SEMESTER -4

ECT202	ANALOG CIRCUITS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course aims to develop the skill of analyse and design of different types of analog circuits using discrete electronic components.

Prerequisite: EST130 Basics of Electrical and Electronics Engineering

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

CO 1	Design analog signal processing circuits using diodes and first order RC circuit
CO 2	Analyse basic amplifiers using BJT and MOSFET
CO 3	Apply the principle of oscillator and regulated power supply circuits.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2

Assessment Pattern

Bloom's Category		Continuous Assessment Tests		End Semester Examination
		1	2	
Remember	K1	10	10	10
Understand	K2	20	20	20
Apply	K3	20	20	70
Analyse	K4			
Evaluate				
Create				

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Design analog signal processing circuits using diodes and first order RC circuit.

1. For the given specification design a differentiator / integrator circuit.
2. For the given transfer characteristics design clipping / clamping circuit.
3. Design first order RC low-pass / high-pass circuit for the given specification.

Course Outcome 2 (CO2): Analyse basic amplifiers using BJT.

1. For the given transistor biasing circuit, determine the resistor values, biasing currents and voltages.
2. Design a RC coupled amplifier for a given gain.
3. Analyse the frequency response of BJT RC coupled amplifier using hybrid π model.

Course Outcome 2 (CO2): Analyse basic amplifiers using MOSFET.

1. Perform DC analysis of MOSFET circuits.
2. Design a common source amplifier.
3. Deduce the expression for voltage gain of CS stage with diode-connected load.

Course Outcome 2 (CO2): Analyse basic feedback amplifiers using BJT and MOSFET

1. Deduce the expression for voltage gain, input impedance and output impedance of the four feedback amplifier topologies.
2. Design practical discrete amplifiers for the four feedback amplifier topologies.

Course Outcome 3 (CO3): Apply the principle of oscillator and regulated power supply.

1. Design oscillator using BJT to generate sine wave for the given frequency.
2. Deduce the expression for maximum efficiency of class B power amplifiers.
3. Illustrate the DC and AC load line in transformer coupled class A power amplifiers.
4. Design voltage regulator for the given specifications.

SYLLABUS

Module 1:

Wave shaping circuits: First order RC differentiating and integrating circuits, First order RC low pass and high pass filters.

Diode Clipping circuits - Positive, negative and biased clipper. Diode Clamping circuits - Positive, negative and biased clamper.

Transistor biasing: Need, operating point, concept of DC load line, fixed bias, self bias, voltage divider bias, bias stabilization.

Module 2:

BJT Amplifiers: RC coupled amplifier (CE configuration) – need of various components and design, Concept of AC load lines, voltage gain and frequency response.

Small signal analysis of CE configuration using small signal hybrid-pi model for mid frequency and low frequency. (gain, input and output impedance).

High frequency equivalent circuits of BJT, Miller effect, Analysis of high frequency response of CE amplifier.

Module 3:

MOSFET amplifiers: MOSFET circuits at DC, MOSFET as an amplifier, Biasing of discrete MOSFET amplifier, small signal equivalent circuit. Small signal voltage and current gain, input and output impedance of CS configuration. CS stage with current source load, CS stage with diode-connected load.

Multistage amplifiers - effect of cascading on gain and bandwidth. Cascode amplifier.

Module 4 :

Feedback amplifiers: Effect of positive and negative feedback on gain, frequency response and distortion. The four basic feedback topologies, Analysis of discrete BJT circuits in voltage-series and voltage-shunt feedback topologies - voltage gain, input and output impedance.

Oscillators: Classification, criterion for oscillation, Wien bridge oscillator, Hartley and Crystal oscillator. (working principle and design equations of the circuits; analysis of Wien bridge oscillator only required).

Module 5:

Power amplifiers: Classification, Transformer coupled class A power amplifier, push pull class B and class AB power amplifiers, complementary-symmetry class B and Class AB power amplifiers, efficiency and distortion (no analysis required)

Regulated power supplies: Shunt voltage regulator, series voltage regulator, Short circuit protection and fold back protection, Output current boosting.

Text Books

1. Robert Boylestad and L Nashelsky, "Electronic Devices and Circuit Theory", 11/e Pearson, 2015.
2. Sedra A. S. and K. C. Smith, "Microelectronic Circuits", 6/e, Oxford University Press, 2013.

Reference Books

1. Razavi B., "Fundamentals of Microelectronics", Wiley, 2015
2. Neamen D., "Electronic Circuits, Analysis and Design", 3/e, TMH, 2007.
3. David A Bell, "Electronic Devices and Circuits", Oxford University Press, 2008.
4. Rashid M. H., "Microelectronic Circuits - Analysis and Design", Cengage Learning, 2/e,2011
5. Millman J. and C. Halkias, "Integrated Electronics", 2/e, McGraw-Hill, 2010.

Course Contents and Lecture Schedule

No	Topic	No. of lectures
1	**Wave shaping circuits**	
1.1	Analysis and design of RC differentiating and integrating circuits	2
1.2	Analysis and design of First order RC low pass and high pass filters	2
1.3	Clipping circuits - Positive, negative and biased clipper	1
1.4	Clamping circuits - Positive, negative and biased clamper	1
	Transistor biasing	
1.5	Need of biasing, operating point, bias stabilization, concept of load line	1
	Design of fixed bias, self bias, voltage divider bias.	2
2	**BJT Amplifiers**	
2.1	Classification of amplifiers, RC coupled amplifier (CE configuration) – need of various components and design, Concept of AC load lines.	2
2.2	Small signal analysis of CE configuration using small signal hybrid π model for mid frequency. (gain, input and output impedance).	3
2.3	High frequency equivalent circuits of BJT, Miller effect, Analysis of high frequency response of CE amplifier. voltage gain and frequency response	4
3	**MOSFET amplifiers**	
3.1	MOSFET circuits at DC, MOSFET as an amplifier, Biasing of discrete MOSFET amplifier,	2
3.2	Small signal equivalent circuit. Small signal voltage and current gain, input and output impedances of CS configuration.	3

3.3	CS stage with current source load, CS stage with diode-connected load.	2
3.4	**Multistage amplifiers** - effect of cascading on gain and bandwidth. Cascode amplifier.	2
4	**Feedback amplifiers**	
4.1	Properties of positive and negative feedback on gain, frequency response and distortion.	1
4.2	Analysis of the four basic feedback topologies	2
4.3	Analysis of discrete circuits in each feedback topologies -voltage gain, input and output impedance	3
	Oscillators	
4.4	Classification, criterion for oscillation	1
	Wien bridge oscillator, Hartley and Crystal oscillator. (working principle and design equations of the circuits; analysis not required).	2
5	**Power amplifiers**	
5.1	Classification, Transformer coupled class A power amplifier	1
5.2	push pull class B and class AB power amplifiers, complementary-symmetry class B and Class AB power amplifiers, efficiency and distortion (no analysis required)	3
	Linear Regulated power supplies	
5.3	Principle of Linear Regulated power supplies, Shunt voltage regulator	1
5.4	Series voltage regulator, Short circuit protection and fold back protection, Output current boosting	2

Assignment:

Atleast one assignment should be simulation of different types of transistor amplifiers on any circuit simulation software.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, (**Model Question Paper)**

Course Code: ECT202

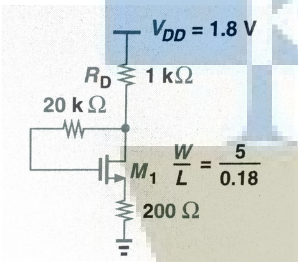
Course Name: ANALOG CIRCUITS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer ALL Questions. Each Carries 3 mark.

1	Design the first order RC high pass filter with cut off frequency 2Kz.	3	K3
2	Describe about the double ended clipping.	3	K2
3	Differentiate between DC and AC load lines.	3	K2
4	What is the significance of Miller effect on high frequency amplifiers?	3	K1
5	What are the effects of cascading in gain and bandwidth of an amplifier?	3	K1
6	Calculate the drain current if $\mu_n C_{ox}$ = 100 $\mu A/V^2$, V_{TH} = 0.5V and λ = 0 in the following circuit.	3	K3



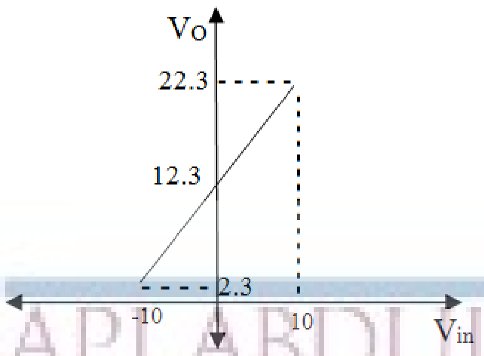
7	Illustrate the effect of negative feedback on bandwidth and gain of the amplifier.	3	K2
8	Explain the criteria for an oscillator to oscillate.	3	K1
9	How to eliminate cross over distortion in class-B power amplifier?	3	K2
10	What is line regulation and load regulation in the context of a voltage regulator?	3	K2

PART – B

Answer one question from each module; each question carries 14 marks.

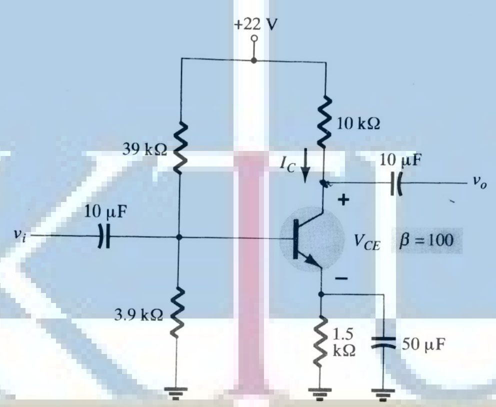
Module - I

11 a	Design a differentiator circuit for a square wave signal with Vpp=10 and frequency 10KHz.	6	CO1 K3
b.	Design a clamper circuit to get the following transfer characteristics, assuming voltage drop across the diodes 0.7V.	8	CO1 K3



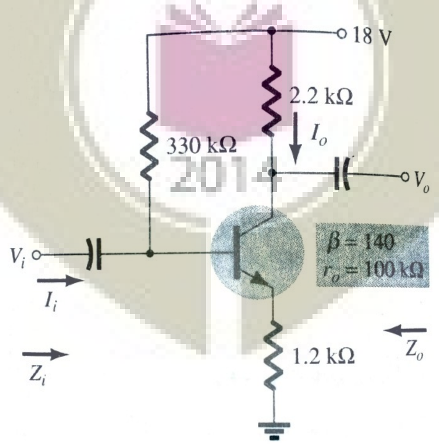
OR

12 a	Explain the working of an RC differentiator circuit for a square wave input with period T. Sketch its output waveform for RC ≫ T, RC ≪ T and RC = T.	5	K2 CO1
b.	With reference to the following circuit, draw the load line and mark the Q point of the Silicon BJT transistor.	9	K3 CO2



Module - II

13	For the following RC coupled amplifier determine r_e , Z_i , Z_o and A_v .	14	K3 CO2



OR

14 a	Draw the high frequency hybrid π model of BJT in CE configuration and explain the significance of each parameter.	6	K2 CO2
b	Analyse BJT RC coupled amplifier in CE configuration at high frequency using hybrid π model.	8	K2 CO2

Module - III

15 a	Draw the circuit of a common source amplifier using MOSFET. Derive the expressions for voltage gain and input resistance from small signal equivalent circuit.	7	K2 CO2
b.	How wide bandwidth is obtained in Cascode amplifier ?	7	K2 CO2

OR

16	Draw the CS stage with current source load and deduce the expression for voltage gain of the amplifier	14	K3 CO2

Module - IV

17	Give the block schematic of current-series feedback amplifier configuration and deduce the expression for gain, input impedance and output impedance with feedback. Design a practical circuit for this current-series feedback amplifier.	14	K3 CO2

OR

18 a	Design wein-bridge oscillator using BJT to generate 1KHz sine wave.	8	K3 CO3
b	Explain the working principle of crystal oscillator	6	K2 CO3

Module - V

19	Illustrate the working principle of complementary-symmetry class B power amplifiers and deduce the maximum efficiency of the circuit	14	K2 CO2

OR

20	Design a discrete series voltage regulator with short circuit protection for regulated output voltage 10V and maximum current 100mA.	14	K3 CO3

Simulation Assignments (ECT202)

The following simulations can be done in QUCS, KiCad or PSPICE.

1. Design and simulate a voltage series feedback amplifier based on BJT/ MOSFET. Observe the input and output signals. Plot the AC frequency response. Observe the Nyquits plot and understand its stability
2. Design and simulate a voltage shunt feedback amplifier based on BJT/ MOSFET. Observe the input and output signals. Plot the AC frequency response. Observe the Nyquits plot and understand its stability
3. Design and simulate series voltage regulator for output voltage $V_O = 10V$ and output current $I_O = 100mA$ with and without short circuit protection and to test the line and load regulations.
4. Design and simulate Wien bridge oscillator for a frequency of $5\,kHz$. Run a transient simulation and observe the output waveform.
5. Design and simulate Colpitts oscillator for a frequency of $455\,kHz$. Run a transient simulation and observe the output waveform.
6. Design and simulate a current series feedback amplifier based on BJT. Observe the input and output signals. Plot the AC frequency response. Observe the Nyquits plot and understand its stability
7. Design and simulate Hartley oscillator for a frequency of $455\,kHz$. Run a transient simulation and observe the output waveform.
8. Design and simulate clipping circuits that clips the $10\,V$ input sinusoid
   - at $+3.5\,V$ and at $-4.2\,V$
   - at $+2.5\,V$ and at $+4.2\,V$
   - at $-2.5\,V$ and at $-4.2\,V$

   with Si diodes

ECT 204	SIGNALS AND SYSTEMS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This couse aims to lay the foundational aspects of signals and systems in both continuous time and discrete time, in preparation for more advanced subjects in digital signal processing, image processing, communication theory and control systems.

