SEMESTER II

Discipline : Electronics and Communication Engineering
Stream : EC3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TEC100	FOUNDATIONS OF DATA SCIENCE	DISCIPLINE CORE 2	3	0	0	3

Preamble: Nil

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

CO 1	Understand the basics of machine learning and different types.
CO 2	Differentiate regression and classification, Understand the basics of unsupervised learning and non-metric methods
CO 3	Apply statistical methods in non-linear classification and neural networks
CO 4	Understand the basics of deep learning networks, convolutional neural networks

Mapping of course outcomes with program outcomes (1-3)

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:
Total : 60 marks
Part A: Answer all – 5 questions x 5 marks : 25 marks
Part B: Answer 5 of 7: 5 questions x 7 marks : 35 marks

The end semester examination will be conducted by the University . 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

Total: 60 marks

Part A (Answer all) 25 marks

1. Discuss different types of machine learning with examples. (5)
2. Differentiate regression and classification with examples (5)
3. How SVM is used for multiclass problem? (5)
4. Explain clustering with examples. (5)
5. Discuss different activation functions used in deep neural networks (5)

Part B (Answer any 5) 35 marks

6. Explain the terms features, training set, target vector, test set, and curse of dimensionality in machine learning. (7)
7. Show that the Bayesian classifier is optimal with respect to minimizing the classification error probability. (7)
8. Give a step by step description of the perceptron algorithm in classification. (7)
9. Obtain the cost function for optimization in SVM for separable classes. (7)
10. Describe convolutional neural networks with detailed description of each layers (7)
11. Obtain the decision surface for an equi-probable two class system, where the probability density functions of n-dimensional feature vectors in both classes are normally distributed. (7)
12. Explain the principle of back propagation neural networks with neat architecture diagram (7)

Syllabus and Course Plan (total hours: 37)

No	Topic	hours
1	**8 hours**	
1.1	Basics of machine learning, supervised and unsupervised learning,examples,	2
1.2	features, feature vector, training set, target vector, test set	1
1.3	over-fitting, curse of dimensionality.	1
1.4	Evaluation and model selection: ROC curves, evaluation measures,	2
1.5	validation set, bias-variance trade-off.	1
1.6	confusion matrix, recall, precision, accuracy.	1
2	**7 hours**	
2.1	Regression: linear regression, error functions in regression	1
2.2	multivariate regression, regression applications, bias and variance.	1
2.3	Classification : Bayes' decision theory,	2
2.4	discriminant functions and decision surfaces,	1
2.5	Bayesian classification for normal distributions, classification applications.	2
3	**7 hours**	
3.1	Linear discriminant based algorithm: perceptron, perceptron algorithm,	1
3.2	support vector machines.	2
3.3	Nonlinear classifiers, the XOR problem,	2
3.4	multilayer perceptrons,	1
3.5	backpropagation algorithm.	1
4	**8 hours**	
4.1	Unsupervised learning:	1
4.2	Clustering, examples, criterion functions for clustering,	2
4.3	proximity measures, algorithms for clustering.	1
4.4	Ensemble methods: boosting, bagging.	2
4.5	Basics of decision trees, random forest, examples.	2
5	**7 hours**	
5.1	Introduction to deep learning networks,	1
5.2	deep feedforward networks,	2
5.3	basics of convolutional neural networks (CNN)	2
5.4	CNN basic structure, Hyper-parameter tuning, Regularization - Dropouts,	1
5.5	Initialization, CNN examples	1

Reference Books

1. Bishop, C. M. "Pattern Recognition and Machine Learning" Springer, New York, 2006.
2. Theodoridis, S. and Koutroumbas, K. "Pattern Recognition". Academic Press, San Diego, 2003.
3. Hastie, T., Tibshirani, R. and Friedman, J. "The Elements of Statistical Learning". Springer.

4. Duda, R.O., Hart, P.E., and Stork, D.G. “Pattern Classification”. Wiley, New York,

5. Ian Goodfellow, Yoshua Bengio, Aaron Courville. “Deep Learning” MIT Press, 2016

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TEC002	ESTIMATION AND DETECTION THEORY	PROGRAM CORE 3	3	0	0	3

Preamble: This course introduces the basics of estimation and detection theory,with a focus on classical and Bayesian estimators, estimation bounds, hypothesis testing, and detectors of signals in noise.

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

CO 1	Recognize, describeand evaluatetwo broad areas of statistical inference namely, estimationand detection.
CO 2	Compute the performance limits of unbiased estimators and compare the performance of a given estimator to these bounds
CO 3	Analyse the performances ofclassical and Bayesian estimation techniques,when applied for solving parameter estimation problems from noisy data.
CO 4	Apply optimal hypothesis tests and analyse the performance of these tests for signal detection from noisy data.
CO 5	Relate real world applications to different types of inference problems and identify appropriate tools for approaching these problems and communicating them via presentations/reports/publications .

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	3	3			
CO 2	3	2	3	3			
CO 3	3	2	3	3	2	2	
CO 4	3	2	3	3	2	2	
CO 5	3	3	3	3	2	2	2

Assessment Pattern

Bloom's Category	CIE	End Semester Examination
Apply	10	30
Analyse	10	15
Evaluate	10	15
Create	10	

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 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

Course Code: 222TEC002

Course Name: ESTIMATION AND DETECTION THEORY

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

PART A

Answer all Questions. Each question carries 5 marks

1.Define Unbiased Estimators ?Find an unbiased estimator for estimating a DC level in white Gaussian noise considering the observations $x[n] = A + w[n],\ n = 0,1,\dots N-1$ where, $w[n]$ is white Gaussian noise and A is the parameter to be estimated.

2.We observe $x[n] = A + w[n],\ n = 0,1,\dots N-1$ where, $w[n]$ is white noise with variance σ^2 (and is of unspecified PDF). Find the Best Linear Unbiased Estimator (BLUE) for estimating the DC level, .

3. Derive the expression for minimum Least squares error in Linear Least squares estimation approach for a scalar parameter.

4.We observe the IID samples $x[n]$ for n = 0,1,…,N-1 from the Rayleigh PDF

$p(x[n]) = \frac{x[n]}{\sigma^2} exp\left(-\frac{1}{2}\frac{x^2[n]}{\sigma^2}\right)$.

Derive the NP test for the hypothesis testing problem

$$\mathcal{H}_0:\ \sigma^2 = \sigma_0^2\ , \qquad \mathcal{H}_1 : \sigma^2 = \sigma_1^2 > \sigma_0^2$$

5.It is desired to detect a known deterministic signal in white Gaussian Noise. How do you decide upon a suitable detector for this case?

PART B

Answer any one full question from each module.

Each question carries 7 marks

6.(a) State the CRLB theorem for scalar parameter. (2)

(b) If$x[n] = r^n + w[n], for\ n = 0,1,\dots.N-1$, are observed, where $w[n]$ is WGN with variance σ^2 and r is to be estimated, find the CRLB. Does an efficient estimator exist and if so find its variance. (5)

7. (a)Illustrate a method for finding sufficient statistics. (3)

(b) The IID observations$x[n]\ for\ n = 0,1,\dots.N-1$, are distributed according to $\mathcal{N}(\theta,\theta), where\ \theta > 0$. Find a sufficient statistic for θ . (4)

8.(a) For the received data $x[n] = A + w[n], for\ n = 0,1, \ldots . N-1$, where A is the unknown DC level to be estimated and $w[n]$is WGN with known variance σ^2, find MLE of A. (3)

(b) Prove the statement: If an efficient estimator exists, the maximum likelihood method will produce it.(Hint: Assuming a scalar parameter, if an efficient estimator exists, then we have $\frac{\partial \ln p(\boldsymbol{x}|\theta)}{\partial \theta} = I(\theta)(\hat{\theta} - \theta)$). (4)

9.Assume that $p(x[n]|\theta) = \begin{cases} \theta \exp(-\theta x[n]) & x[n] > 0 \\ 0 & x[n] < 0 \end{cases}$

where the $x[n]'s$ are conditionally IID, or $p(\boldsymbol{x}|\theta) = \prod_{n=0}^{N-1} p(x[n]|\theta)$

and the prior PDF is $p(\theta) = \begin{cases} \lambda \exp(-\lambda\theta) & \theta > 0 \\ 0 & \theta < 0 \end{cases}$ (7)

Find the MAP estimator for θ.

10.We have the detection problem

$$\mathcal{H}_0: x[n] = w[n] \qquad n = 0,1, \ldots, N-1$$
$$\mathcal{H}_1: x[n] = A + w[n] \quad n = 0,1, \ldots, N-1$$

where $A > 0$ and $w[n]$ is WGN with variance σ^2. Assume that $P(\mathcal{H}_0) = P(\mathcal{H}_1) = \frac{1}{2}$. Determine the minimum probability of error. (7)

11.We model the signal as a zero mean, white, WSS Gaussian random process with varianceσ_s^2,where the noise $w[n]$,is assumed to be WGN with variance σ^2. Suggest a suitable detector for this scenario with reasons for the choice.(7)

12. Derive the expressions for the mean and covariance of the Gaussian Posterior PDF for Bayesian General Linear Model. (7)

Syllabus and Course Plan

Module 1: **Parameter Estimation: Minimum variance unbiased estimation, Cramer-Rao lowerBound and Linear Models**

Review of Linear Algebra and Random Processes, Estimation in Signal Processing; Minimum variance unbiased estimation: Minimum variance criterion; existence of minimum variance unbiased estimator; generalization to vector parameters,Cramer-Rao lower bound: scalar parameters; signal in white Gaussian noise; vector parameters; transformations; general Gaussian case;wide-sense stationary Gaussian processes;Examples from radar, sonar, and speech processing,Linear models: definition and properties; curve fitting; Fourier analysis; system identification; general linear models

Module 2:**General minimum variance unbiased estimation and Best linear unbiased estimators**

General minimum variance unbiased estimation: sufficient statistic; Finding minimum variance unbiased estimators; complete statistics; generalizations,Best linear unbiased estimators: definition; finding the BLUE; example of source localization; generalization to vector parameters.

Module 3:**Maximum likelihood estimators,Linear Least Squares Approach and Bayesian Estimators**

Maximum likelihood estimators: definition; finding the MLE; properties; transformed parameters; vector parameters; examples,Linear Least Squares Approach for Gaussian linear models,Bayesian estimators: priors; posteriors;linear models; Bayes Risks,Minimum Mean Square Error Estimator, Maximum A-Posteriori estimator,State estimation: Kalman Filters

Module 4:**Basics of Statistical Detection Theory**

Simple hypothesis testing;Neyman-Pearson detectors, Minimum probability of error,Minimum Bayes risk detectors; receiver operating characteristics; Multiplehypothesis testing,Composite hypothesis testing: Generalized Likelihood Ratio Test- Detection of signals with Unknown Amplitude.

Module 5:**Detection of signals in noise**

Detection of known signals in noise: Matched filter; performance of matched filter; generalized matched filter; Minimum distance detector; examples from communications, radar/sonar, and pattern recognition,Detection of random signals: energy detector; estimator-correlator; canonical form of detector; performance analysis; examples.

No	Topic	No. of Lectures
1	**Parameter Estimation: Minimum variance unbiased estimation, Cramer-Rao lowerBound and Linear Models**	
1.1	Review of Linear Algebra and Random Processes, Estimation in Signal Processing;Minimum variance unbiased estimation: Minimum variance criterion; existence of minimum variance unbiased estimator; generalization to vector parameters	3
1.2	Cramer-Rao lower bound: scalar parameters; signal in white Gaussian noise; vector parameters; transformations; general Gaussian case;wide-sense stationary Gaussian processes;Examples from radar, sonar, and speech processing	3
1.3	Linear models: definition and properties; curve fitting; Fourier analysis; system identification; general linear models	2
2	**General minimum variance unbiased estimation and Best linear unbiased estimators**	
2.1	General minimum variance unbiased estimation:sufficientstatistic;Finding minimum variance unbiased estimators; complete statistics; generalizations	3
2.2	Best linear unbiased estimators: definition; finding theBLUE;example ofsourcelocalization; generalization to vectorparameters	4
3	**Maximum likelihood estimators,Linear Least Squares Approach and Bayesian Estimators**	
3.1	Maximum likelihood estimators: definition; finding the MLE; properties; transformed parameters; vector parameters; examples	2
3.2	Linear Least Squares Approach for Gaussian linear models	1
3.2	Bayesian estimators: priors; posteriors;linear models; Bayes Risks,Minimum Mean Square Error Estimator, Maximum A-Posteriori estimator.	4
3.3	State estimation: Kalman Filters	2
4	**Basics of Statistical Detection Theory**	
4.1	Simple hypothesis testing;Neyman-Pearson detectors, Minimum probability of error	3
4.2	Minimum Bayes risk detectors; receiver operating characteristics; Multiple hypothesis testing,	3
4.3	Composite hypothesis testing : Generalized Likelihood Ratio Test- Detection of signals with Unknown Amplitude.	2
5	**Detection of signals in noise**	
5.1	Detection of known signals in noise: Matched filter ;performance of matched filter; generalized matched filter; Minimum distance detector; examples from	4

	communications, radar/sonar, and pattern recognition	
5.2	Detection of random signals: energy detector; estimator-correlator; canonical form of detector; performance analysis; examples.	4

Text Books

1. S.M. Kay, Fundamentals of Statistical Signal Processing: Detection Theory, Prentice Hall, 1998

2. S.M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory, Prentice Hall, 1993

Reference Books

1. H.L. Van Trees, Detection, Estimation and Modulation Theory, Part I, Wiley, 1968.

2. H.V. Poor, An introduction to Signal Detection and Estimation, 2nd edition, Springer, 1994.

3. L.L. Scharf, Statistical Signal Processing, Detection and Estimation Theory, Addison-Wesley,1990

COURSE CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222PEC100	MINI PROJECT	PROJECT	0	0	4	2

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem solving skills.

The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs.The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Evaluation Committee - Programme Coordinator, One Senior Professor and Guide.

Sl. No	Type of evaluations	Mark	Evaluation criteria
1	Interim evaluation 1	20	
2	Interim evaluation 2	20	
3	Final evaluation by a Committee	35	Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	15	the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level(not more than 25%)
5	Supervisor/Guide	10	
	Total Marks	100	

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222LEC001	SIGNAL PROCESSING LAB II	LABORATORY 2	0	0	2	1

Preamble: This labis envisaged as a specialization lab for the streams: Signal Processing, Communication Engineering & Signal Processing, and Signal Processing and Embedded Systems

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

CO 1	Apply knowledge of Advanced Signal Processing, Image Processing,Deep learning, Communication Engineering and Embedded systems 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	Implement the fundamental principlesand algorithmslearned inSignal Processing/Communication Engineering/ Embedded systems

Assessment Pattern

Bloom's Category	CIE
Apply	50
Analyse	30
Evaluate	10
Create	10

Mark distribution

Total Marks	CIE	ESE
100	100	--

Continuous Internal Evaluation Pattern:

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

Tools :

Numerical Computing Environment – MATLAB or any other equivalent tool.

