – MATLAB or any other equivalent tool.

Syllabus

No	Topics
1	**Linear Algebra**
1.1	Row Reduced Echelon Form: To reduce the given mxn matrix into Row reduced Echelon form
1.2	Gram-Schmidt Orthogonalization: To find orthogonal basis vectors for the given set of vectors. Also find orthonormal basis.
1.3	Least SquaresFit to a Sinusoidal function
1.4	Least Squares fit to a quadratic polynomial
1.5	Eigen Value Decomposition
1.6	Singular Value Decomposition
1.7	Karhunen- Loeve Transform
2	**Advanced DSP**
2.1	Sampling rate conversion: To implement Down sampler and Up sampler and study their characteristics
2.2	Two channel Quadrature Mirror Filterbank: Design and implement a two channel Quadrature Mirror Filterbank
3	**Random Processes**
3.1	To generate random variables having the following probability distributions (a) Bernoulli(b) Binomial(c) Geometric(d) Poisson(e)Uniform,(f) Gaussian(g)Exponential (h) Laplacian
3.2	Central Limit Theorem: To verify the sum of sufficiently large number of Uniformly distributed random variables is approximately Gaussian distributed and to estimate the probability density function of the random variable.
4	**Machine Learning**
4.1	Implementation of K Nearest Neighbours Algorithm with decision region plots
4.2	Implementation of K Means Algorithm with decision region plots
4.3	Implementation of Perceptron Learning Algorithms with decision region plots
4.4	Implementation of SVM algorithmfor classification applications
5	**Implement a mini project pertaining to an application of Signal Processing in real life, make a presentation and submit a report**

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221RGE100	RESEARCH METHODOLOGY & IPR	General Course	2	0	0	2

Preamble:

This course introduces the strategies and methods related to scientific research. The students are also trained in the oral presentation with visual aids and writing technical thesis/reports/research papers. The salient aspects of publication and patenting along with the crucial role of ethics in research is discussed.

Course Outcomes

After the completion of the course the student will be able to

CO 1	Approach research projects with enthusiasm and creativity.
CO 2	Conduct literature survey and define research problem
CO 3	Adopt suitable methodologies for solution of the problem
CO 4	Deliver well-structured technical presentations and write technical reports.
CO 5	Publish/Patent research outcome.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	✓	✓				✓	
CO 2	✓	✓				✓	
CO 3	✓	✓				✓	
CO 4	✓	✓				✓	
CO 5	✓	✓				✓	
CO 6	✓	✓				✓	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	70 %
Analyse	30 %
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Course based task: 15 marks

Some sample course based tasks that can be performed by the student given below.

- *Conduct a group discussion based on the good practices in research.*
- *Conduct literature survey on a suitable research topic and prepare a report based on this.*

Seminar: 15 marks

Test paper: 10 marks

End Semester Examination Pattern:

Total Marks: 60

The examination will be conducted by the respective college with the question provided by the University. The examination will be for 150 minutes and contain two parts; Part A and Part B. Part A will contain 6 short answer questions with 1 question each from modules 1 to 4, and 2 questions from module 5. Each question carries 5 marks. Part B will contain only 1 question based on a research article from the respective discipline and carries 30 marks. The students are to answer the questions based on that research article.

Model Question paper

QP Code:		**Total Pages:**
Reg No.: _______________		**Name:** ___________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIRST SEMESTER M. TECH DEGREE EXAMINATION, Month & Year

Course Code: 221RGE100
Course Name: RESEARCH METHODOLOGY & IPR

Max. Marks: 60		**Duration: 2.5 Hours**

PART A

		Answer all questions. Each question carries 5 marks	**Marks**
1		Discuss the salient recommendations for great research recommended by Richard Hamming in his famous talk “You and Your Research”	**30**
2		What are the characteristics of a good research question? Discuss with an example.	
3		Explain the difference between continuum, meso-scale and micro scale approaches for numerical simulation.	
4		Discuss any four rules of scientific writing.	
5		What are the requirements for patentability?	
6		What are the differences between copyright and trademark protection?	
		Read the given research paper and write a report that addresses the following issues **(The paper given can be specific to the discipline concerned**)	
7		What is the main research problem addressed?	**3**
8		Identify the type of research	**3**
9		Discuss the short comings in literature review if any?	**6**
10		Discuss appropriateness of the methodology used for the study	**6**
11		Discuss the significance of the study and summarize the important results and contributions by the authors	**6**
12		Identify limitations of the article if any.	**6**