Prerequisite: Nil

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

CO 1	Apply properties of signals and systems to classify them
CO 2	Represent signals with the help of series and transforms
CO 3	Describe orthogonality of signals and convolution integral.
CO 4	Apply transfer function to compute the LTI response to input signals.
CO 5	Apply sampling theorem to discretize continuous time signals

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										
CO 2	3	3	3									
CO 3	3	3	3									
CO 4	3	3										
CO 5	3	3	3									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total	CIE	ESE	ESE Duration

Marks			
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1) : Apply properties of signals and systems to classify them

1. Check whether the following systems are stable, causal, linear, and time-invariant (a) y[n] = x[2n] (b) $y(t) = x^2(t) + 3$ (c) y[n] = nx[n]
2. Plot (a) u(t-1) + u(1-t) (b) u(t-1) – u(t+1) (c) sinc(t/T) (d) r(t) – r(t-2) – 2u(t-2)

Course Outcome 2 (CO2) : Represent signals with the help of series and transforms

1. Compute the Fourier transform of (a) x(t) = 1, -T/2 < t < T/2, and 0 elsewhere (b) x(t) = 1 - (|t|/T), -T < t < T, and 0 elsewhere
2. Show that a square wave has only odd harmonics.
3. State and prove Parsevals theorem

Course Outcome 3 (CO3) : Describe orthogonality of signals and convolution integral.

1. Show that δ(t-a) and δ(t-b), a ≠ b are orthogonal
2. Define convolution of x(t) and h(t)

Course Outcome 4 (CO4) : Apply transfer function to compute the LTI response to input signals.

1. Give the frequency response of a first-order low pass filter. What is the 3-dB cut off frequency?
2. What is the signficance of linear phase response?

Course Outcome 5 (CO5) : Apply sampling theorem to discretize continuous time signals

1. Derive the interpolation formula for finite-energy band-limited signals from its samples.

SYLLABUS

Elementary signals, Continuous time and Discrete time signals and systems, Signal operations, Differential equation representation, Difference equation representation, Continuous time LTI Systems, Discrete time LTI Systems, Correlation between signals, Orthogonality of signals, Frequency domain representation, Continuous time Fourier series, Continuous time Fourier transform, Using Laplace transform to characterize Transfer function, Stability and Causility using ROC of Transfer transform, Frequency response, Sampling, Aliasing, Z transform, Inverse Z transform, Unilateral Z-transform, Frequency domain representation of discrete time signals, Discrete time Fourier series and discrete time Fourier transform (DTFT), Analysis of discrete time LTI systems using the above transforms.

Text Books

1. Alan V. Oppenheim and Alan Willsky, Signals and Systems, PHI, 2/e, 2009

2. Simon Haykin, Signals & Systems, John Wiley, 2/e, 2003

Reference Books

1. Anand Kumar, Signals and Systems, PHI, 3/e, 2013.

2. B P. Lathi, Priciples of Signal Processing & Linear systems, Oxford University Press.

3. Gurung, Signals and System, PHI.

4. Mahmood Nahvi, Signals and System, Mc Graw Hill (India), 2015.

5. P Ramakrishna Rao, Shankar Prakriya, Signals and System, MC Graw Hill Edn 2013.

6. Rodger E. Ziemer, Signals & Systems - Continuous and Discrete, Pearson, 4/e, 2013

Course Contents and Lecture Schedule

Module	Topic	Number of lecture hours
I	Elementary Signals, Classification and representation of continuous time and discrete time signals, Signal operations	4
	Continuous time and discrete time systems – Classification, Properties.	3
	Representation of systems: Differential equation representation of continuous time systems. Difference equation representation of discrete systems.	2
	Continuous time LTI systems and convolution integral.	2

	Discrete time LTI systems and linear convolution.	2
	Stability and causality of LTI systems.	2
	Correlation between signals, Orthogonality of signals.	1
II	Frequency domain representation of continuous time signals - continuous time Fourier series and its properties.	4
	Continuous time Fourier transform and its properties. Convergence and Gibbs phenomenon	3
	Review of Laplace Transform, ROC of Transfer function, Properties of ROC, Stability and causality conditions.	3
	Relation between Fourier and Laplace transforms.	1
III	Analysis of LTI systems using Laplace and Fourier transforms. Concept of transfer function, Frequency response, Magnitude and phase response.	4
	Sampling of continuous time signals, Sampling theorem for lowpass signals, aliasing.	3
IV	Frequency domain representation of discrete time signals, Discrete time fourier series for discrete periodic signals. Properties of DTFS.	4
	Discrete time fourier transform (DTFT) and its properties. Analysis of discrete time LTI systems using DTFT. Magnitude and phase response.	5
V	Z transform, ROC , Inverse transform, properties, Unilateral Z transform.	3
	Relation between DTFT and Z-Transform, Analysis of discrete time LTI systems using Z transforms, Transfer function. Stability and causality using Z transform.	4

Simulation Assignments (ECT 204)

The following simulation assignments can be done with Python/MATLAB/ SCILAB/OCTAVE

1. Generate the following discrete signals
   - Impulse signal
   - Pulse signal and
   - Triangular signal
2. Write a function to compute the DTFT of a discrete energy signal. Test this function on a few signals and plot their magnitude and phase spectra.
3. - Compute the linear convolution between the sequences $x = [1, 3, 5, 3]$ with $h = [2, 3, 5, 6]$. Observe the stem plot of both signals and the convolution.
   - Now let $h = [1, 2, 1]$ and $x = [2, 3, 5, 6, 7]$. Compute the convolution between h and x.
   - Flip the signal x by 180° so that it becomes $[7, 6, 5, 3, 2]$. Convolve it with h. Compare the result with the previous result.
   - Repeat the above two steps with $h = [1, 2, 3, 2, 1]$ and $h = [1, 2, 3, 4, 5, 4, 3, 2, 1]$
   - Give your inference.
4. - Write a function to generate a unit pulse signal as a summation of shifted unit impulse signals
   - Write a function to generate a triangular signal as a convolution between two pulse signals.
5. - Relaize a continuous time LTI system with system response

     $$H(s) = \frac{5(s+1)}{(s+2)(s+3)}$$

     . One may use *scipy.signal.lti* package in Python.
   - Make it into a discrete system (possibly with *scipy.signal.cont2discrete*)
   - Observe the step response in both cases and compare.

Model Question Paper

A P J Abdul Kalam Technological University

Fourth Semester B Tech Degree Examination

Course: ECT 204 Signals and Systems

Time: 3 Hrs **Max. Marks: 100**

PART A

Answer All Questions

1	Differentiate between energy and power signal with example.	(3)	K_2
2	Test if the signals $x_1[n] = [1, -2, 3, 1]$ and $x_2[n] = [-1, 2, 1, 2]$ are orthogonal.	(3)	K_3
3	Compute the Fourier transform of $x(t) = \delta(t) + 0.5\delta(t-1)$	(3)	K_2
4	Write the Fourier series for $x(t) = A\cos 2\pi f_c t$ and use it to plot its line spectrum	(3)	K_2
5	Explain the transfer function of an LTI system in the s- domain.	(3)	K_1
6	What is the discrete frequency resulting when a $2\,kHz$ signal is sampled by an $8\,kHz$ sampling signals?	(3)	K_2
7	Give three properties of the ROC pertaining to Z-transform.	(3)	K_1
8	Compute the DTFT of $x[n] = \delta[n] - 2\delta[n-1] + 0.5\delta[n-3]$	(3)	K_3
9	Write the transfer function $H(z)$ of an LTI system described by $y[n] = 0.3y[n-1] + 0.1y[n-2] + x[n] + 0.2x[n-1]$	(3)	K_2
10	Give the relation between DTFT and Z transform	(3)	K_2

PART B

Answer one question from each module. Each question carries 14 mark.

Module I

11(A)	Test if the following systems are stable and time invariant i. $y[n] = \cos x[n]$ ii. $y[n] = x[n] - x[n-1]$	(8)	K_3
11(B)	Classify the following signals are energy and power signals i. $x[n] = 0.8^n U[n]$ ii. $x[n] = U[n] - U[n-10]$ iii. $x[n] = \cos 2\pi f_0 n$	(6)	K_3

OR

12(A)	Compute the convolution between $U[t] - U[t-5]$ with itself.	(7)	K_3
12(B)	Compute the output of the LTI system with input $x[n] = [1, -1, 2, -2]$ and impulse response $h[n] = [1, 2, 1]$	(7)	K_3

Module II

13(A)	Compute the Fourier transform of the triangular signal $x(t) = A[1 - \frac{\|t\|}{T}]$	(8)	K_3
13(B)	Compute the Fourier series of a half wave rectified sinusoid with period T and amplitude A	(6)	K_3

OR

14(A)	Compute the Laplace transforms of i. $x(t) = 2e^{-t}U[t] + 0.5e^{-3t}U[t]$ i. $x(t) = 2e^{-3t}\cos 4tU[t]$	(8)	K_3
14(B)	Compute the Fourier transform of a rectangukar pulse with unit amplitude and width T and centred around origin. Plot the Fourier tranform in the frequency domain.	(6)	K_3

Module III

15(A)	Define sampling theorem. Determine the Nyquist rate and Nyquist interval for the signal $$x(t) = \cos \pi t + 3 \sin 2\pi t + \sin 4\pi t$$	(6)	K_2
15(B)	Analyze and characterize the LTI system $x(t)$ using Laplace Transform $$x(t) = \frac{2}{3}e^{-t}u(t) + \frac{1}{3}e^{2t}u(t)$$	(8)	K_2

OR

16(A)	Obtain the response of an LTI system with impulse response $h(t) = \delta(t)$ with input signal $x(t) = e^{-at}u(t)$ using Fourier transform	(6)	K_2
16(B)	Explain spectral aliasing and the need for anti-aliasing filter with an example spectrum	(8)	K_2

Module IV

17(A)	Describe the magnitude response and phase response of a discrete LTI system with the help of DTFTs.	(7)	K_2
17(B)	Compute the magnitude response of an LTI system described by $$y[n] = 0.1y[n-1]+0.1y[n-3]+x[n]+0.2x[n-1]+0.1x[n-2]$$ in terms of the DTFTs	(7)	K_2

OR

18	An LTI system has impulse response $h[n] = (\frac{1}{4})^n U[n]$. Use DTFT to compute the output for each of the following inputs: (i) $x[n] = (\frac{3}{4})^n U[n]$ (ii) $x[n] = (n+1)(\frac{1}{4})^n U[n]$ (iii) $x[n] = (-1)^n$.	(14)	K_2

Module V

19(A) Compute the inverse Z transform of (7) K_3

$$H(z) = \frac{1}{(1-\frac{1}{2}z^{-1})(1-\frac{1}{5}z^{-1})}$$

for all possible ROCs

19(B) Compute the inverse Z transform of (7) K_3

$$H(z) = cos(\alpha z^{-1})$$

for all possible ROCs

OR

20 Compute the Z-transform with ROC of

i. $x[n] = (\frac{1}{3})^n U[n]$ (4) K_3

ii. $x[n] = n(\frac{1}{3})^n U[n]$ (5) K_3

iii. $x[n] = \sum_{i=-\infty}^{n} (\frac{1}{3})^i U[i]$ (5) K_3

ECT 206	COMPUTER ARCHITECTURE AND MICROCONTROLLERS*	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course aims to impart knowledge of basic computer architecture and modern microcontrollers.

Prerequisite: ECT203 Logic Circuit Design

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

CO 1	Explain the functional units, I/O and memory management w.r.t a typical computer architecture.
CO 2	Distinguish between microprocessor and microcontroller.
CO 3	Develop simple programs using assembly language programming.
CO 4	Interface 8051 microcontroller with peripheral devices using ALP/Embedded C
CO 5	Familiarize system software and Advanced RISC Machine Architecture.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											3
CO 2	3											3
CO 3	3		3		3							3
CO 4	3	3	3		3							3
CO 5	3				3							3

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Course project : 15 marks

It is mandatory that a *course project* shall be undertaken by a student for this subject. The course project can be performed either as a hardware realization/simulation of a typical embedded system using Embedded C/ Assembly Language Programming. Instead of two assignments, two evaluations may be performed on the course project along with series tests, each carrying 5 marks. Upon successful completion of the project, a brief report shall be submitted by the student which shall be evaluated for 5 marks. The report has to be submitted for academic auditing. A few sample course projects are listed below:

Sample Course Projects

The below projects shall be done with the help of IDE for 8051/PIC/MSP/Arduino/Raspberry Pi-based interfacing boards/sensor modules.