Based on the specialization of the streams, experiments must be chosen mandatorily from **ANYONE** of the sets listed below:

Set I(Specialization: Signal Processing**)**
Set II (Specialization: Communication Engineering and Signal Processing)
Set III (Specialization: Signal Processing and Embedded systems).

Syllabus

No	Topics
Set I	**Speech, Image and Deep Learning Lab**
1	Image processing fundamentals-Simulation and Display of an Image, Negative of an Image- Implementation of Relationships between Pixels Geometric transformations- Image rotation, scaling, and translation
2	Apply 2 D DFT, DCT and DWT transform for an image and compare the results
4	Image enhancement-Point/spatial/transform operations Enhance an image using image arithmetic and logical operations--- Gray level slicing/Sharpening/histogram equalization/Filtering/homomorphic filtering
5	Colour image processing --Wavelet-based Image Processing.
6	Image Segmentation
7	Edge detection-basic edge detection methods- parametric and non-parametric approaches Morphological operations -dilation, erosion.
8	Object recognition in an image Template matching/ clustering
9	Feature extraction from speech Implement the steps for the extraction of MFCC/rhythmic features from a given audio file Visualization of spectrogram/Mel-spectrogram---narrow-band and wide-band spectrogram
10	Implement the steps to extract LPC coefficient from the given speech file
11	Implement the steps to extract formants using homographic filtering
12	Pattern classification using machine learning/Deep learning, Implementation of KNN, K-Means Clustering, Implementation of Logistic Regression, SVM (*speech or image data)* Deep learning architectures using TensorFlow/Keras*(speech or image data)*
Set II.	**Communication Engineering**
1	Simulation of probability Distributions- Continuous and Discrete. -Illustration of Central Limit theorem.

2	Simulation of PAM and PCM systems and performance evaluation.
3	Implementation of digital modulation schemes-BASK,BFSK, BPSK. Plot BER vsE_b/N_0 in AWGN channel.
4	Implementationand performance comparison of QPSK , DPSK, MSK& GMSK.
5	Plotting Eye pattern and Constellation diagram of various digital modulation schemes
6	Implementation of Matched filter, Correlation receiver.
7	Communication over fading Channels-Rayleigh fading & Rician fading
8	Simulation of RAKE receiver.
9	Spread spectrum communication systems-Develop simulation models for Direct sequence Spread spectrum systems and Frequency Hopping spread spectrum systems.
10.	Simulation of OFDM system.
Set III.	**Embedded Systems**
A	***FPGA based experiments:***
1	Design entry using Verilog/ VHDL examples for circuit description.
2	Sequential and concurrent statements.
3	Structural and behavioral descriptions, principles of operation and limitation of HDL simulators.
4	Examples of sequential and combinational logic design and simulation.
5	Test vector generation.
6	Synthesis principles, logical effort, standard cell-based design and synthesis, interpretation synthesis scripts, constraint introduction and library preparation and generation.
7	FPGA programming
8	I/O interfacing
9	Analog interfacing
10	Real time application development.
B	***Microcontroller based Experiments*:**
1	Design with ARM Processors: I/O programming, ADC/DAC, Timers, Interrupts.
2	Study of one type of Real Time Operating Systems (RTOS)

SEMESTER II

PROGRAM ELECTIVE III

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC012	WIRELESS SENSOR NETWORKS	PROGRAM ELECTIVE 3	3	0	0	3

Preamble: The core modules of this elective course include introduction to wireless sensor networks, localisation and synchronisation techniques, wireless MAC protocols, routing in wireless sensor networks and fundamentals of network security. This course aims to teach the student to understand the concepts of wireless sensor networks.

Course prerequisites: NIL

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

CO 1	Evaluate the performance of schedule based and random Medium Access Control protocols for power consumption, fairness, channel utilization and control packet overhead.
CO 2	Evaluate the performance of Geographic routing protocols for power consumption, scalability and latency parameters.
CO 3	Relate the performance of transport control protocols for congestion detection and avoidance, reliability and control packet overhead parameters.
CO 4	Understand about the routing challenges in WSN.
CO 5	Classify the security issues in wireless network.

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 (Marks)
Apply	20

Analyse	20
Evaluate	20
Create	

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

SECOND SEMESTER M. TECH DEGREE EXAMINATION

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

Course Code: 222EEC012

Course Name: WIRELESS SENSOR NETWORKS

Max. Marks: 60 Duration: 150 Minutes

PART A

Answer ALL Questions. Each Carries 5 mark.

1. The communication subsystem of a wireless sensor node is usually interfaced with the processor subsystem through a SPI bus instead of an I2C bus. Why is this?
2. What are the advantages and disadvantages of contention-free and contention-based medium access strategies? Can you think of scenarios where one would be preferable over the other?
3. Why is time synchronization needed in a WSN? Name at least three concrete examples.
4. What is the concept behind hierarchical routing and what advantages does it have over other techniques?
5. Why is it necessary to provide the opportunity to dynamically reprogram a sensor network? What is challenging in distributing a new program to all sensor nodes in the network?

PART B

Answer any 5 questions: Each question carries 7 marks

6. Explain the architecture of wireless sensor node with neat diagram.
7. The five requirements of MAC protocols for wireless sensor networks are energy efficiency, scalability, adaptability, low latency, and reliability. Can you describe a concrete WSN application for each of these five requirements, where the requirement would be more important than the others?

8. How does the S-MAC protocol reduce the duty cycles of sensor nodes? How does the S-MAC protocol attempt to reduce collisions? How does it address the hidden-terminal problem? Name at least three disadvantages of the S-MAC protocol.

9. Explain the concept behind the RBS protocol. How can RBS be extended to work in multi-hop scenarios?

10. RSS-based localization techniques are often combined with a process called RF profiling, that is, the mapping of the effects of objects in the environment on signal propagation. Why is this necessary and can you think of examples of such objects?

11. What is the difference between a proactive routing protocol and a reactive routing protocol? Name at least two examples for each category. Consider the following WSN scenarios and explain why you would choose either a proactive or a reactive routing solution: (a) A WSN is used to monitor air pollution in a city where every sensor reports its sensor data once every minute to a single remote base station. Most sensors are mounted on lamp posts, but some are also mounted on city buses. (b) A WSN is used to measure humidity in a field, where low-power sensors report measurements only when certain thresholds are exceeded. (c) A WSN is used to detect the presence of vehicles, where each sensor locally records the times of vehicle detection. These records are delivered to the base station only when the sensor is explicitly queried.

12. Describe the CIA security model. Which services described in this model do you think are essential for the following scenarios? Justify your answers. (a) A WSN that allows emergency response teams to avoid risky and dangerous areas and activities. (b) A WSN that collects biometric information collected at an airport. (c) A WSN that measures air pollution in a city for a research study. (d) A WSN that alerts a city of an impending earthquake.

SYLLABUS

Module 1: 8 hours

Fundamentals of sensor networks: Introduction wireless sensor networks, Wireless Sensor nodes- Sensing and sensors challenges and constraints - node architecture-sensing subsystem, processor subsystem, communication interfaces-prototypes, Application of Wireless sensors,Introduction of Tiny OS Programming.

Module 2: 8 hours

Communication characteristics and deployment mechanisms: Basics of time synchronization-Time synchronization protocols - Localization- Ranging Techniques- Range based Localization-Range Free Localization- Event driven Localization

Module 3: 8 hours

MAC Layer: Overview-Wireless Mac Protocols-Characteristics of MAC protocols in Sensor networks – Contention free MAC Protocols- characteristics- Traffic Adaptive Medium Access-Y-MAC, Low energy Adaptive Clustering - Contention based MAC Protocols Power Aware Multi-Access with signalling, Sensor MAC-Timeout MAC-Data gathering MAC

Module 4: 8 hours

Routing in wireless sensor networks: Design Issues in WSN routing- Data Dissemination and Gathering-Routing Challenges in WSN - Flooding-Flat Based Routing – SAR, Directed Diffusion, Hierarchical Routing- LEACH, PEGASIS - Query Based Routing- Negotiation Based Routing- Geographical Based Routing.

Module 5: 8 hours

Middleware and security issues: WSN middleware principles-Middlewarearchitecture-Existing middleware - operating systems for wireless sensor networks-performance and traffic management - Fundamentals of network security-challenges and attacks.

Course Plan

No	Topic	No. of Lectures
1	**Fundamentals of sensor networks:**	
1.1	Introduction wireless sensor networks, Wireless Sensor nodes- Sensing and sensors challenges and constraints.	2
1.2	Node architecture-sensing subsystem, processor subsystem	3
1.3	Communication interfaces- prototypes, Application of Wireless sensors,Introduction of Tiny OS Programming	3
2	**Communication characteristics and deployment mechanisms:**	
2.1	Basics of time synchronization-Time synchronization protocols	3
2.2	Localization- Ranging Techniques- Range based Localization-	3
2.3	Range Free Localization- Event driven Localization	2
3	**MAC Layer:**	
3.1	Overview-Wireless Mac Protocols-Characteristics of MAC protocols in Sensor networks	2
3.2	Contention free MAC Protocols- characteristics- Traffic Adaptive Medium Access-Y-MAC, Low energy Adaptive Clustering	3
3.3	Low energy Adaptive Clustering - Contention based MAC Protocols Power Aware Multi-Access with signalling, Sensor MAC-Timeout MAC-Data gathering MAC	3
4	**Routing in wireless sensor networks:**	
4.1	Design Issues in WSN routing- Data Dissemination and Gathering	2
4.2	Routing Challenges in WSN - Flooding-Flat Based Routing – SAR, Directed Diffusion,	2
4.3	Hierarchical Routing- LEACH, PEGASIS - Query Based Routing- Negotiation Based Routing- Geographical Based Routing	3
5	**Middleware and security issues:**	
5.1	WSNmiddleware principles-Middleware architecture-Existing middleware	3
5.2	Operating systems for wireless sensor networks-performance and traffic management.	3
5.3	Fundamentals of network security-challenges and attacks	2

Text Books

1. DargieWaltenegus, Poellabauer Christian (2011): Fundamentals of Wireless Sensor Networks, Theory and Practice: Wiley Series on wireless Communication and Mobile Computing.
2. SohrabyKazem, Manoli Daniel (2010): Wireless Sensor networks-Technology, Protocols and Applications, New Jersey: Wiley Inter Science Publications.

Reference Books

1. Krishnamachari Bhaskar (2005): Networking Wireless Sensors, Cambridge: Cambridge University Press.
2. Raghavendra C.S., Sivalingam Krishna M., Taiebznati (2004): Wireless Sensor Networks: Springer Science.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC013	IMAGE PROCESSING AND COMPUTER VISION	PROGRAM ELECTIVE 3	3	0	0	3

Preamble: Image processing is a method to perform certain operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Computer vision is a field of artificial intelligence (AI) that enables computers and systems to derive meaningful information from digital images, videos and other visual inputs — and take actions or make recommendations based on that information. Students will be able to learn image processing fundamentals, understand the different types of algorithms in image processing and computer vision, develop in-depth knowledge of image and video processing tasks such as image representation, image transforms, image enhancement, Image restoration, image segmentation and image compression.

Prerequisite: A sound knowledge of the fundamentals and basics of digital signal processing techniques.

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 image processing and computer vision.
CO 2	Understand and analyse the principles of image restoration and segmentation and illustrate the methods and algorithms for image restoration and segmentation.
CO 3	Understand and analyse the principles of image compression and video processing and illustrate the methods and algorithms for image compression and video processing.
CO 4	Analyze and evaluate the performance of depth estimation and multi-camera views. for computer vision.
CO 5	Evaluate critically the techniques for motion analysis and optical flow in computer vision.

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	2			3		
CO 3	3	2			2	2	3
CO 4					2	2	2
CO 5	3	2		3			

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.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND 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: 222EEC013

Course Name: IMAGE PROCESSING AND COMPUTER VISION

Max. Marks: 60 Duration: 2.5Hours

PART A

Answer all Questions. Each Question Carries 5 marks.

1	Explain the properties of Fourier transform specific to image processing.	CO1	
2	Explain basic principles of LoG and DoG filters. Discuss the merits and demerits compared with other type of filters. Discuss the shape of LoG(x, y, σ) with an indicative plot.	CO1	
3	Explain the basic principles of transform coding. Give the block schematic of a transform coder. Compare the performance of different transforms based coders with a graph.	CO2	
4	Illustrate the concept of depth estimation. What is stereo dept estimation ?	CO2	
5	Comment on Phong Lighting Model. Why shading is important in computer vision? Disccuss Phong shading.	CO3	

PART – B

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

1. a)	Compare and contrast spatial and spectral domain processing of images. Discuss some applications that require these type of processing. Write a MATLAB program snippet	4	CO 1	

	for generating a checker box pattern of size 8 × 8.			
1. b)	Briefly explain edges in images. What do you mean by edge magnitude and edge direcion? Discuss some techniques for edge sharpening.	3	CO 2	
2.a)	Let f represents a M × N image. If the DFT and IDFT of f is given by P f Q and $P^{-1}f\,Q^{-1}$ respectively, then give expression for all transformation matrices.	3	CO 1	
2. b)	Let f (x, y) be a continous image function. The image is sampled at points x = jΔx, y = kΔy, for j = 1, ..., M and k = 1, ..., N. Where Δx and Δy are sampling intervals. Find expression for the sampled image fs (x, y). Also represent the sampled image in the frequency domain. (Hint: Assume ideal sampling using shifted dirac functions δ.)	4	CO 2	
3.a)	Explain the significance of Weiner filter in image restoration. Obtain expression for Wiener filter transfer function.	4	CO 2	
3.b)	List the steps involved in image restoration using Weiner filter. With a neat block schematic explain the digital implementation of Wiener filter.	3	CO 1	
4. a)	For the number plate identification of vehicles, the pre-processing step uses segmentation. Explain a suitable technique for this. Illustrate how do you arrive on thresholds ?	4	CO 3	
4.b)	Explain region merging technique. Discuss the criterion for merging two different regions in an image.	3	CO 1	
5.a)	Discuss the principles of fixed length and variable length encoding techniques. The word MISSISSIPPI RIVER is to be encoded using Huffman coding technique. Draw the Huffman tree and determine the Huffman code for the same.	4	CO 3	
5.b)	Compare and contrast lossy and loss-less compression techniques. Discuss entropy based compression techniques. Also explain fundamental properties of information.	3	CO 5	
6.a)	What is homography estimation? Explain the significance of homography matrix.	3	CO 5	
6.b)	Illustrate how RANSAC helps in estimating a mathematical model from a data set that contains outliers.	4	CO 2	
7.a)	Explain how to segment the foreground objects from the background of a sequence ? Discuss the principles of background subtraction.	3	CO 2	
7.b)	What do you mean by motion estimation? How do we estimate parameters?	4	CO 1	

Syllabus

Module - 1 (Image Representation) :

Image Representation: Gray scale and colour images, image sampling and quantization. Two dimensional orthogonal transforms: DFT, WHT, Haar transform, KLT, DCT. Image representation using SIFT, GIST and HOG features. Image enhancement - Filters in spatial and frequency domains, histogram- based processing, homomorphic filtering.

