Syllabus S5 & S6 (Biomedical Engineering)

Semester 5

Core Courses

Minor Courses

Honours Courses

Semester 6

Core Courses

Program Elective I

Minor Courses

Honours Courses

SEMESTER V

BMT301	ANALYTICAL & DIAGNOSTIC EQUIPMENTS	CATEGORY	L	T	P	CREDIT
		PCC	4	0	0	4

Preamble: This course describes the basic principles and the instrumentation of different analytical and diagnostic equipment used in clinical environments.

Prerequisite: The students undergoing the courses are expected to have a thorough knowledge on basics of Electronic Instrumentation and concept of Sensors and Transducers used in healthcare sector.

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

CO 1	Familiarize the instrumentation of various analytical equipment used in clinical laboratory.
CO 2	Recognize the principle and applications of biochemistry equipment used in clinical environment.
CO 3	Analyze the instrumentation of bioelectric devices.
CO 4	Analyze the impedance measurement concepts and related measurements.
CO 5	Interpret the principles related to respiratory, blood flow and audiometric measurements.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	2	2							2		2
CO 2	3	2	2							2		2
CO 3	3	2	2							2		2
CO 4	3	2	2							2		2
CO5	3	2	2							2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	10	10	20
Apply	15	15	30
Analyze	15	15	30

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):

1. With respect to visible Spectrophotometers, describe single beam photometers
2. Explain the concept of solid-state ISE electrolyte analyser
3. With the help of a block diagram explain IR spectrophotometer.

Course Outcome 2 (CO2):

1. What is the principle of electrophoresis?
2. Explain high pressure liquid chromatography
3. Describe the concept of ELISA test. What are its applications

Course Outcome 3(CO3):

1. Explain the instrumentation of a single channel ECG machine
2. What is polysomnography. What are the different types of sleep disorders?
3. Explain the instrumentation of an ambulatory recorder.

Course Outcome 4 (CO4):

1. Explainbipolar and tetra polar circuits.
2. What are the different types of cardiac output measurement?
3. What are apnoea monitors

Course Outcome 5 (CO5):

1. What are impedance audiometers
2. With the help of a schematic diagram explain the principle of Coulter counter
3. What are the different types of sensors used in wearable health monitors?

Model Question paper

		SET 1	**Total Pages:**
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIFTH SEMESTER B. TECH DEGREE EXAMINATION, --- 20--			
Course Code: BMT301			
Course Name: ANALYTICAL & DIAGNOSTIC EQUIPMENTS			
Max. Marks: 100			Duration: 3 Hours
PART A			

		Answer all questions (3 marks)	Marks
1		State Beer Lambert's Law.	
2		What is the basic principle of measurement of UV spectrometer?	
3		Compare paper electrophoresis and gel electrophoresis	
4		List the applications of radioimmunoassay.	
5		What are arrhythmias?	
6		What are the basic parameters monitored in central station patient monitoring systems	
7		Compare invasive and non-invasive methods of BP measurement.	

8		What the difference between functional and fractional oxygen saturation.	
9		What are spirometers?	
10		State the principle of Electromagnetic Flow meters	
PART B			
Answer any one full question (14 marks)			
11	a)	The linearity of the Beer-Lambert's law is limited by chemical and instrumental factor, what can be the causes for non-linearity.	(7)
	b)	Explain the instrumentation of IR spectrophotometer	(7)
OR			
12	a)	What are applications of electrolyte analyzers?	(9)
	b)	Explain the working of automated clinical analyzers	(5)
13	a)	With a block diagram explain a high-pressure liquid chromatography in detail.	(7)
	b)	State the principle of RIA. What are the tracers used in this RIA process	(7)
OR			
14	a)	Explain the working of a flow cytometer with the help of a schematic diagram.	(7)
	b)	State the principle of electrophoresis. Prove that the electrophoretic mobility is proportional to charge on the molecules and inversely proportional to the radius of the molecules.	(7)
15	a)	How cardiac stress testing is done. Give an account of ST analysis	(7)
	b)	What is phonocardiograph? Discuss the microphones used in phonocardiograph.	(7)
OR			
16	a)	Discuss the essential components in an ECG machine with necessary diagrams.	(7)
	b)	With the help of a block diagram explain how EEG signals can be used for BCI applications.	(7)