1. Relay control
2. Distance measurement
3. Temperature measurement / Digital Thermometer
4. RF ID tags
5. Alphanumeric LCD display interface.
6. OLED display interfacing

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

SYLLABUS

Module 1: Computer Arithmetic and Processor Basics

Algorithms for binary multiplication and division. Fixed and floating-point number representation. Functional units of a computer, Von Neumann and Harvard computer architectures, CISC and RISC architectures. Processor Architecture – General internal architecture, Address bus, Data bus, control bus. Register set – status register, accumulator, program counter, stack pointer, general purpose registers. Processor operation – instruction cycle, instruction fetch, instruction decode, instruction execute, timing response, instruction sequencing and execution (basic concepts, datapath.

Module 2: 8051 Architecture

Microcontrollers and Embedded Processors. Architecture – Block diagram of 8051, Pin configuration, Registers, Internal Memory, Timers, Port Structures, Interrupts. Assembly Language Programming - Addressing Modes, Instruction set (Detailed study of 8051 instruction set is required).

Module 3: Programming and Interfacing of 8051

Simple programming examples in assembly language. Interfacing with 8051 using Assembly language programming: LED, Seven segment LED display. Programming in C - Declaring variables, Simple examples – delay generation, port programming, code conversion.

Interfacing of – LCD display, Keyboard, Stepper Motor, DAC and ADC -- with 8051 and its programming.

Module 4: Advanced Concepts

8051 Timers/Counters - Modes and Applications. Serial Data Transfer – SFRs of serial port, working, Programming the 8051 to transfer data serially. Introduction to ARM - ARM family, ARM 7 register architecture. ARM programmer's model. System software - Assembler, Interpreter, Compiler, Linker, Loader, Debugger.

Module 5: The Memory System

Types of memory - RAM, ROM. Memory Characteristics and Hierarchy. Cache memory – The basics of Caches, Mapping techniques, Improving Cache performance. Virtual memory – Overlay, Memory management, Address translation. Input/Output Organization – Introduction, Synchronous vs. asynchronous I/O, Programmed I/O, Interrupt driven I/O, Direct Memory Access.

Text Books

1. Muhammed Ali Mazidi & Janice Gilli Mazidi, R.D. Kinley, The 8051 microcontroller and Embedded System, Pearson Education, 2nd edition.
2. Subrata Ghoshal, Computer Architecture and Organization: From 8085 to Core2Duo and beyond, Pearson, 2011.
3. Steve Furber, ARM System - on-chip Architecture, Pearson Education

Reference Books

1. Mano M M, Computer System Architecture, 3rd Ed, Prentice Hall of India.
2. Computer organization and design: The Hardware/Software interface/David A. Patterson, John L. Hennessy. — 5th ed.
3. Computer Organisation V. Carl Hamacher, Zvonko G. Vranesic, Safwat G.Zaky.
4. John P Hayes, Computer Architecture and Organization, McGraw Hill.
5. Ramesh S Goankar, 8085 Microprocessor Architecture, Applications and Programming, Penram International, 5/e.
6. The 8051 Microcontrollers: Architecture Programming and Applications, K Uma Rao & Andhe Pallavi, Pearson, 2011.
7. Stallings W., Computer Organisation and Architecture, 5/e, Pearson Education.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures

1	**Computer Arithmetic and Processor Basics**	
1.1	Algorithms for binary multiplication and division	2
1.2	Fixed- and floating-point number representation in computers.	1
1.3	Functional units of a computer, Von Neumann and Harvard computer architectures, CISC and RISC architectures.	1
1.4	Processor Architecture – General internal architecture, Address bus, Data bus, control bus. Register set – status register, accumulator, program counter, stack pointer, general purpose registers.	2
1.5	Processor operation – instruction cycle, instruction fetch, instruction decode, instruction execute, timing response, instruction sequencing and execution (basic concepts), data path	3
	.	
2	**8051 Architecture**	
2.1	Microcontrollers and Embedded Processors and Applications	1
2.2	Architecture – Block diagram of 8051, Pin configuration, Registers, Internal Memory, Timers, Port Structures, Interrupts.	3
2.3	Addressing Modes of 8051	1
2.4	Instruction sets (Detailed study of 8051 instructions)	4
3	**Programming and Interfacing of 8051**	
3.1	Simple programming examples in assembly language.	2
3.2	Interfacing programming in Assembly language	2
3.3	Programming in C - Declaring variables, Simple examples – delay generation, port programming, code conversion.	3
3.4	Interfacing of 7 segment LCD display	1
3.5	Interfacing of Keyboard and stepper motor	2
3.6	Interfacing of DAC and ADC	2
4	**Advanced Concepts**	
4.1	8051 Timers/Counters - Modes and Applications	2
4.2	Serial Data Transfer – SFRs of serial port, working, Programming the 8051 to transfer data serially	2
4.3	Introduction to ARM - ARM family, ARM 7 register architecture. ARM programmer's model	2
4.4	System software - Assembler, Interpreter, Compiler, Linker, Loader, Debugger.	2
5	**Memory System**	
5.1	Types of memory - RAM, ROM. Memory Characteristics and Hierarchy	2
5.2	Cache memory – The basics of Caches, Mapping techniques, Improving Cache performance	2
5.3	Virtual memory – Overlay, Memory management, Address translation	2
5. 4	Input/Output Organization – Introduction, Synchronous vs. asynchronous I/O, Programmed I/O, Interrupt driven I/O, Direct Memory Access.	3

Simulation assignments

The following examples may be solved in C program

1. Program to convert the ASCII number into unpacked BCD.
2. Program to swap a number 0 x ab to 0 x ba, where a and b are hex digits.
3. Program to find the number of 1's in an 8-bit data item.
4. Program to display 'M' and 'E' on the LCD connected to 8051 using the BUSY FLAG.
5. Program to rotate a stepper motor 50^0 in the clock wise direction.
6. Program to toggle pin P1.4 every second using interrupts for a frequency of 22 MHz. Use timer 1 in mode 1.
7. Program to generate a square wave of 1 kHz with duty cycle 33%. Use timer 1 in interrupt mode with a crystal frequency of 11.0592 MHz.

Model Question Paper

A P J Abdul Kalam Technological University

Fourth Semester B Tech Degree Examination

Branch: Electronics and Communication

Course: ECT 206 COMPUTER ARCHITECTURE AND MICROCONTROLLERS

Time: 3 Hrs | Max. Marks: 100

Part – A

*Answer all questions. Questions carry **3 marks** each.*

1. Represent 4946.278941 as a 32 bit number in IEEE 754 format.
2. Which is more important for the functioning of a basic processor, Program Counter or Stack Pointer. Justify your answer.
3. List the components of 8051 microcontroller.
4. Write the operations happening in the following instructions:
   ADD A, 56
   XCHD A, @R1
   DJNZ R6, LABEL
   DIV AB
   XRL A, #0FFh
   JB P1.2 LABEL
5. Write an embedded C program for 8051 microcontroller to continously rotate a stepper motor clockwise.
6. Write an embedded C program for 8051 microcontroller to blink P2.5 every 2 seconds
7. List the different modes and give corresponding uses of timers in 8051 microcontroller
8. Which are the SFRs used for serial communication in 8051 microcontroller. Give there functions.
9. Illustrate the memory hierarchy in a computer system.
10. Is ROM a random access memory? Justify your answer.

Part – B

Answer one question each from all modules

Module – 1

11. a) With an example explain the “shift and add” algorithm for multiplying two binary numbers. (5 marks)

b) With relevant diagrams illustrate the functioning of a basic (non – pipelined) processor. (9 marks)

OR

12. a) Differentiate RISC and CISC architectures. (4 marks)

b) Explain Instruction Cycle with a sample timing diagram (10 marks)

Module – 2

13. a) Illustrate the complete memory organisation of 8051 microcontroller (10 marks)

b) Differentiate microprocessors and microcontrollers. (4 marks)

OR

14. a) Explain about the Addressing Modes of 8051 microcontroller with examples. (7 marks)

b) Describe the classification of the Instruction Set of 8051 microcontroller with examples. (7 marks)

Module – 3

15. a) Write an embedded C program for 8051 microcontroller to read an analogue signal from an ADC and reproduce the same using a DAC (9 marks)

b) Write an assembly language program for 8051 microcontroller to sort N number in ascending order. Assume that the numbers are stored in continuous locations starting from 0x4321 onwards. (5 marks)

OR

16. a) Write an embedded C program for 8051 microcontroller to repeatedly display the sequence 1,5,8,0,2,6,4,9,3,7 using a 7 – segment display with a delay of 1.5 seconds between each number. (9 marks)

b) Write an assembly language program for 8051 microcontroller to find the cube of an 8 – bit number (5 marks)

Module – 4

17. a) Assume a switch is connected to pin PL7. Write a embedded C program for 8051 microcontroller to monitor its status and
send two messages to serial port continuously as follows:
SW=0 send “NO”
SW=1 send “YES”
Assume XTAL = 11.0592 MHz, 9600 baud, 8-bit data, and 1 stop bit. (10 marks)

b) Describe the ARM 7 register architecture (4 marks)

OR

18. a) Write a embedded C program for 8051 microcontroller to send the message "Hello World !" to serial port. Assume a SW is connected to pin P1.2. Monitor its status and set the baud rate as follows:
SW = 0 , 4800 baud rate
SW = 1 , 9600 baud rate
Assume XTAL = 11.0592 Mhz, 8 – bit data, and 1 stop bit (10 marks)
b) Explain how a HLL program is executed as machine language in a processor (4 marks)

Module – 5

19. a) Differentiate synchronous and asynchronous I/O.
Which is more efficient with respect to processor utilisation? Justify your answer (8 marks)
b) Explain direct mapping of cache memory with an example (6 marks)

OR

20. a) Differentiate interrupt driven and programmed I/O.
Which is more efficient with respect to processor utilisation? Justify your answer (8 marks)
b) Explain about memory management using virtual memory. (6 marks)

ECL 202	ANALOG CIRCUITS AND SIMULATION LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This course aims to

(i) familiarize students with the Analog Circuits Design through the implementation of basic Analog Circuits using discrete components.

(ii) familiarize students with simulation of basic Analog Circuits.

Prerequisite: Nil

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

CO 1	Design and demonstrate the functioning of basic analog circuits using discrete components.
CO 2	Design and simulate the functioning of basic analog circuits using simulation tools.
CO 3	Function effectively as an individual and in a team to accomplish the given task.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3						2			2
CO 2	3	3	3		3				2			2
CO 3	3	3	3						3			3

Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions: End-semester practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the examination only on submitting the duly certified record. The external examiner shall endorse the record.

Part A : List of Experiments using discrete components [Any Six experiments mandatory]

1. RC integrating and differentiating circuits (Transient analysis with different inputs and frequency response)
2. Clipping and clamping circuits (Transients and transfer characteristics)
3. RC coupled CE amplifier - frequency response characteristics
4. MOSFET amplifier (CS) - frequency response characteristics
5. Cascade amplifier – gain and frequency response
6. Cascode amplifier -frequency response
7. Feedback amplifiers (current series, voltage series) - gain and frequency response
8. Low frequency oscillators –RC phase shift or Wien bridge
9. Power amplifiers (transformer less) - Class B and Class AB
10. Transistor series voltage regulator (load and line regulation)

PART B: Simulation experiments [Any Six experiments mandatory]

The experiments shall be conducted using open tools such as QUCS, KiCad or variants of SPICE.

1. RC integrating and differentiating circuits (Transient analysis with different inputs and frequency response)
2. Clipping and clamping circuits (Transients and transfer characteristics)
3. RC coupled CE amplifier - frequency response characteristics
4. MOSFET amplifier (CS) - frequency response characteristics
5. Cascade amplifier – gain and frequency response
6. Cascode amplifier – frequency response

7. Feedback amplifiers (current series, voltage series) - gain and frequency response
8. Low frequency oscillators – RC phase shift or Wien bridge
9. Power amplifiers (transformer less) - Class B and Class AB
10. Transistor series voltage regulator (load and line regulation)

ECL 204	MICROCONTROLLER LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This course aims to

(i) Familiarize the students with Assembly Language Programming of modern microcontrollers.

(ii) Impart the skills for interfacing the microcontroller with the help of Embedded C/Assembly Language Programming.

Prerequisite: Nil

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

CO 1	Write an Assembly language program/Embedded C program for performing data manipulation.
CO 2	Develop ALP/Embedded C Programs to interface microcontroller with peripherals
CO 3	Perform programming/interfacing experiments with IDE for modern microcontrollers.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3		3		3				3			3
CO 2	3		3	2	3				3			3
CO 3	3		3	3	3	3			3		3	3

Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks
(d) Viva voce : 20 marks

(e) Record : 5 Marks

General instructions: End-semester practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the examination only on submitting the duly certified record. The external examiner shall endorse the record.

PART – A (At least 6 experiments are mandatory)

These experiments shall be performed using 8051 trainer kit. The programs shall be written either in embedded C or in assembly language.