Module -2 (Image Resoration and Segmentaton)

Image Restoration: Degradation models, PSF, circulant and block-circulant matrices, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods. Image segmentation: pixel classification, bi-level thresholding, multi- level thresholding. Edge detection, edge sharpening, edge profiles, edge operators, LoG, DoG. Hough transform.

Module 3 (Image Compression and Video Processing)

Fundamental Concepts of Image Compression: Compression models - Information theoretic perspective - Fundamental coding theorem-Lossless compression: Huffman Coding- arithmetic coding – bit plane coding - run length coding - Lossy compression: Transform
coding - Image compression standards. Video processing: Representation of digital video, Spatio-temporal sampling; Motion estimation; video filtering; Video compression, video coding standards.

Module -4 (Depth estimation and Multi-camera views)

Depth estimation and Multi-camera views: Perspective, binocular stereopsis: Camera and epipolar geometry; homography, rectification, DLT, RANSAC, 3-D reconstruction framework; auto-calibration.

Module -5 (Motion Analysis)

Motion Analysis: Background subtraction and modeling, Optical flow, KLT, spatio-temporal analysis, dynamic stereo; motion parameter estimation. Light at surfaces- Phong Model, shape from texture, color, motion and edges.

Text Book

1. Fundamentals of Digital Image Processing, A. K. Jain, Prentice Hall of India, 1989.

2. Digital Image Processing , R. C. Gonzalez, R. E. Woods, Digital Image Processing, Pearson Education, 2nd Edition, 2002.

3. Computer Vision algorithms and Applications, Richard Szeliski, Springer, New York, 2nd Edition, 2022.

Reference Books

1. Digital Image Processing, 4th Edition, Wiley Interscience, W. K. Pratt, Prentice Hall,2007.

2. Digital Image Processing, A. Rosenfold and A. C. Kak, Vols. 1 and 2, Prentice Hall, 2014.

3. Digital Image Restoration, H. C. Andrew and B. R. Hunt, Prentice Hall, 1977

4. Machine Vision, R. Jain, R. Kasturi and B.G. Schunck, McGraw-Hill International Edition, 1995

5. Digital Video Processing,A. M. Tekalp, Digital Video Processing , Prentice-Hall, 1995

6. Handbook of Image & Video Processing, A. Bovik, Academic Press, 2000.

7. Dictionary of Computer Vision and Image Processing, Second Edition, R. B. Fisher, T. P. Breckon, K. Dawson-Howe et al., ISBN:9781119941866, John Wiley & Sons Ltd., 2016

Course Plan

No	Topic	No. of Lectures [40Hrs]
1	**Image Representation**	
1.1	Image Representation: Gray scale and colour Images, image sampling and quantization.	2
1.2	Two dimensional orthogonal transforms: DFT, WHT, Haar transform, KLT, DCT.	2
1.3	Image representation using SIFT, GIST and HOG features.	2
1.4	Image enhancement - filters in spatial and frequency domains, histogram- based processing, homomorphic filtering.	3
2	**Image Resoration and Segmentaton**	
2.1	Image Restoration: Degradation Models, PSF, circulant and block-circulant matrices, deconvolution, restoration using inverse filtering.	2
2.2	Wiener filtering and maximum entropy-based methods.	2
2.3	Image Segmentation: Pixel classification, Bi-level thresholding, Multi- level thresholding.	3
2.4	Edge detection, edge sharpening, edge profiles, edge operators, LoG, DoG. Hough transform.	2
3	**Image Compression and video Processing**	
3.1	Fundamental Concepts of Image Compression: Compression models- Information theoretic perspective - Fundamental coding theorem.	2
3.2	Lossless Compression: Huffman Coding- Arithmetic coding – Bit plane coding - Run length coding.	
3.3	Lossy compression: Transform coding - Image compression	3

	standards.	
3.4	Video Processing: Representation of Digital Video, Spatio-temporal sampling; Motion Estimation; Video Filtering; Video Compression, Video coding standards.	3
4	**Depth estimation and Multi-camera views**	
4.1	Depth estimation and Multi-camera views: Perspective, Binocular Stereopsis.	2
4.2	Camera and Epipolar Geometry; Homography, Rectification.	
4.3	DLT, RANSAC, 3-D reconstruction framework.	3
4.4	Auto-calibration.	2
5	**Motion Analysis**	
5.1	Motion Analysis: Background Subtraction and Modeling.	2
5.2	Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo.	2
5.3	Motion parameter estimation.	1
5.4	Light at Surfaces: Phong Model, Shape from Texture, color, motion and edges.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC014	ARRAY SIGNAL PROCESSING	PROGRAM ELECTIVE 3	3	0	0	3

Preamble: This course aims to introduce the concept of sensor arrays and spatial signals to perform beam-forming in the context of direction of arrival estimation in noisy and interference environments.

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

CO 1	Understand the concept of spatial signals and spatial frequency.
CO 2	Understand the concept of sensor arrays and beam-forming.
CO 3	Understand the different methods of direction of arrival estimation.
CO 4	Understand the impact of noise and interference in DoA estimation.
CO 5	Understand the concept of spatial smoothing.

Mapping of course outcomes with program outcomes

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

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 (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.

Syllabus

Signals in space and time : Spatial and Temporal Characteristics, Spatial Frequency, Noise and Interferences, Wave fields.

Spatial Frequency: Spatial Frequency Transform, Spatial Spectrum, Spatial Filtering, Beam-forming, Spatially white signal, Spatial sampling, Nyquist criterion. Aliasing.

Arrays and Spatial Filter : Sensor arrays - linear arrays, planar and random arrays, Uniform linear and weighted array, Delay Sum Beam-former, Beam Pattern Parameters, Array Steering, Null Steering, Array Performance Measures.

Optimum Waveform Estimation : Optimum Beam-formers – MVDR, MPDR, MMSE Beam-formers, Maximum SNR Beam-former, Discrete Interference.

Direction of Arrival Estimation : Parameter Estimation-Maximum Likelihood (ML) Estimation, Cramer-Rao Bounds. Non-parametric methods (Subspace Methods) – ESPRIT, MUSIC, Root MUSIC, Min-Norm Techniques. Spatial Smoothing.

Course Plan

No	Topic	No. of Lectures
1	**Signals in space and time**	
1.1	Spatial and Temporal Characteristics	2
1.2	Spatial Frequency or Wavenumber, Noise and Interferences	2
1.3	Wave fields - Far field and Near field signals	2
2	**Spatial Frequency**	
2.1	Spatial Frequency Transform, Spatial Spectrum.	2
2.2	Spatial Domain Filtering, Beam-forming, Spatially white signal	3
2.3	Spatial sampling, Nyquist criterion. Aliasing in spatial frequency domain	3
3	**Arrays and Spatial Filter**	
3.1	Sensor arrays - linear arrays, planar and random arrays.	2
3.2	Uniform linear array, Uniformly weighted linear array, Delay Sum Beam-former, Beam Pattern Parameters.	4
3.3	Array Steering, Null Steering. Array Performance Measures – Directivity, Array gain vs. Spatially white Noise.	3
4	**Optimum Waveform Estimation**	
4.1	Optimum Beam-formers – MVDR or Capon Beam-former, MPDR Beam-former.	3
4.2	MMSE Beam-former, Maximum SNR Beam-former	3
4.3	Discrete Interference-Plane wave interfering Signal	2
5	**Direction of Arrival Estimation**	
5.1	Parameter Estimation-Maximum Likelihood (ML) Estimation, Cramer-Rao Bounds.	3
95.2	Non-parametric methods (Subspace Methods) – ESPRIT, MUSIC, Root MUSIC, Min--Norm Techniques.	4
5.3	Spatial Smoothing – Forward Smoothing and Backward Smoothing	2

Text Book

1. 1. Harry L. Van Trees, “Optimum Array Processing- Part IV of Detection, Estimation, and Modulation Theory”, Wiley.

Reference Books

2. Dan E. Dugeon and Don H. Johnson. (1993). Array Signal Processing: Concepts and Techniques. Prentice Hall.
3. Petre Stoica and Randolph L. Moses. (2005, 1997) Spectral Analysis of Signals. Prentice Hall.

Model Question Paper

QP CODE
Reg.No:----------
Name----------

M.TECH DEGREE EXAMINATION

Discipline: Electronics and Communication Engg.

ARRAY SIGNAL PROCESSING

Time : 2.5 Hours Maximum: 60 Marks

PART-A

Answer all questions. Each question Carries 5 Marks.

1. Differentiate far field and near field signals.
2. Let the 3-Dimensional space be sampled by three vectors given by $X = [1\ 1\ 0]^T$, $Y = [0\ 2\ 1]^T$ and $Z = [0\ 0\ ½\ ]^T$. Obtain the periodicity of the sampling grid.
3. 'Array configuration is an issue in array signal processing'. Comment on this statement.
4. Evaluate how to estimate the signal waveform in the presence of noise using CAPON Beamformer.
5. 'MUSIC is a search procedure whereas ESPRIT is an eigen decomposition procedure'. Substantiate this statement with proper mathematical expressions.

(5 x 5 = 25 marks)

PART-B

Answer any 5 questions. Each question carries 7 Marks.

1. What is an interference signal? Bring out its impact in array signal processing.
2. What is a Vandermonde matrix? Illustrate its importance in direction of arrival estimation techniques.
3. Figure out the impact of array steering on the following beam pattern parameters?
   i) Shape of the beam pattern ii) Position of Nulls
   iii) Half Power Beam Width (HPBW) iv) Side lobe position
4. Consider a ULA with single source from a direction θ_1.Obtain the signal and noise subspaces using the correlation of the array output. Assume the signal power is σ_s^2 and the spatially white noise power to be σ_n^2.
5. Derive the expressions of Forward and Backward Covariance Smoothing Vectors for a ULA with N Sensors by dividing the total array.

6. Consider the modification to the MVDR Beamformer criterion. Let there be no distortion for $k = k_S$ and let there be a null at $k = k_I$. Let $Sn = \sigma^2 I$. Obtain the Beamformer.
7. Consider two ULAs of 8 sensors with spacing d. The two Beamforming vectors for the ULAs are given below.

   W_1^H = [½ ½ 1 1 1 1 ½ ½] and

   W_2^H = [1 1 ½ ½ ½ ½ 1 1]

Obtain the expression for the two Beam Patterns and the SNR array gain for each one.

(5 x 7 = 35 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC015	EMBEDDED NETWORKS	PROGRAM ELECTIVE 3	3	0	0	3

Preamble: This course focuses into the aspects of networking and then to the wireless concept. The aim of this course is to teach the student to understand about different embedded communication protocols, CAN and USB bus, embedded ethernet and wireless embedded networking and their applications.

Course prerequisites: NIL

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

CO 1	Understand the Serial and Parallel Communication Protocol in Embedded networking
CO 2	Apply USB in serial communication applications.
CO 3	Apply CAN protocols in network applications.
CO 4	Build an internet network using ethernet protocol.
CO 5	Implement Wireless sensor networks.

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	2	
CO 2	3		3	3	3		
CO 3	3		3	3	3		
CO 4	3		3	3	3	2	
CO 5	3		3	3	3	2	

Assessment Pattern

Bloom's Category	End Semester Examination (%)
Apply	40%
Analyse	20%
Evaluate	20%
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. (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

SECOND SEMESTER M. TECH DEGREE EXAMINATION

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

Course Code: 222EEC015

Course Name: EMBEDDED NETWORKS

Max. Marks: 60 Duration: 150 Minutes

Part A

Answer All Questions. Each Carries 5 mark.

1. Justify the need for RS-485 standard.
2. With a neat diagram discuss USB interfacing with microcontroller.
3. Calculate the timing parameters of CAN Bus with Oscillator clock rate is 20 MHz and CAN bit rate is 125 KHz.
4. Discuss Internet Protocol addressing & routing
5. Explain the concept of robust routing in detail.

Part B

Answer any five questions: Each question carries 7 marks.

6. Illustrate the asynchronous serial input communications from serial devices.
7. Demonstrate about how serial data communication is preferred in I2C bus.
8. Implement an Universal Serial Bus (USB) based atmospheric pressure display on personal computer.
9. Elaborate the architecture of CAN with necessary sketches
10. Why Ethernet is popular for networks of embedded systems. Justify the statement, “Ethernet doesn’t guarantee real time transfers”.
11. Explain Sensor MAC protocol
12. Summarize the concept of data centric routing

SYLLABUS

Module 1 (10 hours)

Embedded communication protocols: Embedded Networking, Introduction, Serial/Parallel Communication – PC Parallel port programming: ISA/PCI Bus protocols
Serial communication protocols: RS232 standard, RS485 standard, Synchronous Serial Protocols - Serial Peripheral Interface (SPI), Inter Integrated Circuits (I2C), Firewire.

Module 2 (6 hours)

USB bus: Introduction, USB bus, Speed Identification on the bus – USB States.
USB bus communication: Packets –Data flow types –Enumeration –Descriptors

Module 3 (8 hours)

CAN Bus: Introduction, Frames –Bit stuffing –Types of errors – Nominal Bit Timing – PIC microcontroller CAN Interface –A simple application with CAN.

Module 4 (8 hours)

Ethernet: Elements of a network – Inside Ethernet – Building a Network: Hardware options – Cables, Connections and network speed.
Design choices: Selecting components –Ethernet Controllers – Using the internet in local and internet communications – Inside the Internet protocol.

Module 5 (8 hours)

Wireless embedded networking: Wireless sensor networks, Introduction – Applications – Network Topology – Localization – Time Synchronization - Energy efficient MAC protocols –SMAC – Energy efficient and robust routing – Data Centric routing.