17	a)	Explain the doppler method used for cardiac output measurement.	(7)
	b)	Describe the pulse oximetry measurement in detail	(7)
OR			
18	a)	Interpret the detection of respiratory activity using impedance technique	(7)
	b)	Illustrate invasive and noninvasive blood pressure measurements	(7)
19	a)	Explain the principle of ultrasonic blood flow meters	(6)
	b)	Define the respiratory terms i) Total Lung Capacity ii) Forced Inspiration iii) vital capacity	(8)
OR			
20	a)	Explain in detail about wearable devicesand its applications	(7)
	b)	Explain the principle of working of pure tone audiometers.	(7)

Syllabus

Module 1

Introduction: Analytical equipment used in the clinical environment Beer-Lambert's Law, Colorimeters, Spectrophotometers: Instrumentation - Filters-Monochromators -Detectors -UV & Visible, IR Spectrophotometer – Instrumentation- Radiation Source -Monochromators & Detectors-Applications, Electrolyte Analysers-Measurement methods -Ion selective electrode method (ISE) -Solid state ISE -Ion-Selective Optodes, Lab On a Chip (LOC) biochemical sensor, Miniaturized Systems for (Bio)Chemical analysis and synthesis- glucometer-Point Of Care Test equipment(POCT)

Module 2

Biochemistry Equipment: Automated clinical analysers-Biochemistry analysers, Blood Culture Equipment, Antibody based analytical techniques-Radioimmunoassay (RIA) -Enzyme Linked Immuno Sorbent Assay (ELISA/CLIA)-Applications, Immunoprecipitation-Immunofluorescence- Polymerase Chain Reaction (PCR)- RT-PCR instrumentation, Electrophoresis- Principles ,Chromatography – Gas- high-pressure liquid and paper chromatography - principle and applications, Flow Cytometry-Applications ,Blood cell counters- Coulter Counters, Blood Gas Analysers

Module 3

Bioelectric Devices: Electro cardiograph- Pre-amplifiers- Filters- Isolation circuits- RL driven circuit- protection circuits-Power amplifiers -Recorders, Phonocardiograph–Instrumentation, Cardiac stress testing, Patient monitoring systems -ECG-NIBP-PPG-Temperature, Arrhythmia monitors, Ambulatory recorders-Holter monitors, Electroencephalography – Instrumentation, Evoked potential measurement systems-applications, Sleep Studies-Polysomnography, Sleep apnoea monitors

Module 4

Impedance Techniques: Bipolar and tetrapolar circuits-detection of physiological activities using impedance techniques - respiratory activity- Impedance Cardiography- Impedance Plethysmography, Pulse Oximeter Instrumentation, Cardiac output measurement- Fick method -Dilution Methods-Doppler method, Blood pressure monitors-invasive and non-invasive methods

Module 5

Audiometers – Pure tone - speech audiometers and impedance audiometry.**Respiratory measurements**: Spirometry – Basic system and applications- Pulmonary function measurements: Respiratory volumes, lung capacity -different volume measurement.**Blood flowmeters** - Electromagnetic – Ultrasonic Doppler blood flowmeters.Introduction to wearable health monitors.

Text Books

1. Basha, Mahin. Analytical Techniques in Biochemistry. Humana Press, 2020.
2. Kramme, Rüdiger, and Heike Kramme. "Technology in Medicine: Its Role and Significance in Terms of Health Policy." In Springer Handbook of Medical Technology, pp. 3-6. Springer, Berlin, Heidelberg, 2011.
3. Webb, Andrew G. Principles of biomedical instrumentation. Cambridge University Press, 2018.
4. Chan, Anthony YK. Biomedical device technology: principles and design. Charles C Thomas Publisher, 2016.
5. Khandpur R S, Handbook of Bio-Medical Instrumentation, Tata McGraw Hill, 2nd Ed., 2003
6. Skoog A Dogulas, F. James Holler, Stanley R Crouch, Principles of Instrumental Analysis, 6th Edition.2014.
7. Joseph D. Bronzino, The Biomedical Engineering Handbook, CRC Press, 1995