1. Data transfer/exchange between specified memory locations.
2. Largest/smallest from a series.
3. Sorting (Ascending/Descending) of data.
4. Addition / subtraction / multiplication / division of 8/16 bit data.
5. Sum of a series of 8 bit data.
6. Multiplication by shift and add method.
7. Square / cube / square root of 8 bit data.
8. Matrix addition.
9. LCM and HCF of two 8 bit numbers.
10. Code conversion – Hex to Decimal/ASCII to Decimal and vice versa.

PART – B (At least 4 experiments are mandatory.)

Interfacing experiments shall be done using modern microcontrollers such as 8051 or ARM. The interfacing modules may be developed using Embedded C.

1. Time delay generation and relay interface.
2. Display (LED/Seven segments/LCD) and keyboard interface.
3. ADC interface.
4. DAC interface with wave form generation.
5. Stepper motor and DC motor interface.
6. Realization of Boolean expression through port.

SEMESTER -4
MINOR

ECT282	Microcontrollers	CATEGORY	L	T	P	CREDIT
		Minor	3	1	0	4

Preamble: This course aims to impart the overview of a microcontroller-based system design and interfacing techniques.

Prerequisite: Nil

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

CO 1 K2	Explain the building blocks of a typical microcomputer/microcontroller system
CO 2 K2	Familiarize the instruction set of 8051 and perform assembly language programming
CO 3 K3	Interface the various peripheral devices to the microcontroller using assembly/ C programming
CO4 K3	Realize external communication interface to the microcontroller
CO5 K2	Familiarize the building blocks of RISC Processors and ARM microcontrollers

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											2
CO 2	3				3							2
CO 3	3	2	3		3							2
CO 4	3	2	3		3							2
CO5	3											2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember K1	10	10	10
Understand K2	20	20	20
Apply K3	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Syllabus

Module 1: Computer Arithmetic and Processor Basics

Functional units of a computer, Von Neumann and Harvard computer architectures. Processor Architecture – General internal architecture, Address bus, Data bus, control bus. Register set – status register, accumulator, program counter, stack pointer, general purpose registers. Processor operation – instruction cycle, instruction fetch, instruction decode, instruction execute.

Module 2: 8051 Architecture

Architecture – Block diagram of 8051, Pin configuration, Registers, Internal Memory, Timers, Port Structures, Interrupts. Addressing Modes, Instruction set (brief study of 8051 instruction set is sufficient).

Module 3: Programming and Interfacing of 8051

Simple programming examples in assembly language: Addition, Subtraction, Multiplication and Division. Interfacing of LCD display, Keyboard, Stepper Motor, DAC and ADC with 8051.

Module 4: Open Source Embedded Development Boards

Introduction. ATmega2560 microcontroller- Block diagram and pin description. Arduino Mega **256** board – Introduction and pin description. Simple Applications - Solar Tracker, 4-Digit 7-Segment LED Display, Tilt Sensor, Home Security Alarm System, Digital Thermometer, IoT applications.

Module 5: ARM Based System

Introduction - ARM family, ARM 7 register architecture, ARM programmer's model. Raspberry pi 4 board – Introduction and brief description. Applications - Portable Bluetooth speaker, Remote-controlled car, Photo Booth, IoT weather station, Home automation centre, Portable Digital eBook Library.

Text Books

1. Computer Architecture and Organization: From 8085 to Core2Duo and beyond, Subrata Ghoshal, Pearson, 2011.

2. The 8051 microcontroller and Embedded System, Muhammed Ali Mazidi & Janice Gilli Mazidi, R.D. Kinley, Pearson Education, 2nd edition.

Reference Books

1. The 8051 Microcontrollers: Architecture Programming and Applications, K Uma Rao & Andhe Pallavi, Pearson, 2011.

2. ARM System - on-chip Architecture, Steve Furber, Pearson Education

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Computer Arithmetic and Processor Basics**	
1.1	Functional units of a computer, Von Neumann and Harvard computer architectures	2
1.2	Processor Architecture – General internal architecture	1
1.3	Address bus, Data bus, control bus	1
1.4	Register set – status register, accumulator, program counter, stack pointer, general purpose registers.	2
1.5	Processor operation – instruction cycle, instruction fetch, instruction decode, instruction execute	3
2	**8051 Architecture**	
2.1	Architecture – Block diagram of 8051	1
2.2	Pin configuration, Registers, Internal Memory, Timers, Port Structures, Interrupts.	3
2.3	Addressing Modes of 8051	1
2.4	Instruction sets (brief study of 8051 instructions)	4
3	**Programming and Interfacing of 8051**	
3.1	Simple programming examples in assembly language	1
3.2	Addition, Subtraction, Multiplication and Division	2
3.3	Interfacing of 7 segment LCD display	1
3.4	Interfacing of Keyboard and stepper motor	2
3.5	Interfacing of DAC and ADC	3
4	**Open Source Embedded Development Boards**	
4.1	Introduction to open source boards	1
4.2	ATmega2560 microcontroller- Block diagram and pin description	3
4.3	Arduino Mega **256** board – Introduction and pin description	2
4.4	Simple Applications - Solar Tracker, 4-Digit 7-Segment LED Display, Tilt Sensor, Home Security Alarm System, Digital Thermometer, IoT applications	3
5	**ARM Based System**	

5.1	Introduction - ARM family, ARM 7 register architecture, ARM programmer's model	3
5.2	Raspberry pi 4 board – Introduction and brief description	2
5.3	Applications - Portable Bluetooth speaker, Remote-controlled car, Photo Booth, IoT weather station, Home automation centre, Portable Digital eBook Library	4

MODEL QUESTION PAPER

			Total Pages: 2

Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, ____________ 20__

Course Code: ECT 282

Course Name: MICROCONTROLLERS

Max. Marks: 100 | Duration: 3 Hours

PART A

		Answer all questions; each question carries 3 marks.	Marks
1		Distinguish between Harvard and Von-Neumann architecture.	(3)
2		Write down the control signal for a register transfer.	(3)
3		Explain the concept of memory banks in 8051.	(3)
4		Mention the difference between AJMP, LJMP and SJMP instructions.	(3)
5		Write a program to multiply two 8 bit numbers from external memory in 8051microcontroller	(3)
6		Explain the format of SCON special function register.	(3)
7		Discuss the features of ARM processor.	(3)
8		How do you interface an ADC with 8051?	(3)
9		List 5 main features of Atmega 2560 microcontroller	(3)
10		Give 5 features of ARM processors.	(3)

PART B

Answer one question from each module; each question carries 14 marks.

		Module 1	
1	a)	Explain the different stages of microprocessor operations.	(6)
	b)	Explain the role of different buses in a processor architecture.	(8)
		OR	
2	a)	Explain the data path for branch execution showing all control signals and sequences.	(6)
	b)	Explain the function of following registers: status register, accumulator, program counter, stack pointer, general purpose registers.	(8)
		Module 2	
3	a)	Draw the circuit diagram of port 1 and port 2 and describe their operation briefly.	(8)
	b)	Explain the internal architecture of 8051 microcontroller with a block diagram.	(6)
		OR	
4	a)	Briefly explain the following instructions of 8051: (i) MOV A, @Ri (ii) PUSH direct (iii) XCH A, Rn (iv) DAA	(8)
	b)	Explain the addressing modes of 8051.	(6)
		Module 3	
5	a)	Write an ALP to find the sum of an array of 8 bit numbers stored in the	(8)

		external memory of an 8051 microcontroller.	
	b)	How a DAC can be interfaced to 8051? Explain.	(6)
		OR	
6	a)	Write an ALP to add two 16 bit numbers, stored in consecutive locations in the external memory of an 8051 microcontrollers.	(8)
	b)	Explain the interfacing of LCD display with suitable schematic.	(6)
		Module 4	
7	a)	Explain the pin configuration of Arduino MEGA 256 board using a schematic diagram	(14)
		OR	
8	a)	Write short note on open source boards.	(5)
	b)	Explain the working of a four digit 7 segment LED display using an open source board.	(9)
		Module 5	
9	a)	Draw the ARM-7 register architecture and explain.	(7)
	b)	Draw and explain the programming model of an ARM processor.	(7)
		OR	
10	a)	Explain the features of a Raspberry pi -4 board.	(8)
	b)	Explain any one application using Raspberry pi -4 board and draw a schematic.	(6)
		****	

ECT284	DIGITAL COMMUNICATION	CATEGORY	L	T	P	CREDIT
		Minor	3	1	0	4

Preamble: This course aims to apply the concepts of probability and random processes in communication systems.

Prerequisite: ECT 253 Analog communication

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

CO 1	Explain the main components in a digital communication system
CO 2	Explain the source coding schemes
CO 3	Explain codes for signaling
CO 4	Apply the knowledge of digital modulation schemes in digital transmission.
CO 5	Apply channel coding in digital transmission
CO 6	Explain digital receivers

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										
CO 2	3	3		3								
CO 3	3	3		3								
CO 4	3	3			2							
CO 5	3	3		3								

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	30	30	60
Apply	10	10	20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Main components in digital communication system
1. Draw the block diagram of a digital communication system and explain the blocks.
2. Compare and contrast analog communication system with a digital system. List the advantages of the latter.

Course Outcome 2 (CO2): Source Coding
1. Draw the block diagram of a linear PCM system and explain the functions of all blocks.
2. Explain the a-law and mu-law quantization
3. State sampling theorem and explain the reconstruction of signals

Course Outcome 3 (CO3): Signaling Code
1. Explain the principle of alternate mark inversion coding. Give an example with an arbitrary binary data pattern
2. Explain B3ZS code. Give an example with an arbitrary binary data pattern

Course Outcome 4 (CO4): Apply the knowledge of digital modulation schemes in digital transmission.
1. Explain the BPSK transmitter and receiver. Apply its principle to draw the output waveform of a BPSK transmitter that is fed with the bit pattern {1,0,0,1,1,00}.
2. Explain a baseband BPSK system. Give its probability of error. Draw the BER-SNR curve
3. Explain the QPSK transmitter and receiver. Apply its principle to draw the output waveform of a QPSK transmitter that is fed with the bit pattern {1,0,0,1,1,00}.

Course Outcome 5 (CO5): Digital Receivers
1. Explain encoding and decoding with (7,4) block codes
2. Explain the working of a matched filter receiver. Draw the BER-SNR curve at the output.
3. Explain Cyclic codes with an example.

SYLLABUS

Module 1: Linear Source Coding [1]

Elements of digital communication system. Sources, channels and receivers. Classification of communication channels. Discrete sources. Source coding techniques. Waveform coding methods. Sampling theorem. Sampling and reconstruction. Pulse code modulation. Sampling, quantization and encoding. Different quantizers. A-law and mu-law quantization. Practical 15 level mu and A law encoding.

Module 2: Nonlinear Source Coding [1,2]

Differential PCM, adaptive PCM, Delta modulator and adaptive delta modulator. Issues in delta modulation. Slope overload.

Module 3: Signaling Codes in Telephony [1]

Signalling codes in digital telephony. T1 signalling system. AMI and Manchester codes. Binary N-zero substitution, B3ZS code, B6ZS code.

Module 4: Digital Modulation Schemes [1,2]

Digital modulation schemes. Baseband BPSK system and the signal constellation. BPSK transmitter and receiver. Base band QPSK system and Signal constellations. Plots of BER Vs SNR (Analysis not required). QPSK transmitter and receiver. Quadrature amplitude modulation.

Module 5: Channel Coding and Receivers [1,2]

Transmission through AWGN Channel. Capacity of an AWGN channel. Receivers. Correlation and matched filter receiver. Channel coding schemes. Repetition code. Block codes Cyclic codes.

Text Books

1. John C. Bellamy, “Digital Telephony”,Wiley
2. Simon Haykin, “Communication Systems”, Wiley.
3. Sklar, “Digital Communications: Fundamentals and Applications”, Pearson.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Linear Source Coding**	
1.1	Block diagram of digital communication system, Sorces, channel and receivers. Classification of Channels	2
1.2	Source coding , waveform coding , sampling and reconstruction	2
1.3	PCM, Compression, 15 level A and mu-law coding	4
1.4	Uniform and Gaussian Pdf and correspoding CDF. Properties	1
2	**Nonlinear Source Coding**	
2.1	DPCM,Adaptive DPCM	4
2.2	Delta modulation, slope overload	3
3	**Signaling Codes**	
3.1	Overview of T1 signaling systems. Need for signaling codes, AMI and Manchestre codes	4
3.2	Binary N-zero substitution, B3ZS code, B6ZS code	3
3.5	Mutual information and channel capacity. Capacity of AWGN channel	2
4	**Digital Modulation**	
4.1	Need of digital modulation in modern communication.	1
4.2	Baseband BPSK system, signal constellation. Effect of AWGN, probability of error. BER-SNR curve, BPSK transmitter and receiver.	4
4.3	Baseband QPSK system, signal constellation. Effect of AWGN, probability of error. BER-SNR curve, QPSK transmitter and receiver.	4
4.4	QAM system	2
5	**Channel Coding and Receivers**	
5.1	Mutual information and channel capacity	2
5.2	Correlation and matched filter receiver, BER-SNR curve	2
5.3	Channel coding schemes. Repetition code. Block codes. Cyclic codes	5

Simulation Assignments

The following simulations can be done in MATLAB, Python,R or LabVIEW.