Course Plan

Sl. No	Topic	No. of Lectures
1	**Embedded communication protocols**	
1.1	Introduction, Embedded Networking	2
1.2	Serial/Parallel Communication – PC Parallel port programming - ISA/PCI Bus	2
1.3	Serial communication protocols – RS232 standard – RS485 standard – Synchronous Serial Protocols	3
1.4	Serial Peripheral Interface (SPI), Inter Integrated Circuits (I2C) protocols, Firewire	3
2	**USB Bus**	
2.1	USB bus, Introduction, USB bus, Speed Identification on the bus – USB States	3
2.2	USB bus communication: Packets Data flow types – Enumeration –Descriptors	3
3	**CAN Bus**	
3.1	Introduction, Frames –Bit stuffing	2
3.2	Types of errors – Nominal Bit Timing	2
3.3	PIC microcontroller CAN Interface	2
3.4	A simple application with CAN.	2
4	**Embedded Ethernet**	
4.1	Elements of a network – Inside Ethernet	1
4.2	Building a Network: Hardware options – Cables, Connections and network speed	2
4.3	Design choices: Selecting components –Ethernet Controllers Using the internet in local and internet communications – Inside the Internet protocol	5
5	**Wireless Embedded Networking**	
5.1	Wireless sensor networks, Introduction – Applications	2
5.2	Network Topology – Localization – Time Synchronization	3
5.3	Energy efficient MAC protocols –SMAC – Energy efficient and robust routing – Data Centric routing	3

Text Books

1. Frank Vahid, Tony Givargis"Embedded Systems Design: A Unified Hardware/Software Introduction", John & Wiley Publications, 2002.
2. Jan Axelson, "USB Complete The Developer's Guide" Fifth Edition, Lakeview Research.
3. BhaskarKrishnamachari, "Networking Wireless Sensors", Cambridge press 2005.
4. Marco Di Natalem, Haibo Zeng, Paolo Giusto, ArkadebGhosal, "Understanding and Using the Controller Area Network Communication Protocol - Theory and Practice", Springer 2012

Reference Books

1. Dogan Ibrahim, "Advanced PIC microcontroller projects in C", Elsevier 2008.
2. Jan Axelson,"Embedded Ethernet and Internet Complete", Penram publications, 2003.
3. Glaf P.Feiffer, Andrew Ayre and Christian Keyold, "Embedded Networking with CAN and CAN open", Embedded System Academy 2005.
4. Don Anderson, "USB System Architecture", Mindshare, Inc.
5. Jan Axelson, "Parallel Port Complete: Programming, interfacing and using the PC"s parallel printer port", Penram publications, 1996.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC016	SIGNAL COMPRESSION TECHNIQUES	PROGRAM ELECTIVE 3	3	0	0	3

Preamble: This course gives a comprehensive knowledge of the essentials of Signal Compression Techniques.

Pre-requisites: Nil

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

CO 1	Differentiate between lossless and lossy compression/ coding techniques.
CO 2	Explain the concept of rate distortion theory and quantization theory.
CO 3	Understand different types of transforms
CO 4	Distinguish between different data compression standards
CO 5	Understand various audio compression techniques, Video compression Techniques and standards

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 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):	
Course based task/Seminar/Data	**15 marks**
Collection and interpretation:	**15 marks**
Test paper, 1 no.: Test paper shall include minimum 80% of the syllabus	**10 marks**

End Semester Examination Pattern: 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

Slot **[SLOT]**

Reg. No: Name:

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SECOND SEMESTER M.TECH DEGREE EXAMINATION

222EEC016 SIGNAL COMPRESSION TECHNIQUES

Time : 2.5 Hours Maximum : 60 Marks

PART A (Answer all questions)

Module I

1 Examine the necessary conditions for an optimal variable-length binary code. 5 marks

Module II

2 Define rate distortion function. List its properties. What is the rate distortion theorem? 5 marks

Module III

3 Explain Sub-band coding and briefly analyze its relevance in high quality audio compression. 5 marks

Module IV

4 Distinguish between Gzip and JBIG. 5 marks

Module V

5 Analyse the features of the MPEG video compression standard. 5 marks

PART B (Answer any one question from each module)

Module I

6 a Encode and correctly decode the given sequence using the Burrows Wheeler Transform algorithm. Sequence: this~~b~~is~~b~~the 7 marks

OR

7 a Detail the steps of Adaptive Huffman coding. 7 marks

Module II

8 a Distinguish between the two types of Uniform quantizers. Give the expressions for SNR in dB — 7 marks

OR

9 a Explain the Vector Quantisation procedure, with appropriate schematics. — 7 marks

Module III

10 a Why is the Walsh Hadamard transform used for compression? — 7 marks

Find the Hadamard transform of a one-dimensional image represented by F(x) = {1, 2, 0, 3}.

Module IV

11 a What is the Dolby AC3 standard? Give the block schematic of its algorithm. — 7 marks

Module V

12 a Explain the working and applications of the H.264 standard. — 7 marks

Syllabus:

Compression Techniques; Huffman Coding; Arithmetic coding, Run Length Coding, Dictionary Techniques; Rate distortion theory; Quantization; vector quantization. Transforms for Compression, Coding. Data Compression standards; Speech Compression Standards; Audio Compression standards; Image Compression standards; Video Compression Standards

Course Plan

No.	Topic	No. of Lectures
1.	**Compression Techniques**	**8**
1.1	Lossless and Lossy Compression	1
1.2	Huffman Coding - Optimality of Huffman codes	1
1.3	Extended Huffman coding	1
1.4	Adaptive Huffman coding	1
1.5	Arithmetic coding	1

1.6	Run Length coding,	1
1.7	Lempel-Ziv coding,	1
1.8	Burrows Wheeler Transform.	1
2.	**Rate distortion theory, quantization techniques**	**8**
2.1	Rate distortion function R(D)	1
2.2	Properties of R(D)	1
2.3	Calculation of R(D) for the binary source	1
2.4	Rate distortion theorem - Converse of the Rate distortion theorem	1
2.5	Quantization – Uniform & Non-uniform	1
2.6	Optimal and adaptive quantization	1
2.7	Vector quantization,	1
2.8	Optimality conditions for VQ	1
3	**Transforms for Compression, Coding**	**8**
3.1	Mathematical Preliminaries for Transforms,	1
3.2	Karhunen Loeve Transform	1
3.3	Discrete Cosine and Sine Transforms	1
3.4	Discrete Walsh Transform Discrete Hadamard Transform	1
3.5	Discrete Walsh Hadamard Transform	1
3.6	Wavelet Based Compression	1
3.7	Transform coding	1
3.8	Subband coding	1
4.	**Data Compression and Image compression standards**	**8**
4.1	Zip and Gzip	1
4.2	PCM, G.711, G.729	1
4.3	ADPCM G.726	1
4.4	SBC CODEC	1
4.5	LD-CELP	1
4.6	G.722	1
4.7	G.723.1	1
4.8	JPEG 2000 standards, JBIG	1
5.	**Audio compression techniques, Video compression Techniques, Standards**	**8**
5.1	Need for audio compression	1
5.2	MPEG audio encoding	1
5.3	MPEG audio decoding	1
5.4	AC standard	1
5.5	Dolby AC3	1
5.6	Need for video compression, Motion Compensation	1
5.7	H.261	1
5.8	H.264	1

Text books

1. Khalid Sayood, “Introduction to Data Compression”, Morgan Kaufmann Publishers.,
   Second Edn, 2005.
2. David Salomon, “Data Compression: The Complete Reference”, Springer Publications, 4th Edn., 2006.
3. Thomas M. Cover, Joy A. Thomas, “Elements of Information Theory," John Wiley &
   Sons, Inc., 1991.

Reference books

1. Toby Berger, “Rate Distortion Theory: A Mathematical Basis for Data Compression”, Prentice Hall, Inc., 1971.
2. K.R.Rao, P.C.Yip, “The Transform and Data Compression Handbook”, CRC Press.,
   2001.
3. R.G.Gallager, “Information Theory and Reliable Communication”, John Wiley & Sons, Inc., 1968.
4. Ali N. Akansu, Richard A. Haddad, “Multiresolution Signal Decomposition: Transforms, Subbands and Wavelets”, Academic Press., 1992
5. Martin Vetterli, Jelena Kovacevic, “Wavelets and Subband Coding”, Prentice Hall Inc., 1995.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC017	FIBER OPTIC COMMUNICATION SYSTEMS	PROGRAM ELECTIVE 3	3	0	0	3

Preamble: Development of fiber optics together with microelectronics is a major breakthrough in information revolution. In fiber optic communication light is the carrier and the optical fiber is communication channel. This course analyses characteristics of different optical devices, optical fiber and optical networks.

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

CO 1	Analyse of different optical fiber parameters and nonlinear effects
CO 2	Evaluate variousOptical sources and modulators
CO 3	Evaluate the performance of different optical detectors.
CO 4	Design a Fibre Optic communication link.
CO 5	Analyse optical multiplexing and Optical Wireless Communication Channels
CO 6	Analyse Optical networks.

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 hours

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

A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY
M.TECH DEGREE EXAMINATION

First Semester

Branch:

FIBER OPTIC COMMUNICATION SYSTEMS

Time: 2.5 Hours **Marks: 60**

Part A

Answer ALL Questions. Each question carries 5 marks

1. Classify optical fibers with their refractive index profile. (b)An optical signal at a specific wavelength has lost 50% of its power after traversing 3 Km of fiber. What is the attenuation in dB/km of this fiber.
2. Explain the photon generation technique in LED. A double hetrojunctionInGaAsP LED emitting at peak wavelength of 1310nm has radiative and non radiative recombination times of 30ns and 90ns respectively. If the drive current is 25mA find the internal quantum efficiency and internal power level.
3. Comment on SPM and XPM in, also the principle of solitons.
4. With a suitable figure describe Radio over Fibre system?
5. Explain the frame structure of SONET/SDH

Part B

Answer ANY FIVE Questions. Each question carries 7 marks

6. (a)Describe the mechanism of group velocity dispersion in optical fibers (4)

   (bExplain the principle and structure of photonic crystal fiber. (3)
7. Derive an expression for GVD in optical fibers. (7)
8. Explain the structure and working of VCSEL. (7)
9. Derive an expression for the Bit Error Rate in optical receivers. (7)
10. (a)Make the power budget and calculate the maximum transmission distance for a 1310nm light wave system operating at 100Mb=s and using an Laser for launching 1mW of average power into the fiber. Assume 0.2dB/km fiber loss, 0.2dB splice loss every 2 km, 1dB connector loss at each end of fiber link, and 100nW receiver sensitivity. Allow 6 dB system margin. (3)

    (b)Explain the working principle of EDFA with suitable diagram (4)
11. With suitable diagrams explain OFDM system. (7)

12. Explain Photonic Packet Switching and Optical Time Division Multiplexing (7)

Syllabus

Module I

Overview of Optical Communication System: Evolution of Fibre-Optic Communications, Light wave System Components, Optical Fibers-Types, Wave propagation, Fiber Modes, Dispersion in fibers, Fiber Losses, Nonlinear Effects, Plastic Optical Fibers, Photonic Crystal Fibers

Module II

Optical Transmitters and Receivers- LEDs and Semiconductor Lasers, Optical Signal Generation, MZM, Advanced Modulation Formats, Optical Receivers, Sources of Noise, SNR, Coherent Detection, Performance Evaluation (BER, Q, Receiver Sensitivity).

Module III

Lightwave System Design- Point to Point Links, Link Budget, Loss Management-Optical Amplifiers, OSNR,Dispersion Management-DCF, FBG,Dispersion-Equalizing Filters, Control of Nonlinear Effects-Solitons.

Module IV

Introduction to Multiplexing and Communication channels: WDM, DWDM, WDM Components, Subcarrier Multiplexing , Radio over Fiber, OFDM, Indoor Optical Wireless Communication Channels.

Module V

Optical Networks –SDH/SONET, Layers, Physical network topologies, Access Networks- Optical Transport Network , WDM Network Elements, Storage-area networks, Photonic Packet Switching, Optical Time Division Multiplexing and Synchronization

Course Plan

No	Topic	No. of Lectures
1	**Overview of Optical Communication System :**	
1.1	Evolution of Fibre-Optic Communications, Light wave System Components.	1
1.2	Optical Fibers-Types, Wave propagation, Fiber Modes, Dispersion in fibers, GVD, PMD , Fiber Losses	3
1.3	Nonlinear Effects- Self Phase Modulation Cross Phase Modulation, Four Wave Mixing, Stimulated Raman and Brillouin Scattering.	2
1.4	Fiber Design- Plastic Optical Fibers, Photonic Crystal Fibers	2

2	**Optical Transmitters and Receivers-**	
2.1	LEDs and Semiconductor Lasers- structure and characteristics, VCSEL	2
2.2	Optical Signal Generation-Direct Modulation, External Modulation, MZM, Advanced Modulation Formats	2
2.3	Optical Receivers- PIN and APD Detectors, Receiver design, Sources of Noise, SNR,	2
2.4	Coherent Detection , Homodyne and Heterodyne detection, SNR	2
2.5	Performance Evaluation of an OOK link- BER, Q, Receiver Sensitivity	2
3	**Lightwave System Design**	
3.1	Point-to-Point Links, Link Budget(Power & Rise time)	2
3.2	Loss Management-Compensation of Fiber Losses, Optical Amplifiers- EDFA and RAMAN Amplifiers, Optical Signal-To-Noise Ratio.	2
3.3	Dispersion Management-Dispersion-Compensating Fibers,Fiber Bragg Gratings, Dispersion-Equalizing Filters	3
3.4	Control of Nonlinear Effects-Solitons in Optical Fibers	1
4	**Introduction to Multiplexing and Communication channels**	
4.1	WDM Light wave Systems, Architecture,WDM Components, DWDM , Applications	4
4.2	Subcarrier Multiplexing-Analog and Digital SCM Systems, -Radio over Fibre Systems, OFDM.	3
4.3	Indoor Optical Wireless Communication Channels – Infrared Optical Wireless Communications, Visible Light Communications	2
5	**Optical Networks –**	
5.1	SDH/SONET Layers, Frame Structure, Physical Layer, topologies, Access Networks	3
5.2	Optical Transport Network, OTN hierarchy. Frame Structure, Multiplexing	3
5.3	WDM Network Elements, Optical Line terminals. Optical add/Drop multiplexers, Optical crossconnects	2
5.4	Storage-area networks, Photonic Packet Switching OpticalTimeDivisionMultiplexing and Synchronization	2

Reference Books

1. Fiber Optic Communication- GP Agrawal(Wiley 4th ed)
2. Rajiv Ramaswami and Kumar N Sivarajan- Optical networks, A practical perspective (Morgan kaufmann , 2nd 2001)
3. R.G.Hunsperger , Integrated optics Theory and technology (Springer series in Optical Sciences “, 5th edition 2002)
4. Advanced Optical and Wireless Communications Systems, IvanB.Djordjevic (Springer)
5. G.G Keiser , Optical Fiber Communication (TMH,4th Ed)
6. John M.Senior ,OpticalFiber Communications Principles and practice PHI,1992 .

SEMESTER II

PROGRAM ELECTIVE IV

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC018	WIRELESS AND MOBILE COMMUNICATION	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: This course introduces the important aspects in Wireless & Mobile Communication. The evolution of different generations of mobile systems, access and diversity techniques are dealt in the course. The course gives an overview from RF channel modelling to next generation networks.