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Introduction**	
1.1	Meaning and significance of research, Skills, habits and attitudes for research, Types of research,	1
1.2	Characteristics of good research, Research process	1
1.3	Motivation for research: Motivational talks on research: "You and Your Research"- Richard Hamming	1
1.4	Thinking skills: Levels and styles of thinking, common-sense and scientific thinking, examples, logical thinking, division into sub-problems, verbalization and awareness of scale.	1
1.5	Creativity: Some definitions, illustrations from day to day life, intelligence versus creativity, creative process, requirements for creativity	1
2	**Literature survey and Problem definition**	
2.1	Information gathering – reading, searching and documentation, types of literature.	1
2.2	Integration of research literature and identification of research gaps	1
2.3	Attributes and sources of research problems, problem formulation, Research question, multiple approaches to a problem	1
2.4	Problem solving strategies – reformulation or rephrasing, techniques of representation, Importance of graphical representation, examples.	1
2.5	Analytical and analogical reasoning, examples, Creative problem solving using Triz, Prescriptions for developing creativity and problem solving.	1
3	**Experimental and modelling skills**	
3.1	Scientific method, role of hypothesis in experiment, units and dimensions, dependent and independent variables, control in experiment	1
3.2	precision and accuracy, need for precision, definition, detection, estimation and reduction of random errors, statistical treatment of data, definition, detection and elimination of systematic errors,	1
3.3	Design of experiments, experimental logic, documentation	1

3.4	Types of models, stages in modelling, curve fitting, the role of approximations, problem representation, logical reasoning, mathematical skills.	1
3.5	Continuum/meso/micro scale approaches for numerical simulation, Two case studies illustrating experimental and modelling skills.	1
4	**Effective communication - oral and written**	
4.1	Examples illustrating the importance of effective communication, stages and dimensions of a communication process.	1
4.2	Oral communication –verbal and non-verbal, casual, formal and informal communication, interactive communication, listening, form, content and delivery, various contexts for speaking- conference, seminar etc.	1
4.3	Guidelines for preparation of good presentation slides.	1
4.4	Written communication – Rules of scientific writing, form, content and language, layout, typography and illustrations, nomenclature, reference and citation styles, contexts for writing – paper, thesis, reports etc. Tools for document preparation-LaTeX.	1
4.5	Common errors in typing and documentation	1
5	**Publication and Patents**	
5.1	Relative importance of various forms of publication, Choice of journal and reviewing process, Stages in the realization of a paper.	1
5.2	Research metrics-Journal level, Article level and Author level, Plagiarism and research ethics	1
5.3	Introduction to IPR, Concepts of IPR, Types of IPR	1
5.4	Common rules of IPR practices, Types and Features of IPR Agreement, Trademark	1
5.5	Patents- Concept, Objectives and benefits, features, Patent process – steps and procedures	2

Reference Books

1. E. M. Phillips and D. S. Pugh, "How to get a PhD - a handbook for PhD students and their supervisors", Viva books Pvt Ltd.
2. G. L. Squires, "Practical physics", Cambridge University Press
3. Antony Wilson, Jane Gregory, Steve Miller, Shirley Earl, Handbook of Science Communication, Overseas Press India Pvt Ltd, New Delhi, 1st edition 2005
4. C. R. Kothari, Research Methodology, New Age International, 2004
5. Panneerselvam, Research Methodology, Prentice Hall of India, New Delhi, 2012.

6. Leedy P. D., Practical Research: Planning and Design, McMillan Publishing Co.
7. Day R. A., How to Write and Publish a Scientific Paper, Cambridge University Press, 1989.
8. William Strunk Jr., Elements of Style, Fingerprint Publishing, 2020
9. Peter Medawar, 'Advice to Young Scientist', Alfred P. Sloan Foundation Series, 1979.
10. E. O. Wilson, Letters to a Young Scientist, Liveright, 2014.
11. R. Hamming, You and Your Research, 1986 Talk at Bell Labs.