A-Law and μ-Law Characteristics

- Create a vector with say 1000 points that spans from -1 to 1.
- Apply A-Law companding on this vector get another vector. Plot it against the first vector for different A values and appreciate the transfer characteristics.
- Repeat the above steps for μ-law as well.

Practical A-Law compander

- Implement the 8-bit practical A-law coder and decoder in Appendix B 2 (pp 583–585) in *Digital Telephony by Bellamy*
- Test it with random numbers and speech signals. Observe the 15 levels of quantization.

Practical μ-Law compander

- Implement the 8-bit practical μ-law coder and decoder in Appendix B 1 (pp 579–581) in *Digital Telephony by Bellamy*
- Test it with random numbers and speech signals. Observe the 15 levels of quantization.

B3ZS Encoder and Decoder

- Implenet a B3ZS encoder and decoder.
- Test it with random bits.
- Decode and compare the result with the original bit pattern.

B6ZS Encoder and Decoder

- Implenet a B6ZS encoder and decoder.
- Test it with random binary vector.
- Decode and compare the result with the original bit pattern.

Base Band BPSK System

- Cretae a random binary sequence of 5000 bit. Convert it into a bipolar NRZ code.
- Create a BPSK mapper that maps bit 0 to zero phase and bit 1 to π phase.
- Plot the real part of the mapped signal against the imaginary part to observe the signal constellation
- Add AWGN of difference variances to the base band BPSK signal and observe the changes in constellation.
- Realize the BPSK transmitter and receiver in Fig. 6.4 in pager 352 in *Communication Systems by Simon Haykin* .
- Add AWGN of different variances and compute the bit error rate (BER) for different SNR values.
- Plot the BER Vs. SNR.
- Plot the theoretical BER-SNR curve, using Eq. 6.19 in pager 351 in *Communication Systems by Simon Haykin* .

Model Question Paper

A P J Abdul Kalam Technological University

Fourth Semester B Tech Degree Examination

Course: ECT 284 Digital Communication

Time: 3 Hrs **Max. Marks: 100**

PART A

Answer All Questions

1	State sampling theorem	(3)	K_2
2	Give the classification of communication channels	(3)	K_2
3	Explain the term slope overload	(3)	K_2
4	Why is a logarithmic quantizer preferred in DPCM?	(3)	K_2
5	Explain the needs for signalling codes	(3)	K_1
6	Draw the Manchester code for the bit pattern $\{1, 0, 1, 1, 0, 0\}$	(3)	K_3
7	Draw the BER-SNR curve for a BPSK system	(3)	K_2
8	Draw the signal constellation for a baseband QPSK system	(3)	K_2
9	Define mutual information and channel capacity	(3)	K_2
10	Explain a (7,4) block code.	(3)	K_2

PART B

Answer one question from each module. Each question carries 14 mark.

Module I

11(A)	Draw the block diagram of a linear PCM system and explain the blocks	(8)	K_2
11(B)	Explain μ-law companding	(6)	K_2

OR

12(A)	Explain how companding is achieved practically using different levels	(8)	K_2

12(B)	Explain mid-rise and mid-tread quantizers	(6)	K_2

Module II

13(A)	Explain the need for differential PCM. What is the advantage over linear PCM	(6)	K_2
13(B)	Draw the block diagram of a DPCM transmitter and receiver and explain the functions of ech block.	(8)	K_3

OR

14(A)	Draw the block diagram of a delta modulator and explain the functions of each block	(8)	K_2
14(B)	Explain the principle of adaptive delta modulation	(6)	K_2

Module III

15(A)	What is binary zero substitution? Explain the B3ZS line coding scheme	(8)	K_2
15(B)	Encode {101000010000000001} using B3ZS code	(6)	K_3

OR

16(A)	Explain the principle of alternate mark inversion coding. Give an example with an arbitrary binary data pattern	(8)	K_2
16(B)	Encode {101000010000000001} using B6ZS code	(6)	K_3

Module IV

17(A)	Draw the block diagram of BPSK transmitter and receiver and explain the functions of each block. Draw the BER-SNR curve.	(8)	K_2
17(B)	Draw the signal constellation of base band BPSK and indicate the effect of AWGN on it	(6)	K_2

OR

18(A)	Draw the block diagram of QPSK transmitter and receiver and explain the functions of each block. Draw the BER-SNR curve.	(8)	K_2
18(B)	Explain the QAM modulation and demodulation.	(6)	K_2

Module V

19(A)	Explain how matched filter is used in digital reception? Draw the BER-SNR curve at the output.	(8)	K_3
19(B)	Explain how correlation receiver is used in digital reception?	(6)	K_3

OR

20	Explain channel encoding and decoding with (7,4) block codes	(14)	K_3

ECT286	INTRODUCTION TO DIGITAL SIGNAL PROCESSING	CATEGORY	L	T	P	CREDIT
		Minor	3	1	0	4

Preamble: This course aims to give an introduction to digital signal processing

Prerequisite: ECT255 Introduction to Signals and Systems

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

CO 1	Explain how digital signals are obtained from continuous time signals.
CO 2	Apply Fourier transform in the analysis of signals
CO 3	Implement digital filters
CO 4	Explain the practical limitations in DSP implementations
CO 5	Explain the structure of a DSP processor.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1										
CO 2	3	3	2	2	3				3			1
CO 3	3	2	3	3	3				3			
CO 4	3	1										
CO 5	3	1			1							

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	25	25	50
Apply	15	15	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Discrete Signals and Sampling Theorem

1. Define a digital signal. Give the frequency range of digital signal. Explain the sampling theorem and show graphically how samples are generated from a continuous time signal.

2. What should be the minimum frequency to sample a 2.5kHz analog signal? Explain graphically how the continuous time signal is reconstructed from samples.

Course Outcome 2 (CO2): Application of Fourier Transform

1. Give the expression for DFT of an N-point sequence. Compute the 10 point DFT of a unit impulse sequence.

2. Derive the raddix-2 decimation in time algorithm for N=8.

Course Outcome 3 (CO3): Implementation of Digital Filters

1. Give the difference equation of an IIR filter. Give an example and draw its structure

2. Design an IIR Butterworth filter for passband frequency 5kHz and stopband frequency 10kHz. The stop band and passs band attenuations are 0.1 respectively.

Course Outcome 4 (CO4): Practical Limitations of Digital Filters

1(A). Explain the limit cycle oscillations in IIR filters

(B) Explain the effects of coefficient quantization in IIR filters

2. (A) Explain the effects of round of noise in digital filters
2(B) Explain the fixed and floating point arithmetic used in DSP processors.

Course Outcome 5 (CO5): Structure of Digital Signal Processors

1(A). Explain the function of the MAC unit in a DSP

(B) Explain the differences between Harvard and Von Neumann architecture.

2. Draw the internal structure of a floating point processor and explain its functional blocks

Syllabus

Module 1: Signal Processing Fundamentals
Discrete-time and digital signals. Basic elements of digital processing system- ADC, DAC and Nyquist rate. Frequency aliasing due to sampling. Need for anti-aliasing filters. Discrete Time Fourier Transforms – Properties. Computation of spectrum.

Module 2: Discrete Fourier Transform – Properties and Application
Discrete Fourier transform - DFT as a linear transformation, Properties - circular convolution. Filtering of long data sequences - FFT-Radix-2 DIT and DIF algorithms. Computational complexity of DFT and FFT -application.

Module 3: Digital Filters
Digital FIR Filter: Transfer function - Difference equation, Linear phase FIR filter, Concept of windowing, Direct form and cascade realization of FIR and IIR filters. Digital IIR Filters - Transfer function, Difference equation. Direct and parallel Structures. Design of analogue Butterworth filters, Analog frequency transformations, Impulse invariance method. Bilinear transformation, Analog prototype to digital transformations.

Module 5: Finite word length effects in digital filters and DSP Hardware
Fixed point arithmetic, Floating point arithmetic, Truncation and Rounding, Quantization error in ADC, Overflow error, Product round off error, Scaling , Limit cycle oscillation.

General and special purpose hardware for DSP: Computer architectures for DSP – Harvard, pipelining, MAC, special instruction, replication, on chip cache. General purpose digital signal processors (TMS 320 family) - Implementation of digital filtering on dsp processor. Special purpose DSP hardware

Text Books
1. Proakis, J.G. & Manolakis, D.G., “Digital Signal Processing: Principles, Algorithms,& Applications”, 3/e Prentice Hall of India, 1996.
2. Ifeachor, E.C., & Jervis, B.W., “Digital Signal Processing: A Practical Approach”,2/e, Pearson Education Asia, 2002.
3. Chen, C.T., “Digital Signal Processing: Spectral Computation & Filter Design”, Oxford Univ. Press, 2001.
4. Mitra, S.K., “Digital Signal Processing: A Computer-Based Approach”, McGraw Hill, NY, 1998
5. Monson H Hayes, Schaums outline: Digital Signal Processing.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Signal Processing Fundamentals**	
1.1	Overview of signals. Frequency elements of DSP sytems	2
1.2	Conversion of analog signals to digital signals, Sampling theorem, reconstruction ADC and DAC , spectra and antialiasing filter	3
1.3	DTFT properties, spectrum	3

2	**DFT**	
2.1	DFT from DTFT, DFT as a linear transformation. W matrix. Properties of DFT, Computational challenges.	3
2.2	FFT for comptational advantage, Radix -2 DIT and Dif algorith, in place computation. Bit reversal permutation. complexity	4
2.3	Filtering of long sequences	2
3	**Digital Filters**	
3.1	Model of FIR and IIR filters. Direct form I and II of FIR filter, simple FIR design	4
3.2	IIR filter, design of Butterworth filter, Direct and parallel realization	4
3.3	Analog to digital transformation, impulse invariance and bilinear transformation.	4
4	**Finite Word-length Effects**	
4.1	Number representation Truncation - Rounding - Quantization error in ADC - Overflow error- product round off error - Scaling - Limit cycle oscillation.	2
4.2	Truncation-Rounding - Quantization error in ADC - Overflow error - product round off error - Scaling - Limit cycle oscillation.	5
5	**DSP Architecture**	
5.1	Von Neumann and Harvard architecture, Comparison	1
5.2	Data paths of fixed and floating point DSP processors. Functions of various blocks Architecture of a typical DSP processor	5
5.3	Implementation of systems on DSP chip	2

Simulation Assignments

The following simulation assignments can be done with Python/MATLAB/ SCILAB/OCTAVE

1. Generate the following discrete signals
   - Impulse signal
   - Pulse signal and
   - Triangular signal
2. Write a function to compute the DFT of a discrete energy signal. Test this function on a few signals and plot their magnitude and phase spectra.
3.
   - Compute the linear convolution between the sequences $x = [1, 3, 5, 3]$ with $h = [2, 3, 5, 6]$. Observe the stem plot of both signals and the convolution.
   - Now let $h = [1, 2, 1]$ and $x = [2, 3, 5, 6, 7]$. Compute the convolution between h and x.
   - Flip the signal x by 180° so that it becomes $[7, 6, 5, 3, 2]$. Convolve it with h. Compare the result with the previous result.
   - Repeat the above two steps with $h = [1, 2, 3, 2, 1]$ and $h = [1, 2, 3, 4, 5, 4, 3, 2, 1]$
   - Give your inference.
4.
   - Compute the DFT matrix for $N = 8, 16, 64, 1024$ and 4098
   - Plot the first 10 rows in each case and appreciate these basis functions
   - Plot the real part of these matrices as images and appreciate the periodicities and half periodicities in the pattern
   - Normalize each matrix by dividing by $\sqrt{N}$. Compute the eigenvalues of every normalized matrix and observe that all eigenvalues belong to the set $\{1, j, -j, -1\}$.
5.
   - Realize a continuous time LTI system with system response

     $$H(s) = \frac{5(s+1)}{(s+2)(s+3)}$$

     . One may use *scipy.signal.lti* package in Python.
   - Make it into a discrete system (possibly with *scipy.signal.cont2discrete*)
   - Observe the step response in both cases and compare.
6.
   - Download a vibration signal in *.wav* format.
   - Load this signal into an array. One may use the *scipy.io.wavfile* module in Python.
   - understand the sampling rate of this signal.

- Plot and observe the vibration signal waveform.
- Compute the absolute squared value of the FFT of the vibration signal.
- Plot it and observe the spectral components in the discrete frequency domain.
- Multiply prominent discrete frequencies by the sampling rate and observe and appreciate the major frequency components in Hz.

Model Question Paper

A P J Abdul Kalam Technological University

Fourth Semester B. Tech. Degree Examination

Branch: Electronics and Communication

Course: ECT 286 Introduction to Digital Signal Processing

Time: 3 Hrs **Max. Marks: 100**

PART A

Answer All Questions

1	Define frequency of a discrete signal and identify its range.	(3)	K_1
2	State Nyquist sampling theorem for low pass signals and the formula for signal reconstruction.	(3)	K_3
3	Explain why DFT operation is a linear transformation.	(3)	K_2
4	Explain how FFT reduces the computational complexity of DFT.	(3)	K_2
5	Write the expresssion for the Hamming window and plot it.	(3)	K_1
6	Give the expression for bilinear tranformation and explain the term frequency warping.	(3)	K_2
7	Explain the quantization error in ADCs.	(3)	K_2
8	Explain the 1s and 2s complement representation of numbers in DSP processor.	(3)	K_2
9	Compare floating point and fixed point data paths in a DSP processor.	(3)	K_2
10	Explain function of a barrel shifter in a DSP processor.	(3)	K_2

PART B

Answer one question from each module. Each question carries 14 mark.