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

CO 1	Analyse the characteristics of wireless channels.
CO 2	Apply the diversity concepts for wireless communication.
CO 3	Evaluate different multiple access techniques.
CO 4	Evaluate the challenges in mobile communication systems.
CO 5	Analyse the new trends in wireless & mobile communications networks.

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	2	
CO 2	3		3	2	2	2	
CO 3	3		3	3	2	2	
CO 4	3		2	3	3	2	
CO 5	3		2	2	3	3	

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Evaluation Method	**Marks**
Preparing a review article based on peer reviewed Original publications (minimum 10 Publications shall be referred)	15
Course based task/ Seminar/ Data Collection and interpretation	15
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.)	10
Total	40

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
Answer all questions. Each question carries 5 marks.
This section will have 5 numerical/ short answer questions with 1 question from each module.

Part B
Answer any five. Each question carries 7 marks.
This section will have 7 long answer questions, with minimum one question from each module.

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

Slot [E]

Reg. No: Name:

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH DEGREE EXAMINATION

Subject: 222EEC018 Wireless and Mobile Communication

Time : 2.5 Hours Maximum : 60 Marks

PART A (Answer all questions)

			Marks
		Module I	
1		Analyse the factors affecting path loss in wireless communication.	5
		Module II	
2		Evaluate the different diversity technique used in wireless receivers.	5
		Module III	
3		With the help of a block schematic, analyse the working of a PN sequence generator.	5
		Module IV	
4		Analyse the advantages and disadvantages of 2G and 3G systems.	5
		Module V	
5		Analyse how Quality of Service is achieved in 5G communication.	5
		PART B (Answer any Five question)	
6	a	Define the terms coherence bandwidth, Doppler spread and coherence time.	3
	b	Differentiate between fast fading and slow fading of channels.	4
7	a	Analyse the working of different transmit diversity schemes.	3
	b	Draw the relevant block schematics and evaluate the array gains of Maximal Ratio Combining (MRC) and Equal Gain (EG) combining methods.	4
8		Prove that a Multiple Input Multiple output (MIMO) system can be represented by a set of parallel channels.	7
9		Prove that a DSSS - CDMA system is capable of both jamming rejection and multipath rejection.	7

10	a	Give the expression for calculating PAPR and explain its significance.	3
	b	Describe a method to create a multicarrier signals from discrete inputs.	4
11	a	Analyse the different handover procedures in cellular communication.	3
	b	Evaluate different methods for improving coverage & capacity in a cellular systems.	4
12		Enumerate the key enablers and Key Performance Indicators of a 6G network.	7

Syllabus

Module 1:Channel Models: (8)

Shannon's capacity, bandwidth and power-limited regimes. Free space propagation model, factors affecting path loss. Parameters of mobile multipath channels-time dispersion parameters, coherence bandwidth, Doppler spread and coherence time. Types of small-scale fading-fading effects due to multipath time delay spread, flat fading, frequency selective fading, fading effects due to Doppler spread-fast fading, slow fading. Narrow band and wideband fading models. Physical modeling of wireless channels - time and frequency coherence - statistical channel models - power delay profile.

Module 2:Diversity Techniques: (8)

Independent fading paths - receiver diversity - selection combing -threshold combing - maximal-ratio combing - equal gain combing - transmitter diversity - channel known at transmitter - channel unknown at transmitter - Rake receiver - The Alamouti scheme-transmit & receive diversity-MIMO systems. MIMO applications in wireless system - MIMO-OFDM.

Module 3:Multi - Access Methods: (8)

TDMA/FDMA: A case study of GSM. CDMA: Direct sequence spread spectrum - Frequency hopping systems-Anti-jamming - Pseudo Random (PN) sequence - Maximal length sequences - Gold sequences - Generation of PN sequences. Power control in CDMA. Data transmission using multiple carriers - Discrete implementation of multicarrier modulation - OFDM - Advantages Mitigation of subcarrier fading - Timing and frequency offset in OFDM- PAPR reduction of OFDM signals.

Module 4:Cellular Communication: (8)

Overview of cellular systems and evolution 1G to 3G. Cellular concepts - Frequency reuse, Co-channel and Adjacent channel Interference. Improving coverage & capacity in Cellular Systems - Cell splitting, Sectoring. Hand over - Hard and soft hand off strategies. Fundamentals of 4G - Advantages and Applications of 4G - Architecture and representative protocols.

Module 5: Emerging Connectivity: (8)

Introduction to 5G - Architecture - Quality of Service - Radio Network - requirements, Security - Specifications – Standardization. B5G- Introduction to 6G- requirements - spectrum- key enablers- Key Performance Indicators - Introduction to Vehicle-to-Vehicle communications.

Course Plan

No	Topic	No. of Lectures
1	**Channel Models**	**(8)**
1.1	Shannon's capacity - bandwidth and power-limited regimes.	1
1.2	Free space propagation model - factors affecting path loss.	1
1.3	Parameters of mobile multipath channels-time dispersion parameters, coherence bandwidth- Doppler spread and coherence time.	1
1.4	Types of small-scale fading-fading effects due to multipath time delay spread - flat fading- frequency selective fading,	1
1.5	Fading effects due to Doppler spread-fast fading slow fading.	1
1.6	Narrow band and wideband fading models.	1
1.7	Physical modelling of wireless channels - time and frequency coherence	1
1.8	Statistical channel models - power delay profile.	1
2	**Diversity Techniques**	**(8)**
2.1	Independent fading paths - receiver diversity - selection combing -threshold combing - maximal-ratio combing - equal gain combing	2
2.2	Transmitter diversity - channel known at transmitter - channel unknown at transmitter - Rake receiver	2
2.3	The Alamouti scheme-transmit & receive diversity-MIMO systems.	2
2.4	MIMO applications in wireless system - MIMO-OFDM.	2
3	**Multi - Access Methods**	**(8)**
3.1	TDMA/FDMA: A case study of GSM. CDMA: Direct sequence spread spectrum - Frequency hopping systems.	2
3.2	Anti-jamming - Pseudo Random (PN) sequence - Maximal length sequences - Gold sequences - Generation of PN sequences. Power control in CDMA.	2
3.3	Data transmission using multiple carriers - Discrete implementation of multicarrier modulation - OFDM - Advantages	2
3.4	Mitigation of subcarrier fading - Timing and frequency offset in OFDM- PAPR reduction of OFDM signals.	2
4	**Cellular Communication**	**(8)**

4.1	Overview of cellular systems and evolution 1G to 3G. Cellular concepts	2
4.2	Frequency reuse, Co-channel and Adjacent channel Interference.	2
4.3	Improving coverage &capacity in Cellular Systems - Cell splitting, Sectoring. Hand over - Hard and soft hand off strategies.	2
4.4	Fundamentals of 4G - Advantages and Applications of 4G - Architecture and representative protocols.	2
5	**Emerging Connectivity**	**(8)**
5.1	Introduction to 5G - Architecture - Quality of Service - Radio Network requirements,	2
5.2	Security - Specifications – Standardization - B5G	2
5.3	Introduction to 6G- requirements - spectrum- key enablers- Key Performance Indicators	2
5.4	Introduction to Vehicle to-Vehicle communications.	2

Text Books

1. Andrea Goldsmith, Wireless Communications, Cambridge University press.
2. A.J.Viterbi, CDMA- Principles of Spread Spectrum, Addison Wesley.4.
3. Shinsuke Hara and Ramjee Prasad, Multicarrier Techniques for 4G MobileCommunications, Artech House.
4. AngelikiAlexiou, 5G Wireless Technologies, IET.

Reference Books

1. Simon Haykin and Michael Moher, Modern Wireless Communications, Pearson Education.
2. Jonathan Rodriguez, Fundamentals of 5G Mobile Networks, Wiley.
3. Paulo Sergio Rufino Henrique and Ramjee Prasad, 6G: The Road to the Future Wireless Technologies 2030, River Publishers.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC019	BIOMEDICAL SIGNAL PROCESSING	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: The course introduces the fundamental concepts, principles and application of biomedical signal processing and design. This course goes deeper into the various aspects of artifact removal in biosignals, cardio vascular applications, neurological applications and model based spectral analysis.

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

CO 1	Analyze biomedical signals properties and effects of noise in biomedical instruments
CO 2	Create a model of bio medical signal
CO 3	Analyse ECG signals for Cardio vascular applications
CO 4	Analyse EEG signals for Neurological applications
CO 5	Analyse model based spectral analysis

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		
CO 2			3	3	3		
CO 3			3	3	3		
CO 4			3	3	3		
CO 5			3	3	3		

Assessment Pattern

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

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.

Model Question Paper

Name:
Reg. No:

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH DEGREE EXAMINATION

Subject: 222EEC019BIOMEDICAL SIGNAL PROCESSING

Time : 3 Hours Maximum : 60 Marks

PART A (Answer all questions)

1		Explain the structure of neuron with diagram.	5 marks
2		With diagram, explain the significance of ECG graph	5 marks
3		Explain artifacts in EEG.	5 marks
4		Discuss about various sleep disorders	5 marks
5		Describe the categorization of EEG activities.	5 marks

PART B (Answer any 5 questions)

6.	a	Describe the following biomedical signals: (i) Electroencephalogram (EEG) (ii) Electromyogram (EMG).	4 marks
	b	Briefly explain the resting and action potential.	3 marks
7.		How matched filters can be used in the waveform analysis of EEG?	7 marks
8.		Give details of any one EEG segmentation scheme which is based on nonparametric estimation of the signal statistics?	7 marks
9.		With the help of a neat block diagram, explain the Pan-Tompkins algorithm for QRS complex detection in an on-going ECG signal.	7 marks
10.		Discuss the following in ECG signal processing: baseline wandering, power line interference and high frequency EM noise.	7 marks
11.	a	Analyse the ECG parameters and their estimation.	4 marks
	b	Discuss the first and second heart sounds and murmurs of heart.	3 marks
12.		With the help of a neat diagram, explain the method of EEG measurement and describe the frequencies of interest.	7marks

Syllabus

MODULE I

Review of biomedical signal :
Tasks in Biomedical Signal Processing - Computer Aided Diagnosis. Origin of bio-potentials - Processing of Random & Stochastic signals - Introduction to Biomedical Signals - Examples of Biomedical signals - ECG, EEG, EMG etc-Fourier Transform and Time-Frequency Analysis - (Wavelet Transform) of biomedical signals- Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments

MODULE II

Concurrent, coupled and correlated processes:
Concurrent, coupled and correlated processes - illustration with case studies
Adaptive and optimal filtering - Modelling of Biomedical signals- Detection of biomedical signals in noise - removal of artifacts of one signal embedded in another -Maternal-Fetal ECG – Muscle - contraction interference. Event detection - case studies with ECG & EEG

MODULE III

Cardio vascular applications :
Basic ECG - Electrical Activity of the heart- ECG data acquisition – ECG parameters & their estimation - Use of multi scale analysis for ECG parameters estimation- Noise & Artifacts - ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering - QRS detection - Arrhythmia analysis

MODULE IV

Neurological Applications:
The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques- EEG applications- Epilepsy, sleep disorders- Brain computer interface. Modelling EEG- linear, stochastic models - Non linear modelling of EEG- Artifacts in EEG & their characteristics and processing -

MODULE V

Model based spectral analysis:
EEG segmentation – Joint Time- Frequency analysis correlation analysis of EEG channels-coherence analysis of EEG channels- Independent component Analysis - Cocktail party problem applied to EEG signals

Course Plan

No	Topic	No. of Lectures
1	**Review of Biomedical Signal**	
1.1	Fourier Transform and Time Frequency Analysis - (Wavelet) of biomedical signals- Processing of Random & Stochastic signals -	2hrs
1.2	Introduction to Biomedical Signals - Examples of Biomedical signals - ECG, EEG, EMG etc	2hrs
1.3	Tasks in Biomedical Signal Processing - Computer Aided Diagnosis. Origin of bio-potentials	2hrs
1.4	Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments	2hrs
2	**Concurrent, coupled and correlated processes**	
2.1	Concurrent, coupled and correlated processes - illustration with case studies	2hrs
2.2	Adaptive and optimal filtering	3hrs
2.3	Modelling of Biomedical signals - Detection of biomedical signals in noise - removal of artifacts of one signal embedded in another -Maternal-Fetal ECG – Muscle - contraction interference. Event detection - case studies with ECG & EEG	3hrs
3	**Cardio vascular applications :**	
3.1	Basic ECG - Electrical Activity of the heart	2hrs
3.2	ECG data acquisition – ECG parameters & their estimation - Use of multiscale analysis for ECG parameters estimation	2hrs
3.3	Noise & Artifacts - ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering	2hrs
3.4	QRS detection - Arrhythmia analysis	2hrs
4	**Neurological Applications:**	
4.1	The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques	2hrs
4.2	EEG applications- Epilepsy, sleep disorders	2hrs
4.3	Brain computer interface. Modelling EEG- linear, stochastic models - Non linear modelling of EEG	2hrs
4.4	Artifacts in EEG & their characteristics and processing - Model based spectral analysis	2hrs
5	**Model based spectral analysis**	
5.1	EEG segmentation	2hrs
5.2	Joint Time- Frequency analysis correlation analysis of EEG channels	2hrs
5.3	coherence analysis of EEG channels	2hrs
5.4	Independent component Analysis - Cocktail party problem applied to EEG signals	2hrs

Reference Books

1. Bruce, Eugene N. "Biomedical signal processing and signal modeling: Wiley series in telecommunications and signal processing." (2001).

2.Sörnmo, Leif, and Pablo Laguna. *Bioelectrical signal processing in cardiac and neurological applications*. Vol. 8. Academic press, 2005.

3.Rangayyan, “Biomedical Signal Analysis”, Wiley 2002.

4.D.C.Reddy , “ Biomedical Signal Processing: Principles and techniques”, Tata McGraw Hill, New Delhi, 2005.

5.Enderle, John, and Joseph Bronzino, eds. *Introduction to biomedical engineering*. Academic press, 2012.

6. Sanei, Saeid, and Jonathon A. Chambers. *EEG signal processing*. John Wiley & Sons, 2013.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC020	AUDIO PROCESSING	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: This course aims to develop in-depth understanding of fundamentals of hearing mechanism, cochlear signal processing, auditory filters, critical band structure, psychoacoustic analysis, spatial audio perception & rendering and audio compression algorithms, enabling them to apply that in the research and development of audio processing applications.

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

CO 1	Explain the hearing mechanism, cochlear signal processing, auditory filter banks, hearing aids and cochlear implants
CO 2	Apply the knowledge of critical band structure, masking phenomenon and psycho acoustic analysis in developing audio processing applications
CO 3	Explain the various audio compression methods and audio coding standards like MPEG2-AAC
CO 4	Apply the knowledge of spacial audio perception and room acoustics in the development of spatial audio systems
CO 5	Analyse the quality of audio signals using objective and subjective methods and explain audio processing techniques for music 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.