Module I

11(A)	Explain how analog signals are converted to digital signals.	(10)	K_2
11(B)	What all digital frequencies are obtained when a $1\,kHz$ signal is sampled by $4\,kHz$ and $8\,kHz$ impulse trains?	(4)	K_3

OR

12(A)	Give the expression for DTFT. Compute the DTFT of the signal $x[n] = [1, -1, 1, -1]$	(8)	K_3
12(B)	Explain how sampling affects the spectrum of the signal and the need of antialiasing filter	(6)	K_3

Module II

13(A)	Give the radix-2 decimation in time algorithm for 8-point FFT computation	(10)	K_3
13(B)	How is in place computation applied in FFT algorithms?	(4)	K_3

OR

14(A)	Find the DFT of the sequence $x(n) = \{1, 2, 3, 4, 4, 3, 2, 1\}$ using radix-2 DIF algorithm	(10)	K_3
14(B)	How is bit reverse addressing used in FFT computations?	(4)	K_3

Module III

15(A)	Write the difference equation representation of IIR filter and explain how its impulse response is infinite in duration	(7)	K_3

15(B)	Convert the analog filter $$H(s) = \frac{1}{(s+1)(s+2)}$$ into digital filter using impulse invariance method.	(7)	K_3

OR

16(A)	Implement the FIR filter $h[n] = [1, 2, 4, 6, 4, 2, 1]$ with minimum multipliers in directform	(6)	K_3
16(B)	Design an IIR Butterworth filter for passband frequency $5\,kHz$ and stopband frequency $10\,kHz$. The stop band and passs band attenuations are 0.1 respectively.	(8)	K_3

Module IV

17(A)	Explain the limit cycle oscillations in IIR filters	(6)	K_3
17(B)	Derive the quantization noise power in an ADC	(8)	K_3

OR

18(A)	Find the output noise variance of a first order system with transfer function $$H(z) = \frac{1}{1-\alpha z^{-1}}$$ that is driven by a zero mean white Gaussian noise of variance σ_N^2	(8)	K_3
18(B)	Explain the fixed and floating point arithmetic used in DSP processors.	(6)	K_3

Module V

19	Draw and explain the functional blocks in a floating point DSP processor.	(14)	K_2

OR

20(A)	Compare Von Neumann architecture with Harvard architecture	(7)	K_2
20(B)	Explain the significance and operation of the MAC unit in a DSP processor	(7)	K_2

SEMESTER -4
HONOURS

ECT292	NANOELECTRONICS	CATEGORY	L	T	P	CREDIT
		Honors	3	1	0	4

Preamble: This course aims to understand the physics behind mesoscopic systems and working of nanoelectronic devices.

Prerequisite: PHT100 Engineering Physics A, ECT201 Solid State Devices

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

CO 1	Explain quantum mechanical effects associated with low dimensional semiconductors.
CO 2	Explain the different processes involved in the fabrication of nanoparticles and nanolayers.
CO 3	Explain the different techniques for characterizing nano layers and particles
CO 4	Explain the different transport mechanisms in nano structures
CO 5	Illustrate the operating principle of nanoscale electronic devices like SET, Resonant tunnelling devices, Quantum lasers etc.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2											
CO 2	2											
CO 3	1											
CO 4	2											
CO 5	2											

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	35	35	70
Apply	5	5	10
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Explain the quantum mechanical effects associated with low dimensional semiconductors.

1. Derive the expression for density of states in a 1D nanomaterial.

2. Compare and contrast triangular, square and parabolic quantum wells.

3. Solve numerical problems to find whether the given material is a nanometric one.

Course Outcome 2 (CO2) : Explain the different processes involved in the fabrication of nanoparticles and nanolayers.

1. Explain Sol-Gel process for synthesis of nanoparticles.
2. Explain the different steps involved in CVD process for fabricating nanolayers.
3. DC sputtering cannot be used for the coating of non- conducting materials. Justify.

Course Outcome 3 (CO3): Explain the different techniques for characterizing nano layers and particles.

1. Illustrate the working principle of an AFM.
2. Explain the different emission and interactions between electron beam and the specimen.
3. Explain the principle of operation of an XRD.

Course Outcome 4 (CO4): Explain the different transport mechanisms in nano structures.

1. Explain Kronig Penney model of a super lattice.

2. Explain modulation doping with an example.

3. Explain the different scattering events encountered by a carrier during parallel transport under the influence of electric field.

Course Outcome 5 (CO5): Illustrate the operating principle of nanoscale electronic devices like SET, Resonant tunnelling devices, Quantum lasers etc.

1. Explain Coulomb blockade effect. Illustrate the working of a single electron transistor.

2. Draw the schematic representation of the conduction band of a resonant tunnel diode for (a) no voltage applied (b) increasing applied voltages. Explain its I-V characteristics.

3. MODFETS are high electron mobility transistors. Justify.

Syllabus

Module I

Introduction to nanotechnology, Limitations of conventional microelectronics, characteristic lengths in mesoscopic systems, Quantum mechanical coherence.

Low dimensional structures - Quantum wells, wires and dots, Density of states of 1D and 2D nanostructures.

Basic properties of square quantum wells of finite depth, parabolic and triangular quantum wells

Module II

Introduction to methods of fabrication of nano-layers: physical vapour deposition- evaporation & Sputtering, Chemical vapour deposition, Molecular Beam Epitaxy, Ion Implantation, Formation of Silicon Dioxide- dry and wet oxidation methods.

Fabrication of nano particle- grinding with iron balls, laser ablation, reduction methods, sol gel, self assembly, precipitation of quantum dots.

Module III

Introduction to characterization of nanostructures: Principle of operation of Scanning Tunnelling Microscope, Atomic Force Microscope, Scanning Electron microscope - specimen interaction, X-Ray Diffraction analysis

Module IV

Quantum wells, multiple quantum wells, Modulation doped quantum wells, concept of super lattices Kronig - Penney model of super lattice.

Transport of charge in Nanostructures - Electron scattering mechanisms, Hot electrons, Resonant tunnelling transport, Coulomb blockade, Effect of magnetic field on a crystal. Aharonov-Bohm effect, the Shubnikov-de Hass effect.

Module V

Nanoelectonic devices - MODFETS, Single Electron Transistor, CNT transistors – Properties of graphene
Resonant tunnel effect, RTD, RTT, Hot electron transistors
Quantum well laser, quantum dot LED, quantum dot laser

Text Books

1. J.M. Martinez-Duart, R.J. Martin Palma, F. Agulle Rueda Nanotechnology for Microelectronics and optoelectronics , Elsevier, 2006
2. W.R. Fahrner, Nanotechnology and Nanoelctronics, Springer, 2005

Reference Books

1. Chattopadhyay, Banerjee, Introduction to Nanoscience & Technology, PHI 2012
2. Poole, Introduction to Nanotechnology, John Wiley 2006.
3. George W. Hanson, Fundamentals of Nanoelectronics, Pearson Education, 2009.
4. K. Goser, P. Glosekotter, J. Dienstuhl, Nanoelectronics and nanosystems, Springer 2004.
5. Supriyo Dutta, Quantum Transport- Atom to transistor, Cambridge, 2013.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	Introduction to nanotechnology, Limitations of conventional microelectronics	1
1.2	Characteristic lengths in mesoscopic systems	1
1.3	Quantum mechanical coherence, Schrodinger's equation, Low dimensional structures - Quantum wells, wires and dots	3
1.4	Density of states of 1D and 2D nanostructures	2
1.5	Basic properties of square quantum wells of finite depth, parabolic and triangular quantum wells	3
2	**MODULE 2**	
2.1	Introduction to methods of fabrication of nano-layers: physical vapour deposition- evaporation & Sputtering,	2
2.2	Chemical vapour deposition, Molecular Beam Epitaxy	2
2.3	Ion Implantation, Formation of Silicon Dioxide- dry and wet oxidation methods	2
2.4	Fabrication of nano particle- grinding with iron balls, laser ablation, reduction methods	2
2.5	Sol - Gel, self assembly, precipitation of quantum dots.	2
3	**MODULE 3**	
3.1	Introduction to characterization of nanostructures: Principle of operation	2

	of Scanning Tunnelling Microscope	
3.2	Atomic Force Microscope	1
3.3	Scanning Electron microscope - specimen interaction.	1
3.4	X-Ray Diffraction analysis	1
4	**MODULE 4**	
4.1	Quantum wells, multiple quantum wells, Modulation doped quantum wells, concept of super lattices	2
4.2	Kronig - Penney model of super lattice.	1
4.3	Transport of charge in Nanostructures - Electron scattering mechanisms, Hot electrons	1
4.4	Resonant tunnelling transport, Coulomb blockade	2
4.5	Quantum transport in nanostructures - Coulomb blockade	1
4.6	Effect of magnetic field on a crystal. Aharonov-Bohm effect	2
4.7	Shubnikov-de Hass effect	1
5	**MODULE 5**	
5.1	Nano electonic devices- MODFETS	2
5.2	Single Electron Transistor	1
5.3	CNT transistors , Properties of graphene	2
5.4	RTD, RTT, Hot electron transistors	3
5.5	Quantum well laser, quantum dot LED, quantum dot laser	2

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

MODEL QUESTION PAPER

ECT 292 NANOELECTRONICS

Time: 3 hours **Max. Marks:100**

PART A

Answer ***all*** questions. Each question carries ***3 marks***.

1. Explain any three characteristic lengths in mesoscopic systems.
2. Explain the terms (i) coherence length (ii) phase coherence.
3. Explain Laser ablation method for nanoparticle fabrication.
4. DC sputtering cannot be used for coating of non-conducting materials. Justify
5. Explain two different modes of operation of a STM.
6. Explain XRD method for characterizing nano materials.
7. Differentiate between the two types of multiple quantum wells.
8. Explain Aharonov-Bohm effect.
9. Explain why MODFETs are called high electron mobility transistors.
10. List any six properties of graphene.

PART B

Answer ***any one*** question from each module. Each question carries 14 marks.

MODULE I

11. (a) Show that DOS in a 2D material is independent of energy. (8 marks)

(b) Explain any three physical limitations in reducing the size of devices in Nano metric scale. (6 marks)

12. Compare and contrast square, parabolic and triangular quantum wells (14 marks)

MODULE III

13. (a) Illustrate the process of Molecular Beam Epitaxi for fabricating nano layers. (8 marks)

(b) Differentiate between dry oxidation and wet oxidation techniques (6 marks)

14. (a) Sketch and label a CVD reactor and explain the different steps involved in the CVD process. (8 marks)

(b) Explain the reduction method for nano particle fabrication (6 marks)

MODULE III

15. Explain the different specimen interactions of an electron beam and illustrate the working of a SEM (14 marks)

16. Explain the principle of operation of an AFM. Explain the different modes of operation. (14 marks)

MODULE IV

17. (a) Explain Kronig–Penney model of a super lattice. What is meant by Zone folding? (10 marks)

(b)Explain the concept of hot electrons in parallel transport (4 marks)

18. (a) Explain Coulomb Blockade effect (8 marks)

(b) Illustrate resonant tunneling effect. (6 marks)

MODULE V

19. (a)) Draw the schematic and explain the working of a single electron transistor (8 marks)

(b) Explain working of resonant tunneling diodes (6 marks)

20. (a) Illustrate the working of a quantum well laser (6 marks)

(b) Explain the different types of Carbon Nanotube transistors (8 marks)

ECT294	STOCHASTIC PROCESSES FOR COMMUNICATION	CATEGORY	L	T	P	CREDIT
		Honors	3	1	0	4

Preamble: This course aims to apply the concepts of probability and random processes in communication systems.

Prerequisite: None

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

CO 1	Explain the concepts of probability, random variables and stochastic processes
CO 2	Apply the knowledge in probability to ststistically characterize communication channels.
CO 3	Apply probability to find the information and entropy
CO 4	Explain source coding and channel coding theorem.
CO 5	Apply stochastic processes in data transmission

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3	3										
CO 2	3	3		3	2							
CO 3	3	3		3	2							2
CO 4	3	3										
CO 5	3	3		3	2							

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	25	25	50
Apply	15	15	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Concepts in probability

1. Give frequentist and axiomatic definitions of probability. State the demerits of frequentist definition.
2. What is a random variable? Illustrate with an example how it becomes useful in studying engineering problems?
3. A six faced die with P(1)=P(3)=1/3, P(4)=P(5)=1/4 is thrown in a game with outcomes listed in the table.

Face	1	2	3	4	5	6
Payoff(Rs)	+50	-40	+60	-60	-20	+100

The + and - signs indicates gain and loss for the the player respectively.

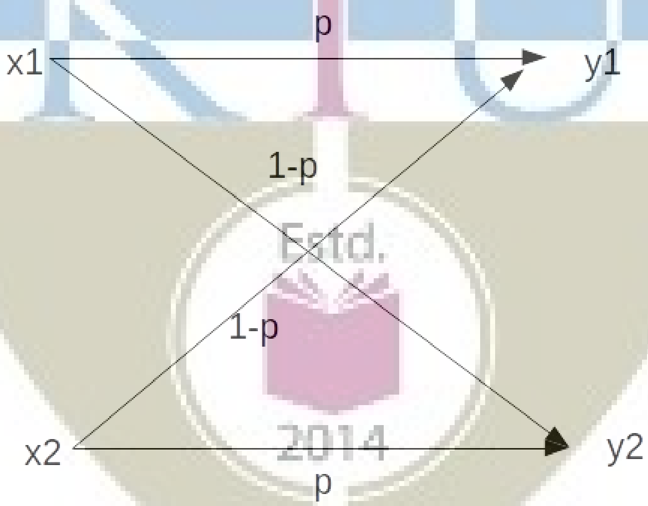
1.Draw the CDF and PDF
2. Compute the expected value of gain/loss. Is it worthwhile to play the game?
3. Compute the entropy of the random variable.

Course Outcome 2 (CO2) : Review of random processes

1. Give the conditions for WSS and SSS.
2. Test if the sinusoid X(t)=Acos(2πft+θ) with θ variying uniformly in the interval [-π,π] is WSS.
3. Define white Gussian noise.
4. State central limit theorem. Why is Guassian model suitable in additive noise channels?

Course Outcome 3 (CO3): Entropy and Information

1. Define discrete memoryless source and discrete menoryless channel.
2. Define entropy and conditional entropy.
3. See the binary symmetric channel in the figure below.



Let p(x1)=1/3 and p =1/4. Compute the mutual information betweeen X and Y.

Course Outcome 4 (CO4): Source coding and Channel Coding

1. State the souce coding theorem.
2. Compute the mutual information between the input and output of an AWGN channel. What is its capacity.
3. Find the capacity of an AWGN channel with 4kHz bandwidth and the noise power spectral density 10^{-12}W/Hz. The signal power at the receiver is 0.1mW.

Course Outcome 5 (CO5): Stochastic processes in data transmission

1. Derive Chapman – Kolmogorov equation.

2. Explain the packet transmission in a slotted ALOHA network
3. Consider a Markov chain with three possible states 1,2,3 with transition probability matrix

$$\begin{pmatrix} \frac{1}{4} & \frac{1}{2} & \frac{1}{4} \\ \frac{1}{3} & 0 & \frac{2}{3} \\ \frac{1}{2} & 0 & \frac{1}{2} \end{pmatrix}$$

a) Draw the state transition diagram.
b) Find $P(X_4=3|X_3=2)$
c) If $P(X_0=1)=1/3$ Find $P(X_0=1,X_1=2)$

SYLLABUS

Module 1 : Review of Probability and Random Variables [1,2]

Review of probability. Relative frequency and Axiomatic definitions of probability, Significance of axiomatic definition. Bayes theorem and conditional probability. Independence. Discrete random variables. The cumulative distribution and density functions for discrete random variables. Joint distribution and conditional distribution. Statistical averages. Mean, Variance and standard deviation, Gaussian density function, Pdf of envelop of two gaussian variables – Rayleigh pdf.

Module 2 : Review of Random Processes [1-3]

Stochastic Processes. Stationarity and ergodicity. WSS and SSS processes. Gaussian Random process, Mean and autocorrelation and power spectral density functions. Weiner Kinchine theorem, Bandwidth of a random process, PSD of a Pulse Amplitude Modulated wave. White noise, Filtering of discrete WSS process by LTI systems. Noise-equivalent bandwidth, Signal to Noise Ratio, Matched Filter, Bandlimited and narrowband random process.

Sum of random variables, Markov Inequality, Chebyshev Inequality, Convergence, The central limit theorem (statement only). Gaussianity of thermal noise.

Module 3: Entropy and Information [1-3]

Basics of discrete communication system, Sources, channels and receivers. Discrete memoryless sources. Entropy. Source coding theorem (statement only). Mutual Information. Discrete memoryless channels. Matrix of channel transmission probabilities. Noiseless and noisy channels, binary symmetry channels. Channel coding theorem (statement only) Channel capacity for BSC (derivation reqruired), Differential entropy, Channel capacity of AWGN channel (statement only).

Module 4 : Markov Process and Queuing Theory [4,5]

Markov process. Definition and model. Markov chain. Transition probability matrix. State diagram and characteristics of a Markov chain. Chapman Kolmogorov equation. Poisson process.

Module 5 : Queues in Communication Networks [4,5]

Overview of queuing theory. M/M/1, M/M/∞, Application to packet transmission in a slotted ALOHA computer communication network.

Text Books

1. Papaulis and Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes", MH
2. Analog and Digital Communication Systems, Hsu, Schaum Outline Series, MGH.
3. Digital Communication, John G Proakis, John Wiley
4. Probability and Random Processes, Miiller and Childers, Ed., 2, Academic Press
5. Data Networks, Bertsekas and Gallager, Ed. 2, PHI

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Review of probability. Relative frequency and Axiomatic definitions of probability, Significance of axiomatic definition.	1
1.2	Bayes theorem and conditional probability. Independence.	1
1.3	Discrete random variables.	1
1.4	The cumulative distribution and density functions for discrete random variables. Joint distribution and conditional distribution.	3
1.5	Statistical averages. Mean, Variance and standard deviation,	2
1.6	Gaussian density function, Pdf of envelop of two gaussian variables – Rayleigh pdf.	2
2	**MODULE 2**	
2.1	Stochastic Processes. Stationarity and ergodicity. WSS and SSS processes. Gaussian Random process	2
2.2	Mean and autocorrelation and power spectral density functions. Weiner Kinchine theorem, Bandwidth of a random process, PSD of a Pulse Amplitude Modulated wave.	3
2.3	White noise, Filtering of discrete WSS process by LTI systems. Noise-equivalent bandwidth, Signal to Noise Ratio, Matched Filter, Bandlimited and narrowband random process.	3
2.4	Sum of random variables, Markov Inequality, Chebyshev Inequality, Convergence, The central limit theorem (statement only). Gaussianity of thermal noise.	2
3	**MODULE 3**	
3.1	Basics of discrete communication system, Sources, channels and receivers.	1
3.2	Discrete memoryless sources. Entropy. Source coding theorem (statement only).	1

3.3	Mutual Information. Discrete memoryless channels. Matrix of channel transmission probabilities. Noiseless and noisy channels, binary symmetry channels.	2
3.4	Channel coding theorem (statement only) Channel capacity for BSC (derivation reqruired),	1
3.5	Differential entropy, Channel capacity of AWGN channel (statement only).	2
4	**MODULE 4**	
4.1	Markov process. Definition and model.	1
4.2	Markov chain. Transition probability matrix. State diagram and characteristics of a Markov chain. Chapman Kolmogorov equation.	4
4.3	Poisson process	3
5	**MODULE 5**	
5.1	Overview of queuing theory.	2
5.2	M/M/1, M/M/∞ systems	3
5.3	Application to packet transmission in a slotted ALOHA computer communication network.	3

Simulation Assignments

The following simulations can be done Python/R/MATLAB/SCILAB.

Generation of Discrete Stochastic Signals

1. Simulate stochastic signals of
   - Uniform
   - Binomial
   - Gaussian
   - Rayleigh
   - Ricean

   probability density functions and test their histograms.

2. Compute the statistical averages such as mean, variance, standard deviation etc.

3. To compute the autocorrelation matrix for each signals. Compare the autocorrelation of Gaussian signal with others.

4. To observe the spectrum of the signal and relate it with the autocorrelation function.

Central Limit Theorem–Gaussianity of Channels

- Simulate a coin toss experiment that generates a string of length N of 0s and 1s that are uniformly distributed.
- Toss the coin M times and sum up the string in every toss.
- Plot the normalized histogram of the sum values for $M = 100, 1000, 5000$.Observe that it is a Binomial distribution.
- Plot the function $q = \binom{M}{r} p^r (1-p)^{M-r}$ and compare with the histogram.
- Make M very large and observe that the histogram tends to become Gaussian, justifying the central limit theorem.

Frequency of Characters in English Text and the Entropy

1. It is required to understand the probabilities of occurrence of characters in English text say an English novel say with more than 300 pages(that contains text only) in .txt format(student may download one such file.).

2. Read the novel in *.txt* format into a single string or array and to identify the unique symbols(all letters, numbers, punctuation marks etc.) in the file and to plot their frequencies of occurrence.

3. Aprreciate the probabilities of occurrences of all symbols.

4. Compute the entropy and the information content in the book.

Simulation of a Point Process

1. It is required to simulate a point Poisson process, say the arrival of packets in a queue.
2. Let the rate of arrival of packets be say 100 per second.
3. Simulate the Poisson process using small time bins of say 1 millisecond.
4. Since Poisson process has no memory, the occurrence of an event is independent from one bin to another.
5. Binary random signals can be used to represent success or failure.
6. Simulate and dispaly each event with a vertical line using say *matplotlib*
7. Generate the couting process $N(t)$ which is the sum of the events until time t.
8. Plot $N(t)$ against t and appreciate it.

Simulation of a Discrete Markov Chain

1. It is required to simulate a birth death process as a discrete Markov chain.
2. Let us consider that the total population cannot exceed 1000 and the initial poulation is 100.
3. Set equal birth and death rates.
4. Iterate for say 10000 steps and plot the population against the iteration number.
5. Repeat the simulation for different rates and different population aand iteration sizes and appreciate the results.

Model Question Paper

A P J Abdul Kalam Technological University

Fourth Semester B Tech Degree Examination

Branch: Electronics and Communication

Course: ECT 294 Stochastic Processes for Communication

Time: 3 Hrs **Max. Marks: 100**

PART A

Answer All Questions

1	Give the three definitions of probability	(3)	K_2
2	In the toss of an unnfair coin, the probability of head is $\frac{1}{3}$.The player gets Rs. 100 if head turns up and loses Rs. 200 if tail turns up. Draw the CDF and PDF of this random variable	(3)	K_3
3	Write the conditions for strict sense and wide sense stationarity	(3)	K_2
4	Explain the Gaussian statistics of communication channels	(3)	K_2
5	State the two source coding theorems	(3)	K_1
6	Give channel matrix of a noiseless binary channel	(3)	K_2
7	With mathematical model, explain Markov process	(3)	K_2
8	Give an example of a Markov chain with its transition probabib-lity matrix	(3)	K_2
9	Explain an M/M/1 queue system in packet transmission	(3)	K_2
10	Explain the statistics of packet arrival in M/M/1 queue system	(3)	K_2

PART B

Answer one question from each module. Each question carries 14 mark.

Module I

11 A random variable $\mathbf{X}$ has the following pdf.

$$f_{\mathbf{X}}(\lambda) = \begin{cases} A[1 - \frac{|\lambda|}{3}]; & -3 \le \lambda \le 3 \\ 0; & \text{else} \end{cases}$$

Find the probability $P[|\lambda| < 1.5]$ (4) K_3
Find the probability $P[1.2 \le \lambda \le 2.3]$ (4) K_3
Find $E[\mathbf{X}]$ (6) K_3

OR

12. A six faced die with $P(1) = P(3) = \frac{1}{6}$, $P(4) = P(5) = \frac{1}{8}$, $P(2) = \frac{1}{12}$ is thrown in a game with outcomes listed in the table.

Face	1	2	3	4	5	6
Payoff	50	-40	60	-60	-20	100

The + and - signs indicates gain and loss for the player respectively.

A Draw the CDF and PDF of the Payoff random variable. (6) K_3
B Compute the expected value of gain/loss. Is it worthwhile to play the game? (5) K_3
C Compute the variance of Payoff. (3) K_3

Module II

13(A) Test if the random process (8) K_3

$$X(t) = A\cos(2\pi f_c t + \theta)$$

is WSS with θ a uniformly distributed random variable in the interval $[-\pi, \pi]$.