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: **2222EEC020** - **AUDIO PROCESSING**

Max. Marks: 60 Duration: 2.5 hours

PART A

Answer all questions. Each question carries 5 marks.

1. Distinguish between Mel frequency scale and Bark scale.
2. How is simultaneous masking made use of in audio applications?
3. How is perceptual irrelevancy removal used in speech compression?
4. How do you create mid and side channels in a Mid-Side stereo?

5. How is automatic Music Information Retrieval performed?

PART B

Answer any five questions. Each question carries 7 marks.

6. How does a hearing aid improve the hearing experience?
7. What do you mean by the term absolute threshold of hearing? Refer to Fig. 1. State which of the following frequencies a person will be able to hear. i) 63Hz of SPL 10dB, ii) 1.5KHz of SPL 10dB and iii) 14KHz of SPL 10dB.

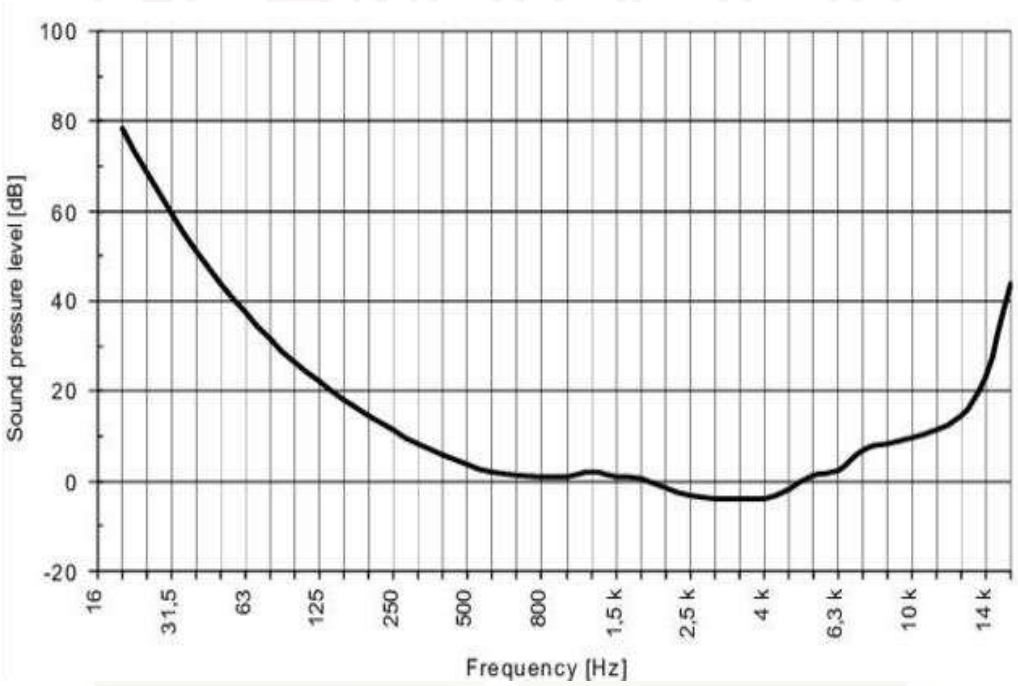

Fig.1

8. How can we suppress the effects of pre-echo?
9. How can we develop a lossless coding method for audio compression?
10. Explore the use of MDCT in audio coding.
11. How do we localize sound?
12. How can we analyse the quality of audio using an objective method?

Syllabus

MODULE I

Signal Processing Models of Audio Perception: Basic anatomy of hearing System-Outer ear, middle ear and inner ear, Cochlea and signal processing in cochlea, Auditory Filter Banks, Gamma-tone filters, Bark Scale, Mel frequency scale, Hearing aids, Cochlear implants,

MODULE II

Psycho-acoustic analysis: Absolute Threshold of Hearing, Critical Band Structure, Simultaneous Masking, Temporal Masking, MPEG psycho-acoustic model

MODULE III

Audio compression methods: Redundancy removal and perceptual irrelevancy removal, Sub-band coding, MDCT, Transform coding, Pre-echo and pre-echo suppression, MPEG2-AAC coding standard, Lossless coding methods

MODULE IV

Spatial Audio Perception and rendering: Sound localization and space perception, Head related transfer functions, Stereo and multi-channel audio, Mid-Side Stereo, Intensity Stereo, Binaural Cue Coding, Spatial audio standards, Room acoustics: Sound propagation in rooms, Modeling the influence of short and long term reverberation, Modeling room impulse responses and head related impulse responses.

MODULE V

Music Transcription: automatically deriving notes, beats, and chords from music signals, Music Information Retrieval: audio-based genre classification, artist/style identification, and similarity estimation, Objective analysis methods-PEAQ, Subjective analysis methods-MOS score, MUSHRA score

Course Plan

No	Topic	No. of Lectures
1	**MODULE I**	
1.1	Basic anatomy of hearing System-Outer ear, middle ear and inner ear, Cochlea and signal processing in cochlea	2
1.2	Auditory Filter Banks, Gamma-tone filters, Bark Scale, Mel frequency scale	2
1.3	Hearing aids, Cochlear implants	2
2	**MODULE II**	
2.1	Absolute Threshold of Hearing, Critical Band Structure	3
2.2	Simultaneous Masking, Temporal Masking	3
2.3	MPEG psycho-acoustic model	2
3	**MODULE III**	
3.1	Redundancy removal and perceptual irrelevancy removal,	3

	Sub-band coding	
3.2	MDCT, Transform coding, Pre-echo and pre-echo suppression	3
3.3	MPEG2-AAC coding standard, Lossless coding methods.	3
4	**MODULE IV**	
4.1	Sound localization and space perception, Head related transfer functions	3
4.2	Stereo and multi-channel audio, Mid- Side Stereo, Intensity Stereo, Binaural Cue Coding, Spatial audio standards	3
4.3	Room acoustics: Sound propagation in rooms, Modeling the influence of short and long term reverberation, Modeling room impulse responses and head related impulse responses.	3
5	**MODULE V**	
5.1	Music Transcription, automatically deriving notes, beats, and chords from music signals.	3
5.2	Music Information Retrieval, audio-based genre classification, artist/style identification, and similarity estimation.	3
5.3	Objective analysis methods- PEAQ, Subjective analysis methods - MOS score, MUSHRA score	2

Reference Books

1. Audio Signal Processing and Coding, Andreas Spanias, Ted Painter and VenkittaramAtti, Wiley-Inter Science publication, 2006
2. Speech and Audio Signal Processing: Processing and Perception of Speech and Music, 2nd Edition, Ben Gold, Nelson Morgan, Dan Ellis, ISBN: 978-0-470-19536-9
3. Spatial Audio (Music Technology Series), 1st Edition, Francis Rumsey, ISBN: 0240516230

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC021	DEEP LEARNING	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: This course provides an introduction to key concept in deep learning and equip students with knowledge required to develop best deep learning solutions for real world problems in domains such as computer vision, natural language processing etc.

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	Demonstrate the uses and limitations of fully connected neural networks
CO 2	Compare different CNN networks for classification and detection in terms of architecture, performance and computational requirements
CO 3	Develop a convolutional neural network for a real-world application
CO 4	Apply regularization and optimization techniques in CNN training
CO 5	Demonstrate the use of RNNS and LSTM for analysing sequential data
CO 6	Apply the concepts of attention models, transformers and generative models

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						
CO 3	3		3	3	3		
CO 4	3						
CO 5	3						
CO 6	3		3	3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	60%
Analyse	40%
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Course project: 15 marks
Course based task/Seminar/Quiz: 15 marks
Test paper, 1 no.: 10 marks

End Semester Examination Pattern:

60 Marks
Part A: 5×5 Marks
Part B: 5×7 Marks

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Suppose you have a 3-dimensional input $x = (x_1, x_2, x_3) = (2, 2, 1)$ fully connected with weights $(0.5, 0.3, 0.2)$ to one neuron which is in the hidden layer with sigmoid activation function. Calculate the output of the hidden layer neuron.
2. Consider the case of the XOR function in which points $\{(0, 0), (1, 1)\}$ belong to one class, and $\{(1, 0), (0, 1)\}$ belong to the other class. Design a multilayer perceptron for this binary classification problem.

Course Outcome 2 (CO2)

1. Implement AlexNet, VGG Net, ResNet and Inception Net for a classification problem. Compare and contrast the performance in terms of accuracy and computational requirements.
2. Implement RCNN, Fast RCNN, Faster RCNN, YOLO and Mask RCNN for detection problem. Compare and contrast the performance in terms of accuracy and computational requirements.

Course Outcome 3(CO3):

3. Draw and explain the architecture of convolutional neural networks.
4. You are given a classification problem to classify the handwritten digits. Suggest a learning algorithm with its architecture, an objective function, and an optimization routine, along with how input and output will be prepared for the classifier

Course Outcome 4 (CO4):

1. Explain how L2 regularization improves the performance of deep feed forward neural networks.
2. Explain the use of data augmentation and dropouts

Course Outcome 5 (CO5):

1. Illustrate the workings of the RNN with an example of a single sequence defined on a vocabulary of four words
2. Draw and explain the architecture of LSTM.
3. List the differences between LSTM and GRU

Course Outcome 6 (CO6):

1. Explain the use of transformers for image recognition
2. Explain the basic principle and architecture of generative adversarial network

Model Question paper

PART A

1 There is huge gap between training accuracy and testing accuracy, while training a particular machine learning model. What might be the reason. Suggest possible methods of overcoming it 5

2 Draw the block diagram of a naïve inception block. What is the disadvantage of this block? Explain how adding 1x1 convolution helps to overcome the difficulty. 5

3 Consider a Convolutional Neural Network having three different convolutional layers in its architecture as 5

Layer-1	Filter Size – 3×3, Number of Filters – 10, Stride – 1, Padding – 0
Layer-2	Filter Size – 5×5, Number of Filters – 20, Stride – 2, Padding – 0
Layer-3	Filter Size – 5×5 , Number of Filters – 40, Stride – 2, Padding – 0

If we give a 51×51 RGB image as input to the network, then determine the dimension of the vector after passing through layer 3 in the architecture.

4 You have a dataset D1 with 1 million labelled training examples for classification, and dataset D2 with 100 labelled training examples. Your friend trains a model from scratch on dataset D2. You decide to train on D1, and then apply transfer learning to train on D2. State one problem your friend is likely to find with his approach. How does your approach address this problem? 5

5 Differentiate between soft attention and hard attention. 5

PART B

6 Astronomers are using a linear classifier to classify long exposed CCD images into star, nebula and galaxy. The predicted scores of this linear classifier, during one particular iteration of training is given below 7

Class	Test Image		
	Star	Nebula	galaxy
Star	3.2	1.3	2.2
Nebula	5.1	4.9	2.5
Galaxy	-1.7	2	-3.1

Calculate the softmax loss for Nebula. Find minimum and maximum softmax loss, if there are C classes.

7 Draw the computational graph and calculate the analytical gradients at each node for the following function 7

$$f(w,x) = \frac{1}{1+e^{-(w_0x_0+w_1x_1+w_2)}}$$

where $w_0 = 2$, $w_1 = -3, w_2 = -3$, $x_0 = -1$, $x_1 = -2$

8 Consider a CNN implemented with following arrangement. 7

Input 128x128x3
Conv 4- 10, stride 2, pad 0
Conv 9-10,stride 2, pad 2
Pool 2 stride 2, pad 0

Conv 3-5 stride 2, pad 0

FC 5

FC-N denotes fully connected layer with N neuron outputs. Conv M-N indicates convolution layer of size MxMxD, with M filters and D activation volume of previous layer. Pool 2 indicates 2x2 maxpooling layer. Find activation volume and number of parameters at each layer.

9	Write disadvantages of SGD. Explain how ADAM overcome it.	7
10	Imagine you were asked to write a poem in the writing style of John Keats. What kind of network will you use? Draw and explain the structure of identified network with equations.	7
11	You were asked to design an object detection frame work to be used in Google's autonomous car Waymo. The designed framework should be able to detect and identify multiple objects (pedestrians, other vehicles etc.) from images obtained from the camera feed of Waymo. Draw and explain the general structure of the network. Justify your answer.	7
12	Design a network to generate your photo in the style of Leonardo DaVinci'sMonalisa.	7

SYLLABUS

MODUE 1: Introduction to Machine Learning

Introduction: Supervised Vs. Unsupervised Learning, Classification Vs. Regression, Machine Learning Vs. Deep Learning

Machine Learning System Design: Data-driven Approach, Datasets: Training, Testing and Validation Sets, Over fitting and Under fitting, Hyper parameters, K-nearestneighbour classification

Linear classification: Loss function, Multiclass SVM,Softmax classifier. Optimization, Numeric andAnalytic gradients.

MODULE 2: Neural Networks

Deep feedforward networks/ Multilayer perception: Perceptron, activation functions, Example: Learning XOR, Architecture of deep neural network

Back propagation, Gradient-Based Learning.

Convolutional Neural Networks: Convolution, Pooling Layers, spatialarrangement, layer patterns, layer sizing patterns.

MODULE 3: Training Neural Networks

Initialization, batch normalization, Hyper parameter optimization.

Optimization algorithms: SGD, Momentum, Adagrad, RMS Prop, Adam

Regularization methods: L1 and L2 regularization, Early stopping, drop outs, ensembles, data augmentation, Update rules, transfer learning

MODULE 4: CNN architectures

AlexNet, VGG Net, ResNet, Inception Net

Object Detection: RCNN, Fast RCNN, Faster RCNN, YOLO, Mask RCNN

Recurrent Neural Networks: RNN, Bidirectional RNN, LSTM, GRU

MODULE 5: Attention Models, Transformers and Generative Models

Attention: Multimodal attention, Self-Attention

Transformers: BERT and vision transformer

Autoencoders, Variational auto encoders, Generative Adversarial Network

Course Plan

No	Topic	No. of Lectures
1	**Introduction to Machine Learning**	
1.1	Introduction: Supervised Vs. Unsupervised Learning, Classification Vs. Regression, Machine Learning Vs. Deep Learning	1
1.2	Machine Learning System Design: Data-driven Approach, Datasets: Training, Testing and Validation Sets, Over fitting and Under fitting, Hyper parameters, K-nearestneighbour classification	3
1.3	Linear classification: Loss function, Multiclass SVM, Softmax classifier. Optimization, Numeric andAnalytic gradients.	4
2	**Neural Networks**	

2.1	Deep feedforward networks/ Multilayer perception: Perceptron, activation functions, Example: Learning XOR, Architecture of deep neural network	2
2.2	Back propagation, Gradient-Based Learning.	2
2.3	Convolutional Neural Networks: Convolution, Pooling Layers, spatialarrangement, layer patterns, layer sizing patterns.	3
3	**Training Neural Networks**	
3.1	Initialization, batch normalization, Hyper parameter optimization.	2
3.2	Optimization algorithms: SGD, Momentum, Adagrad, RMS Prop, Adam	2
3.3	Regularization methods: L1 and L2 regularization, Early stopping, drop outs, ensembles, data augmentation, Update rules, transfer learning	2
4	**CNN architectures**	
4.1	AlexNet, VGG Net, ResNet, Inception Net	3
4.2	Object Detection: RCNN, Fast RCNN, Faster RCNN, YOLO, Mask RCNN	3
4.3	Recurrent Neural Networks: RNN, Bidirectional RNN, LSTM, GRU	3
5	**Attention Models, Transformers and Generative Models**	
5.1	Attention: Multimodal attention, Self-Attention	3
5.2	Transformers: BERT and vision transformer	3
5.3	Autoencoders, Variational auto encoders, Generative Adversarial Network	4

Reference Books

1. Ian Goodfellow, YoshuaBengio, and Aaron Courville. Deep learning. MIT press,2016.
2. Francois Chollet. Deep learning with Python. Simon and Schuster, 2021.
3. Ivan Vasilev. Advanced Deep Learning with Python: Design and implement advanced next-generation AI solutions using TensorFlow and PyTorch. Packt Publishing Ltd, 2019.
4. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006
5. Michael A Nielsen. Neural networks and deep learning. Determination press, 2015.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC022	SIGNAL PROCESSING FOR AUTOMATION	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: This course aims to impart knowledge on thesignal processing and its applications in the field of vehicle automation, process control automation, robotics, and the audio video processing.

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

CO 1	Understand the general principles of automation, sensors and transducers
CO 2	Understand the automotive Protocols and apply the signal processing application in vehicle automation
CO 3	Apply the Signal Processing methods in Process control and Automation
CO 4	Understand the fundamentals of robot and apply the Signal Processing methods in robotics
CO 5	Understand the principles of audio and video signal processing

Mapping of course outcomes with program outcomes

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

Assessment Pattern:

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

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

Preparing a review article based on peer reviewed original publications (minimum 10publications 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 College. There will be twoparts; Part A and Part B. Part A contain 5 numerical questions (such questions shallbe useful in the testing of knowledge, skills, comprehension, application, analysis,synthesis, evaluation and understanding of the students), with 1 question from eachmodule, having 5 marks for each question. Students shall answer all questions. PartB contains 7 questions (such questions shall be useful in the testing of overallachievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solvingand quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 7 marks. Total duration ofthe examination will be 150 minutes.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M. TECH DEGREE EXAMINATION

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

Course Code: 222EEC022

Course Name: Signal Processing for Automation

Max. Marks: 60 Duration: 150 Minutes

Part A

Answer All Questions. Each Carries 5 mark.

1. Differentiate between State space models and Time series models.

2. Explain about the photometric image formation.

3. What are Smart Sensors? Explain the functions of the Components of Smart Sensors.

4. Illustrate the different approaches to SLAM.

5. Compare the Protocols: LIN, CAN and FlexRay.

Part B

Answer any five questions: Each question carries 7 marks.

6. Illustrate the advantages of PLC over PC.

7. With neat sketch explain the functions of a robot.

8. Explain the static characteristics of transducers.

9. With the help of necessary diagrams Explain How can we interface PLC with SCADA.

10. What are the specifications of robots?

11. With necessary diagrams, explain the features and advantages of AUTOSAR Architecture.

12. Explain the key components of a speech recognition system.

Syllabus and Course Plan

Module I :**Introduction to automation (8)**

Introduction to automation, Overview of expert system, Expert system Architecture, Sensor Fundamentals, Sensor classification, Sensor parameters Selection of sensors. Interfacing of Sensors and Signal Conditioning: Change of BIOS and level of signals, Smart Transducers: Smart Sensors, Components of Smart Sensors, General Architecture of Smart Sensors, Evolution of Smart Sensors, Advantages of Smart Sensors.

Module II :**Signal Processing in vehicle Automation** (8)
Overview of automotive subsystems, basic concept and types of automotive Sensors and Transducers- introduction to autonomous vehicles architecture, Automotive Protocols: LIN, CAN, FlexRay, Test, Calibration and Diagnostics tools for networking of electronic systems like ECU Software and Testing Tools, ECU Calibration Tools, AUTOSAR Architecture.

Module III :**Signal Processing in Process control and Automation (10)**
Introduction to Process Modeling: hierarchies. Theoretical model: transfer function, state space models, and time series models. concept of feedback & feed forward control, cascade control, selective control loops, ratio control, feed forward and ratio, split range, selective, override, auctioneering, adaptive and inferential controls. Statistical process control, supervisory control, direct digital control, distributed control, Introduction to Automatic Control: PC based automation. SCADA in process automation. Time Delay Systems and Inverse Response Systems, Special Control Structures, Introduction to Sequence Control, PLC, RLL, Sequence Control. Scan Cycle.

Module IV :Signal Processing in Robotics (8)
Introduction to robotics, Basic components of robotic system. Sensing - Pre-processing – Noise reduction, enhancement of details. Signal Conversion, Introduction to computer vision, Point operators, Linear Filters, More neighborhood operators, Introduction to machine vision system, Overview of SLAM, Different Approaches to SLAM. Introduction to Robot Operating system(ROS).

Module V :**Signal Processing in Audio Video Processing (7)**
Analog video, digital video, time-varying image formation models: three dimensional motion models, geometric image formation, photometric image formation,sampling of video signals, filtering operations. Vocoder- Voice excited channel vocoder, Voice excited and error signal excited LPC vocoders. Adaptive predictive coding of speech, Auditory Modeling. Speech recognition and pattern matching techniques

No	Topic	No. of Lectures
1	**Introduction to automation (8)**	
1.1	Introduction to automation and automated systems, Overview of expert system, Expert system Architecture	**2**
1.2	Fundamentals of sensors, Sensor classification	**1**
1.3	Sensor parameters Selection of sensors. Interfacing of Sensors and Signal Conditioning: Change of BIOS and level of signals,	**2**
1.4	Smart Transducers: Smart Sensors, Components of Smart Sensors, General Architecture of Smart Sensors,	**2**
1.5	Evolution of Smart Sensors, Advantages of Smart Sensors.	**1**
2	**Signal Processing in Vehicle Automation (8)**	
2.1	Overview of automotive subsystems	**1**
2.2	Basic principles and types of automotive Sensors and Transducers-.	**1**
2.3	introduction to autonomous vehicles architecture	**1**
2.4	Intoduction to Automotive Protocols:	**1**
2.5	Automotive Protocols: LIN, CAN, FlexRay, Test, Calibration and Diagnostics tools for networking of electronic systems like ECU Software and Testing Tools, ECU Calibration Tools	**3**
2.6	AUTOSAR Architecture	**1**
3	**Signal Processing in Process control and Automation (10)**	
3.1	Introduction to Process Modeling: hierarchies.	**1**
3.2	Theoretical model: transfer function, state space models, and time series models.	**2**
3.3	concept of feedback & feed forward control, cascade control, selective control loops, ratio control, feed forward and ratio, split range, selective, override, auctioneering, adaptive and inferential controls. Statistical process control, supervisory control, direct digital control, distributed control	**2**
3.4	Introduction to Automatic Control:	**1**

3.5	PC based automation. SCADA in process automation. Time Delay Systems and Inverse Response Systems	**2**
3.6	Special Control Structures, Introduction to Sequence Control, PLC, RLL, Sequence Control. Scan Cycle.	**2**
4	**Signal Processing in Robotics (8)**	
4.1	Introduction to robotics, Basic components of robotic system.	**1**
4.2	Sensing - Pre-processing – Noise reduction	**1**
4.3	Enhancement of details and Signal Conversion in robotic	**1**
4.4	Introduction to computer vision, Point operators, Linear Filters, More neighborhood operators	**2**
4.5	Introduction to machine vision system	**1**
4.6	Overview of SLAM, Different Approaches to SLAM.	**1**
4.7	Introduction to Robot Operating system(ROS).	**1**
5	**Signal Processing in Audio Video Processing (7)**	
5.1	**Overview of** Analog video, digital video	**1**
5.2	Time-varying image formation models: three dimensional motion models,	**1**
53	Geometric image formation, photometric image formation	**1**
5.4	Sampling of video signals, filtering operations.	**1**
5.5	Vocoder- Voice excited channel vocoder, Voice excited and error signal excited LPC vocoders.	**1**
5.6	Adaptive predictive coding of speech, Auditory Modeling.	**1**
5.7	Speech recognition and pattern matching techniques	**1**

Text Books

1. “Anatomy of Automation” – Amber G.H & P.S. Amber, PrenticeHall
2. NikolayKirianaki, Sergey Yurish, Nestor Shpak, VadimDeynega, Data Acquisition and Signal Processing for Smart Sensors, John Wiley & Sons Ltd, 2002.
3. Tao Zhang, Luca Delgrossi, “Vehicle Safety Communications: Protocols, Security and Privacy”, Wiley Publication.
4. Robert Bosch,” Automotive Hand Book”, Fifth edition, SAE Publications.
5. Groover. M.P. Industrial Robotics, technology, programming and application Mc-Graw Hill 2012.

6. S. R.Deb, “Robotics technology and flexible automation”, Tata McGraw Hill publishing company limited, 1994.
7. Bob Connel, Process Instrumentation Applications Manual, McGrawHill, 1996.
8.Ranjan Parekh,Fundamentals of image, audio, and video processing using matlab®: with applications to pattern recognition,CRC Press (Taylor and Francis2021 :
9.Nelson Morgan and Ben Gold, Speech and Audio Signal Processing: Processing and Perception Speech and Music, July 1999, John Wiley & Sons

Reference Books

1. Smart Sensors, Measurement and Instrumentation by Subhas ChandraMukhopadhyay, Springer Book Series.
2. Randy Frank , Understanding Smart Sensors , Second Edition, Artech House sensors library, 2000.
3. Ronald K. Jurgen, “Automotive Electronics Handbook”, Mc -Graw Hill..
3. S. K. Saha, “Introduction to Robotics”, Tata McGraw-Hill Publishing Company Ltd. (2008).
4. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms, Springer Tracts in Advanced Robotics,Volume 118, Second Edition, 2016
5. Seborg, D.E., T.F. Edgar, and D.A. Mellichamp, Process Dynamics and Control, John Wiley , 2004

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC023	EMBEDDED SYSTEMS AND RTOS	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: The objective of the course is to impart the concepts and architecture of Embedded systems,Realtime systems and Real-time Operating Systems and to make the students capable of designing Real-Time EmbeddedSystems. To achieve this, the architecture and programming of Industry popular 32-bit Microcontroller, ARM Cortex is covered in detail.

Course prerequisites: Nil

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

CO 1	To do hardware/software co-design for embedded systems and to develop skills in analysis, approach, optimization, and implementation of embedded systems.
CO 2	To familiarize with ARM cortex Microcontroller architecture.
CO 3	Apply embedded program optimization skills in designing embedded systems.
CO 4	To learn implementation aspects of real time systems.
CO 5	Apply RTOS concepts in solving multi-tasking 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	2		
CO 2	3		2	2			
CO 3	3		3	3	3		
CO 4	3	3	2	3	2		
CO 5	3		2	3	2		

Assessment Pattern

Bloom's Category	End Semester Examination (%)
Apply	40%
Analyse	20%
Evaluate	20%
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. (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

SECOND SEMESTER M. TECH DEGREE EXAMINATION

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

Course Code: 222EEC023

Course Name: EMBEDDED SYSTEMS AND RTOS

Max. Marks: 60 Duration: 150 Minutes

Part A

Answer All Questions. Each Carries 5 mark.

1. Find out how characters are copied from input to output using interrupts and buffers with the help of a program segment.
2. The content of registers is given as below
   R1 = 0xEF00DE12,
   R2 = 0x0456123F,
   R5 = 4, R6 = 28.
   Find the result in the destination register when the following instructions are executed
   a) LSL R1, #8
   b) ASR R1,R5
   c) ROR R2,R6
3. Design a Data Flow Graph for the block shown below:
   r = a+b-c; s = a*r ; t = b-d; r = d+e;
4. Inspect how the clocks are synchronized if the times are close to each other.
5. With the help of an example, explain that the knowledge of data dependencies can help to use the CPU more efficiently.

Part B

Answer any five questions: Each question carries 7 marks.

6. Evaluate system design using requirements and illustrate the type of design and explain.
7. From the fundamentals, draw the architecture of ARM processor with relevant explanation.
8. Evaluate the different techniques used in software performance optimization.
9. Examine the exponentially distributed fault latency with the condition mean $1/\mu$.
10. Investigate this statement with the help of an example. The timing requirements on a set of process can strongly influence the type of appropriate scheduling.

11. Investigate the Loop transformation techniques for optimization of code.
12. Formulate the working of Engine control unit in detail
    i. Theory of operations and requirements
    ii. Specification
    iii. System Architecture
    iv. Component designing and testing
    v. System integration and testing.

SYLLABUS
Module 1 (8 Hours) **Introduction to embedded system design:** Complex systems and microprocessors– Embedded system design process –Design example: Model train controller- Design methodologies- Design flows – Requirement Analysis – Specifications-System analysis and architecture design – Quality Assurance techniques -Designing with computing platforms – consumer electronics architecture –platform-level performance analysis.
Module 2 (8 Hours) **ARM processor and peripherals:** ARM Architecture Versions – ARM Architecture – Instruction Set – Stacks and Subroutines – Features of the LPC 214X Family – Peripherals – The Timer Unit – Pulse Width Modulation Unit – UART – Block Diagram of ARM9 and ARM Cortex M3 MCU.
Module 3 (8 Hours) **Embedded programming:** Components for embedded programs- Models of programs- Assembly, linking and loading – compilation techniques- Program level performance analysis – Software performance optimization – Program level energy and power analysis and optimization – Analysis and optimization of program size- Program validation and testing.
Module 4 (8 Hours) **Real time systems**: Structure of a Real Time System — Estimating program run times – Task Assignment and Scheduling – Fault Tolerance Techniques – Reliability, Evaluation – Clock Synchronisation.

Module 5 (8 Hours)

Processes and operating systems: Introduction – Multiple tasks and multiple processes – Multirate systems- Pre-emptive real time operating systems- Priority based scheduling- Inter process communication mechanisms – Evaluating operating system performance- power optimization strategies for processes – Example Real time operating systems-POSIX-Windows CE. – Distributed embedded systems – MPSoCs and shared memory multiprocessors. – Design Example – Audio player, Engine control unit – Video accelerator.