13(B)	If a random signal is applied as input to an LTI system, how is the power spectral density of the output related to that of the input? Explain.	(6)	K_2

OR

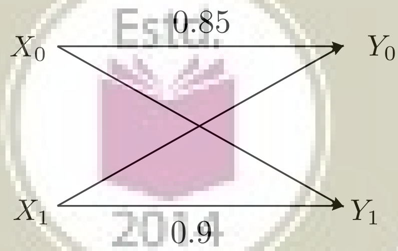
14(A)	State and prove Wiener Kinchine theorem .	(8)	K_3
14(B)	Justify the suitability of using white Gaussian model for noise in a communication system.	(6)	K_2

Module III

15(A)	State source coding theorem for a discrete memoryless source.	(6)	K_2
15(A)	Show that mutual information is always positive.	(3)	K_2
15(C)	What is channel capacity in terms of the conditional entropy? Write down the capacity of an AWGN channel.	(5)	K_3

OR

16(A)	Define entropy of a discrete memoryless source. If the alphabet is finite with size K, show that $H(X) \leq \log_2 K$	(6)	K_2
16(B)	For the binary channel below, compute the channel transition matrix and $P(Y_0)$ and $P(Y_1)$, given that $P(X_0) = P(X_1) = 0.5$	(8)	K_3



Module IV

17(A)	Explain a Poisson random process. Give two practical examples of a Poisson process	(7)	K_2
17(B)	Derive Chapman – Kolmogorov equation.	(7)	K_3

OR

18	Consider a Markov chain with three possible states 1,2,3 with transition probability matrix		
	(A) Draw the state transition diagram.	(4)	K_2
	(B) Find $P(X4 = 3 \| X3 = 2)$	(5)	K_3
	(C) If $P(X0 = 1) = \frac{1}{3}$, find $P(X0 = 1, X1 = 2)$	(5)	K_3

Module V

19	Explain the packet transmission in a slotted ALOHA network	(14)	K_2

OR

20	Explain the M/M/1 queue system pertaining to packet transmission	(14)	K_2

ECT296	STOCHASTIC SIGNAL PROCESSESING	CATEGORY	L	T	P	CREDIT
		Honours	3	1	0	4

Preamble: This course aims to study stochastic signals and their interactions with LTI systems

Prerequisite: None

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

CO 1	Explain the concepts of probability, random variables and stochastic processes
CO 2	Apply the knowledge in probability to ststistically characterize communication channels.
CO 3	Use the properties of WSS for finding the LTI system response
CO 4	Model discrete signals using various methods
CO 5	Estimate the spectra of signals using various methods.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										
CO 2	3	3		3	2							
CO 3	3	3		3	2							
CO 4	3	3										
CO 5	3	3		3	2							

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	15	15	30
Apply	25	25	50
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Concepts in probability

1. Give frequentist and axiomatic definitions of probability. State the demerits of frequentist definition.
2. What is a random variable? With an example, illustrate how it finds application in defining engineering problems?
3. A six faced die with P(1)=P(3)=1/3, P(4)=P(5)=1/4 is thrown in a game with outcomes listed in the table.

Face	1	2	3	4	5	6
Payoff(Rs)	+50	-40	+60	-60	-20	+100

The + and - signs indicates gain and loss for the the player respectively.

1.Draw the CDF and PDF
2. Compute the expected value of gain/loss. Is it worthwhile to play the game?
3. Compute the entropy of the random variable.

Course Outcome 2 (CO2) : Review of random processes

1. State central limit theorem. Explain the validity of using Gaussian model for additive communication channels.
2. Give the conditions for WSS and SSS.
3. Test if the sinusoid X(t)=Acos(2πft+θ) with θ variying uniformly in the interval [-π,π] is WSS.

Course Outcome 3 (CO3): WSS and LTI systems

1. Derive Wiener Hopf equations.
2. Solve Wiener-Hopf equation to get a third order discrete system for a an RV X whose autocorrelation is Rx=[0.89,0.75,0.7,0.6]
3. Prove that autocorretion and power spectral density are Fourier transform pairs

Course Outcome 4 (CO4): Signal modeling

1. Use Prony method to model a unit pulse x[n]=U[n]-U[n-N] as a system with one pole and one zero.
2. Use Pade apprimation to model the signal x whose fisrt six values are [1,1.2,0.9,0.5,0.6,0.25] using a second order all pole model (p=2 and q=0)

Course Outcome 5 (CO5): Stochastic processes in data transmission

1. Explain the periodogram method of spectrum estimation
2. Explain the need pf spectrum estimation
3. Use ARMA(p,q) model to estimate the spectrum

Syllabus

Module 1 : Review of Probability and Random Variables [1]

Review of probability. Relative frequency and Axiomatic definitions of probability, Significance of axiomatic definition. Bayes theorem and conditional probability. Independence. Discrete random variables. The cumulative distribution and density functions for random variables. Joint distribution and conditional distribution. Statistical averages. Mean, Variance and standard deviation, Functions of random variables. Multivariate Gaussian density function.

Module 2 : Review of Random Processes [1]

Stochastic Processes. Stationarity and ergodicity. WSS and SSS processes. Discrete Gaussian, Rayleigh and Ricean processes.

Sums of random variables, Convergence, Markov and Chebyshev inequality, The central limit theorem (statement only).

Module 3: The Autocorrelation Matrix and its Significance [2]

Statistical averages of discrete stationary stochastic processes. Mean and autocorrelation and power spectral density functions. Weiner Kinchine theorem, Filtering of discrete WSS process by LTI systems. The autocorrelation matrix and the significance of its eigen vectors. Whitening. Properties of autocorrelation matrix, its inversion and Levinson-Durbin Recursion. Wiener-Hopf equation. Brownian motion, its mathematical model and its autocorrelation and power spectral density

Module 4 : Signal Modeling - Deterministic and Stochastic [1]

The least square method of signal modeling. The Pade approximation. Prony's method. Stochastic models, AR, MA and ARMA models.

Module 5 : Spectrum Estimation [1,2]

Periodogram method of spectrum estimation. Parametric methods AR, MA and ARMA methods

Text Books

1. Monson Hayes, “Statistical Digital Signal Processing”, Wiley
2. A. Papaulis and Unnikrishna Pillai, “Probability, Random Variables and Stochastic Processes”, McGraw Hill

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Probability and Random Processes**	
1.1	The three definitions. Critique to classical definition. Probability as a function. The domain of probability function. Event and probability space	2
1.2	Conditional probability, Bayes theorem, Meaning and significance of prior. Random variable. Definition. Random variable as a function and its domain. Comparison with probability function.	2
1.3	Examples of RV. Discrete and continuous RV. CDF and PDF of RV(both discrete and continuous) Examples. Relation between the two and properties	1
1.4	Uniform and Gaussian Pdf and correspoding CDF. Properties	1
	Expectation, variance and standard deviation, Examples	2
1.5	Functions of random variables.	2
2	**Stochastic Processes**	
2.1	Stochastic process, Definition. Stationarity and ergodicity	2
2.2	WSS and SSS conditions. Example problems	2
2.3	Sums of random variables, Convergence, Markov and Chebyshev inequality	2
2.4	Gaussian Process. Envelope of Gaussian process. Rayleigh pdf. Example	2

2.5	Central limit theorem. Application in AWGN channel	1
3	**Autocorrelation Matrix**	
3.1	Expectation, variance, autocorrelation and power spectral density	2
3.2	Autocorrelation matrix, properties eigen values	2
3.3	Filtering of WSS, output auotocorrelation and PSD	2
3.4	Inversion of autocorrelation matrix. LD recursion	2
3.5	Whitening	1
3.6	Wiener Hopf equation, Brownian motion. Model and spectral density	3
4	**Signal Modeling**	
4.1	Least squares method	2
4.2	Pade method, Prony method	3
4.3	Stochastic models	3
5	**Spectrum Estimation**	
5.1	Periodogram	3
5.2	Parametric methods	4

Simulation Assignments

The following simulations can be done Python/R/MATLAB/SCILAB.

Generation of Discrete Stochastic Signals

1. Simulate stochastic signals of
   - Uniform
   - Binomial
   - Gaussian
   - Rayleigh
   - Ricean

   probability density functions and test their histograms.
2. Compute the statistical averages such as mean, variance, standard deviation etc.
3. To compute the autocorrelation matrix for each signals. Compare the autocorrelation of Gaussian signal with others.
4. To observe the spectrum of the signal and relate it with the autocorrelation function.

Gambler's Trouble

- It is observed by gamblers that although the number of triples of integers from 1 to 6 with sum 9 is the same as the number of such triples with sum 10, when three dice are rolled, a 9 seemed to come up less often than a 10.
- Simulate a die throwing experiment. One may use the *randint* command in Python.
- Roll three dice together N times.
- Compute the number of times the sum of outcomes is 9 and the corresponding probability.
- Repeat the experiment for the sum of outcomes equal to 10 and observe if the hypothesis is true.
- Compute the two probabilities for $N = 100; 1000; 10000; 50000; 100000$ and plot the two probabilities against N and appreciate.

Central Limit Theorem

- Simulate a coin toss experiment that generates a string of length N of 0s and 1s that are uniformly distributed.
- Toss the coin M times and sum up the string in every toss.
- Plot the normalized histogram of the sum values for $M = 100, 1000, 5000$.Observe that it is a Binomial distribution.
- Plot the function $q = \binom{M}{r} p^r (1-p)^{M-r}$ and compare with the histogram.
- Make M very large and observe that the histogram tends to become Gaussian, justifying the central limit theorem.

Labouchere system

- Labouchere system is a betting game in which a sequence of numbers is written and the player bets for an amount equal to the first and last number written.
- The game may be tossing a coin.
- If the player wins, the two numbers are removed from the list and the player is free to continue. If the list has only one number that becomes the stake amount.
- If he fails the amount at stake is appended to the list and the game continues until the list is completely crossed out, at which point the player has got the desired money or until he runs out of money
- Simulate this game and observe the outcomes for different sequences on the list

Levinson Durbin Recursion

1. It is required to invert large autocorrelation matrices with LD recursion.
2. Realize Gaussian and uniformly distributed random signals and compute their autocorrelation matrices.
3. Load a speech signal in say *.wav* format and compute its autocorrelation matrix.
4. Create a function to perform LD recursion on the above three matrices.

Simulation of Brownian Motion

1. The task is to realize the differential/difference equation for Brownian motion in two dimensions with and without gravity.
2. Observe the particle movement on the GUI and understand.
3. Compute the autocorrelation and power spectral density and appreciate.

Spectrum Estimation

1. Generate a cosinusoid of say 100 Hz frequency and bury it in AWGN of comparable variance.
2. Write functions for periodogram and ARMA method to estimate the spectrum of the cosinusoid.
3. The student may install the Python package *spectrum* and repeat the estimations steps using its modules and compare the plot of spectra with those resulted by your functions.

Model Question Paper

A P J Abdul Kalam Technological University

Fourth Semester B Tech Degree Examination

Branch: Electronics and Communication

Course: ECT 296 Stochastic Signal Processing

Time: 3 Hrs **Max. Marks: 100**

PART A

Answer All Questions

1	Give the three axioms of probability	(3)	K_2
2	You throw a coin and if head turns up you get Rs. 100 and loses Rs. 40 if tails turns up. The probability of a head is is 0.2. Draw the CDF and PDF of the random variable representing gain/loss.	(3)	K_3
3	State central limit theorem. Give its significance.	(3)	K_2
4	Draw the pdf of Rayleigh density function.	(3)	K_2
5	Write and explain the differential equation for Brownian motion	(3)	K_2
6	Give the output mean and autocorrelation of a an LTI system that is driven by a WSS process.	(3)	K_2
7	Explain the term signal modeling	(3)	K_2
8	Explain ARMA model of a signal	(3)	K_2
9	Explain the need for power spectrum estimation	(3)	K_2
10	List the various parametric spectrum estimation methods.	(3)	K_2

PART B

Answer one question from each module. Each question carries 14 mark.

Module I

11(A)	Derive mean and variance of a Gaussian distribution with parameters μ and σ^2	(8)	K_3
11(B)	Write down the probability density of a bivariate Gaussian random variable. What is the signifance of the correlation coefficient?	(6)	K_3

OR

12. A six faced die with $P(1) = P(5) = \frac{1}{6}$, $P(4) = P(3) = \frac{1}{8}$, $P(2) = \frac{1}{12}$ is thrown in a game with outcomes listed in the table.

Face	1	2	3	4	5	6
Payoff	50	-40	60	-60	-20	100

The + and - signs indicates gain and loss for the the player respectively.

A	Draw the CDF and PDF of Payoff random variable.	(6)	K_3
B	Compute the expected value of gain/loss. Is it worthwhile to play the game?	(6)	K_3
C	What is the variance of Payoff?	(3)	K_3

Module II

13(A) Test if the random process (7) K_3

$$X(t) = A\cos(2\pi f_c t + \theta)$$

is WSS with A a random variable in the interval $[-\pi, \pi]$.

13(B) If $\mathbf{X}$ and $\mathbf{Y}$ are zero mean Gaussian RVs, compute the pdf of $\mathbf{Z} = \sqrt{\mathbf{X^2} + \mathbf{Y^2}}$ (7) K_2

OR

14(A)	Express a Binomial random variable X as a sum of many Bernoulli random variables. Derive the mean of X using this connection.	(4)	K_3
14(B)	Derive Chebyshev inequality. How is it helpful in estimating tail probabilities?	(6)	K_3
14(B)	List the conditions for a stochastic process to be WSS.	(4)	K_3

Module III

15(A)	State and prove three properties of autocorrelation matrix.	(8)	K_3
15(B)	Prove that the power spectrum of a real process $\mathbf{X(t)}$ is real.	(6)	K_3

OR

16	Give the mathematical model and compute the autocorrelation of the Brownian motion	(14)	K_3

Module IV

17	Use Pade approximation to model the signal x whose fisrt six values are $[1, 1.6, 0.7, 0.4, 0.6, 0.25]$ using a second order all pole model ($p = 2$ and $q = 0$) and a second order MA model ($p = 0$ and $q = 2$)	(14)	K_3

OR

18	Use Prony method to model a unit pulse $x[n] = U[n] - U[n - N]$ as a system with one pole and one zero.	(14)	K_3

Module V

19	Explain the periodogram method of spectrum estimation	(14)	K_2

OR

20 Explain the three nonparametric methods of spectrum estimation (14) K_2