Course Plan

Sl. No	Topic	No. of Lectures
1	**Introduction to embedded system design**	
1.1	Complex systems and micro processors	1
1.2	Embedded system design process –Design example: Model train controller- Design methodologies- Design flows – Requirement Analysis – Specifications-System analysis and architecture design – Quality Assurance techniques	5
1.3	Designing with computing platforms – consumer electronics architecture –platform-level performance analysis	2
2	**ARM processor and peripherals**	
2.1	ARM Architecture Versions – ARM Architecture - Instruction Set – Stacks and Subroutines	4
2.2	Features of the LPC 214X Family – Peripherals – The Timer Unit – Pulse Width Modulation Unit – UART	2
2.3	Block Diagram of ARM9 and ARM Cortex M3 MCU.	2
3	**Embedded programming**	
3.1	Components for embedded programs- Models of programs- Assembly, linking and loading – compilation techniques	3
3.2	Program level performance analysis – Software performance optimization – Program level energy and power analysis and optimization	2
3.3	Analysis and optimization of program size- Program validation and testing	3
4	**Real time systems**	
4.1	Structure of a Real Time System	1

4.2	Estimating program run times – Task Assignment and Scheduling	3
4.3	Fault Tolerance Techniques – Reliability, Evaluation	2
4.4	Clock Synchronisation.	2
5	**Processes and operating systems**	
5.1	Multiple tasks and multiple processes – Multirate systems- Pre-emptive real time operating systems	1
5.2	Priority based scheduling- Inter process communication mechanisms	1
5.3	Evaluating operating system performance- power optimization strategies for processes	2
5.4	Example Real time operating systems-POSIX-Windows CE	1
5.5	Distributed embedded systems – MPSoCs and shared memory multiprocessors.	1
5.6	Design Example – Audio player, Engine control unit – Video accelerator.	2

Text Books

1. Marilyn Wolf (2012): "Computers as Components - Principles of Embedded Computing System Design", 3rd Edition: Morgan Kaufmann Publisher (An imprint from Elsevier).
2. Simon David. E (2007): "An Embedded Software Primer", 1st Edition, Fifth Impression: Addison Wesley Professional.
3. Prasad K.V.K.K. (2005): "Embedded Real-Time Systems: Concepts, Design & Programming", Dream Tech Press.
4. Muhammad Ali Mazidi, Shujen Chen, Sarmad Naimi, Sepehr Naimi, "Freescale ARM Cortex-M Embedded Programming Using C Language"

Reference Books

1. Lyla B.Das (2013): "Embedded Systems: An Integrated Approach", Pearson Education.
2. Valvano Jonathan W (2012): "Embedded Microcomputer Systems Real Time Interfacing", 3rd Edition: Cengage Learning.
3. Buhr Raymond J.A., Bailey Donald L (1999): "An Introduction to Real-Time Systems- From Design to Networking with C/C++", Prentice Hall.
4. Krishna C.M., Shin Kang G. (1997): "Real-Time Systems", International Editions, Noida: Mc Graw Hill.
5. Iyer Sriram V, Gupta Pankaj (2004): "Embedded Real Time Systems Programming", Noida: Tata Mc Graw Hill.
6. Raj Kamal, "Embedded Systems Architecture Programming and Design": 2nd Edition; Tata McGraw Hill

SEMESTER II

INTERDISCIPLINARY ELECTIVE

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC084	MEMS AND SENSORS	INTERDISCIPLINARY ELECTIVE	3	0	0	3

Course Objectives

- Introduces students to the need of rapidly emerging, area of MEMSand microsystem in engineeringand its applications in sensor technology
- Enable the students to understand the various sensing and actuation mechanisms.

Prerequisite: nil

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

CO1	Identify structural and sacrificial materials for MEMS
CO2	Describe the fabrication steps in designing of various MEMS devices.
CO3	Apply principles for the design of Sensor and actuators
CO4	Apply MEMS for different applications in various fields of engineering

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	*PO5*
CO1					
CO2					
CO3					
CO4					

Assessment Pattern

Bloom'sCategory	Continuous Assessment Tests		End Semester Examination [%] (60Marks)
		Test1 [%] (10Marks)	
Remember		10	20
Understand		20	40
Apply		10	20
Analyse		10	20
Evaluate			
Create			

Mark distribution

Total Marks	CIE (Marks)	ESE (Marks)	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/Micro project : 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.

SYLLABUS

1	**MODULE I**

Introduction: Introduction to MEMS and Microsystems, MEMS Classification, MEMS versus Microelectronics, Applications of MEMS in Various Industries, Some Examples of Microsensors, Microactuators, and Microsystems, Materials for MEMS, Laws of Scaling in miniaturization

2	**MODULE II**

MEMS Fabrication: Structure of Silicon, Single Crystal Growth Techniques, Photolithography, Oxidation, Diffusion, Ion Implantation, Physical Vapor Deposition, Chemical Vapor Deposition, Bulk Micromachining: Overview of Etching, Isotropic and Anisotropic Etching, Wet Etchants, Etch Stop Techniques, Dry Etching, Surface Micromachining, LIGA, SLIGA, Wafer Bonding, Electroplating

3	**MODULE III**

Microsensors and Microactuators: Basic Modeling Elements in Mechanical, Electrical and Thermal Systems, Types of Beams: Cantilevers, Bridges, Fixed-Guided beams, Electrostatic sensing and Actuation: Parallel plate capacitor, Applications of parallel plate capacitors: Inertial sensor, Pressure sensor, Flow sensor, Parallel plate Actuators, Piezoresistive Sensors: Origin and Expressions of Piezoresistivity, Piezoresistive Sensor Materials, Applications of Piezoresistive Sensors, Piezoelectric Sensing and Actuation, Thermal Sensing and Actuation: Sensors and Actuators based on Thermal Expansion, Thermocouples, Thermoresistors, Shape Memory Alloy, Applications: Inertial sensors, Flow sensors, Infrared sensors

4	**MODULE IV**

Layout, Simulation Tools, Packaging and Characterization techniques: Introduction of layout, Simulation Tools, General considerations in Packaging , Bonding techniques for MEMS and Various Characterization Techniques for MEMS Devices

5	**MODULE V**

Advances in MEMS:RF-MEMS: MEMS devices for RF Applications: RF MEMS Switches and their applications, High-Q Capacitors and Inductors and Their

Applications in RF Circuits, Overview of Optical MEMS , Chemical-Bio MEMS and Nanoelectromechanical Systems

Text books

- MEMS and Microsystems design and manufacture by Tai-Ran Hsu, Tata McGraw Hill.
- MEMS by N. P. Mahalik, Tata McGraw Hill.
- Foundations of MEMS by Chang Liu, Pearson Prentice Hall.

Reference books

- Sensors and Transducers by M. J. Usher, McMillian Hampshire.
- Analysis and Design Principles of MEMS Devices by Minhang Bao, Elsevier.
- Fundamentals of Microfabrication by M. Madou, CRC Press.
- Microsensors by R.S. Muller, Howe, Senturia and Smith, IEEE Press.
- Semiconductor Sensors by S. M. Sze, Willy Inderscience Publications.

COURSE CONTENTS AND LECTURE SCHEDULE

No.		No. of Hours
	MODULE 1	
1.1	Introduction to MEMS and Microsystems, MEMS Classification, MEMS versus Microelectronics,	1
1.2	Applications of MEMS in Various Industries, Some Examples of Microsensors, Microactuators, and Microsystems	1
1.3	Materials for MEMS,	2
1.4	Laws of Scaling in miniaturization	1
	MODULE II	
2.1	Structure of Silicon, Single Crystal Growth Techniques,	1
2.2	Photolithography, Oxidation,	1
2.3	Diffusion, Ion Implantation,	1
2.4	Physical Vapor Deposition, Chemical Vapor Deposition,	1
2.5	Bulk Micromachining: Overview of Etching, Isotropic and Anisotropic Etching,	1
2.6	Wet Etchants, Etch Stop Techniques, Dry Etching	1

2.7	Surface Micromachining	1
2.8	LIGA, SLIGA	2
2.9	Wafer Bonding, Electroplating	1
MODULEIII		
3.1	Microsensors and Microactuators: Basic Modeling Elements in Mechanical, Electrical and Thermal Systems,	1
3.2	Types of Beams: Fixed-Free (Cantilevers), Fixed-Fixed (Bridges), Fixed-Guided beams,	1
3.3	Electrostatic sensing and Actuation: Parallel plate capacitor,	1
3.4	Applications of parallel plate capacitors: Inertial sensor,	1
3.5	Pressure sensor, Flow sensor, Parallel plate Actuators,	1
3.6	Piezoresistive Sensors: Origin and Expressions of Piezoresistivity, Piezoresistive Sensor Materials,	1
3.7	Applications of Piezoresistive Sensors,	1
3.8	Piezoelectric Sensing and Actuation,	1
3.9	Thermal Sensing and Actuation: Sensors and Actuators based on Thermal Expansion,	1
3.10	Thermocouples, Thermoresistors,	1
3.11	Shape Memory Alloy, Applications: Inertial sensors, Flow sensors, Infrared sensors	2
MODULEIV		
4.1	Introduction of layout, Simulation Tools,	1
4.2	General considerations in Packaging and bonding techniques in MEMS	2
4.3	Various Characterization Techniques for MEMS Devices	1
MODULEV		
5.1	Advances in MEMS: RF-MEMS: MEMS devices for RF Applications:	1
5.2	RF MEMS Switches and their applications,	1

5.3	High-Q Capacitors and Inductors and Their Applications in RF Circuits,	1
5.4	Overview of Optical MEMS ,	1
5.5	Chemical-Bio MEMS and Nanoelectromechanical Systems	1

Model Question Paper

A P J Abdul Kalam Technological University
Second Semester M.Tech Degree Examination
Course: 222EEC084MEMS and Sensors
Time: 150 Minutes Max. Marks: 60

PART A
Answer All Questions

1	Mention the criteria for selecting materials for the masks used in etching. List four materials used as masks.	5
2	Define etch stop? List different methods used to stop etching and explain one with sketches	5
3	Explain with neat sketches the type of mechanical beams and boundary conditions associated with supports	5
4	State the various levels of micro system packaging	5
5	With neat sketches explain the construction and working of a shunt type RF MEMS switch.	5

PART B
Answer any five question

6	A silicon substrate is doped with phosphorus ions at 100 KeV. Assume the maximum concentration after the doping is 30 x $10^{18}/cm^3$. Find: (a) the dose, Q, (b) the dopant concentration at the depth 0.15 μm, (c) the depth at which the dopant concentration is at 0.15% of the maximum value. (Given: Rp = 135 nm and ΔRp = 53.5 x 10^{-7}cm at 100 KeV energy level).	*7*
7	Explain in the light of scaling, assuming a 10 times reduction of size of the actuator. Which of the electrostatic and electromagnetic forces are best suited for micro device actuation and why?	*7*
8	Explain the purpose of micro cantilevers in MEMS systems. What is the relevance of Spring constant (k) of the mechanical structure in the microsystems.	*7*

9	Explain the principle of operation of the following micro sensors (i) Comb drives (ii) Shape Memory Alloys	*7*
10	Explain the challenges involved in BioMEMS. List three applications of BioMEMS.	*7*
11	Explain Various bonding techniques associated with MEMS and their implications on packaging	*7*
12	Explain the LIGA process associated with MEMS fabrication with suitable sketches	*7*

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC085	NANO MATERIALS FOR DRUG DELIVERY	INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble: To inspire the students with interest to investigate role of new nanomaterials and devices drug delivery.

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

CO 1	Familiarize the concepts of nano materials for drug delivery
CO 2	Investigate the use of nano materials for drug delivery
CO 3	Investigate the use of nanodevices for drug targeting

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern

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 Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 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.

Syllabus and course plan

No	Topic	No. of Lectures
1	**Nanomedicines**	
1.1	Basic concepts in the design, specification and desired features of nanomedicine and general process steps involved in their preparation Nanomedicines for various disease conditions: infectious diseases, neurological diseases, pulmonary disorders, cardiovascular diseases	4
1.2	cancer: nano-chemotherapy, - radiation therapy, - immunotherapy, -nuclear medicine therapy, -photodynamic therapy, - photothermal and RF hyperthermia therapy, scintillation therapy, gene-therapy: DNA, RNA delivery. Theranostic nanomedicines: Basic concept, multifunctional nanomedicines for theranosis	4
2	**Drug Delivery Systems**	
2.1	Administration Routes: Oral Drug Delivery, Features of Gastrointestinal tract (GI), Targeting of drugs in the GI tract.	4
2.2	Design and fabrication of oral systems - Dissolution controlled, diffusion controlled, osmotic controlled, chemically controlled release, Intravenous Drug Delivery - Factors controlling pharmacokinetics of IV formulations, Concept of opsonization	4
3	**Drug Delivery Devices**	
3.1	Transdermal Drug Delivery, Structure of human skin and theoretical advantages of the transdermal route, Transdermal penetration of drugs, adhesion, bioactivity.	4
3.2	Intranasal Drug Delivery - Nasal physiology and intranasal Drug Administration, Nasal drug delivery devices, Ocular Drug Delivery devices; Miscellaneous Drug Delivery	4
4	**Advanced Drug Delivery**	
4.1	Concept of Drug Targeting; Prodrug and Bioconjugation; Nanoscale Drug Delivery Systems - Advantages of nanodrug delivery – Improvements in pharmacokinetics, bioavailability, biodistribution; Concepts of controlled and sustained drug delivery, How nanoparticles pass barriers; Surface modification of nanoparticulate carriers	4

4.2	Nanocarriers for drug delivery - Lipid based pharmaceutical nanoparticles – Liposomes, Solid Lipid Nanoparticles, Nanostructured Lipid Carriers, Cubosomes and Hexosomes, Polymeric Micelles, DNA- Based Nanomaterials, Dendrimers, Polymeric nanoparticles, Inorganic nanoparticles, Hydrogels for controlled drug delivery	4
5	**Active and passive nanocarriers**	
5.1	Concept of targeting, Site Specific Drug delivery utilizing Monoclonal Antibodies, Peptides, Other Biomolecules, Stimuli-Responsive Target Strategies; Implants; Protein and Peptide Drug Delivery; Delivery of Nucleic Acids	3
5.2	Delivery of Vaccines; Aptamers in Advanced Drug Delivery; Biomimetic Self-Assembling Nanoparticles	2
5.3	Nanotechnology Challenges; Regulatory Considerations and Clinical Issues in Advanced Drug Delivery	3

Books-

1. Drug Delivery Systems, Pieter Stroeve and MortezaMahmoudi, World Scientific Series: From
2. Biomaterials towards Medical Devices, Vol I, 2018.
3. Nanoparticulates as Drug Carriers, Vladimir Torchillin, Imperial College Press, 2006
4. Drug Delivery Systems, Third Edition, Vasant V Ranade, John B. Cannon, by CRC Press, 2011