Reference Books

1. Geddes, Leslie Alexander, and Lee Edward Baker. Principles of applied biomedical instrumentation. John Wiley & Sons, 1975.
2. Carr, Joseph J. Elements of electronic instrumentation and measurement. Pearson College Division, 1996.
3. Webster, John G., ed. Medical instrumentation: application and design. John Wiley & Sons, 2009.
4. John, G. Webster. "Encyclopedia of Medical Devices and Instrumentation, 6 Volume Set." (2006).
5. Richard Aston, Principles of Biomedical Instrumentation and Measurements, Merril Publishing Co., 1990.
6. Myer Kutz, Standard Handbook of Biomedical Engineering and Design, McGraw Hill, 1993.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction to medical equipment, Analytical equipment used in the clinical environment Beer-Lambert's Law-Deviation, Colorimeters-Single beam & Double beam instruments.	2
1.2	Spectrophotometers: Instrumentation - Filters-Monochromators -Detectors -UV &Visible -IR Spectrophotometer – Instrumentation- Radiation Source -Monochromators & Detectors-Applications	3
1.3	Electrolyte Analyzers-Measurement methods -Ion selective electrode method (ISE) -Solid state ISE Ion-Selective Optodes,	2
1.4	LabOn a Chip (LOC) biochemical sensor, Miniaturized Systems for (Bio)Chemical analysis and synthesis- glucometer-Point of Care Test equipment (POCT)	2
2	**Module 2**	
2.1	Automated clinical analyzers-Semi & Automated, Biochemistry analyzers, Blood Culture Equipment	2
2.2	Antibody based analytical techniques-Radioimmunoassay (RIA) -Enzyme Linked Immuno Sorbent Assay (ELISA/CLIA)-Applications	2

2.3	Immunoprecipitation- Immunofluorescence- Polymerase Chain Reaction (PCR)- RT-PCR instrumentation	2
2.3	Electrophoresis -Different Techniques-Principles, Chromatography – Gas-high-pressure liquid and paper chromatography - principle and applications	2
2.4	Flow Cytometry-Block Diagram-Applications, Blood cell counters-Coulter Counters, Blood Gas Analyzers-Instrumentation	2
3	**Module 3**	
3.1	Electro cardiograph- Pre-amplifiers- Filters- Isolation circuits- RL driven circuit- protection circuits-Power Amplifiers-Recorders	2
3.2	Phonocardiograph–Instrumentation, Cardiac stress testing, Patient monitoring systems -ECG-NIBP-PPG-Temperature	2
3.3	Arrhythmia monitors-Block Diagram, Ambulatory recorders-Holter monitors.	2
3.4	Electroencephalography– Instrumentation, Evoked potential measurement systems-applications	2
3.5	Sleep studies-Polysomnography, Sleep apnea monitors	1
4	**Module 4**	
4.1	Impedance Techniques: Bipolar and tetrapolar circuits-detection of physiological activities using impedance techniques - respiratory activity-Impedance Cardiography- Impedance Plethysmography	3
4.2	Pulse Oximeter Instrumentation, Cardiac output measurement- Fick method Dilution Methods-Doppler method,	2
4.3	Blood pressure monitors-invasive and non-invasive methods	2
5	**Module 5**	
5.1	Audiometers – pure tone, speech audiometers and impedance audiometry	2
5.2	Spirometry – Basic system and applications- Pulmonary function measurements: Respiratory volumes, -different volume measurement,	2
5.3	Blood flowmeters - Electromagnetic – Ultrasonic Doppler blood flow meters	2
5.4	Introduction to wearable health monitors.	1

BMT303	BIOMEDICAL SIGNAL PROCESSING	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course will enable the students to learn about widely used signal processing techniques, emphasizing biomedical applications.

Prerequisite: Basics of Laplace Transform and Fourier Transform

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

CO 1	Demonstrate the fundamentals of discrete-time signals and systems
CO 2	Apply domain transformation techniques in discrete-time signals
CO 3	Design digital filters and apply the concepts in biomedical scenarios.
CO 4	Apply different power spectrum estimation and noise cancellation techniques for biomedical applications.

Mapping of course outcomes with program outcomes

	PO1	PO2	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	3					2		2
CO 3	3	3	3	3	3					2		3
CO 4	3	3	3	3	3					2		3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	15	15	30
Apply	20	20	40
Analyse	15	15	30
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 (One of the assignments will be implementation of filter design/period gram using any numerical packages)

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 in which students should answer anyone. Each question can have a maximum 2 sub-divisions and carry 14 marks.

Course level Assessment Questions

Course Outcome 1 (CO1):

1. Distinguish between a digital signal and a discrete signal.
2. Give examples of any three biomedical signals with their frequency ranges.
3. With the help of a block diagram explain an Analog-to-Digital Conversion system.

Course Outcome 2 (CO2)

1. Enumerate two properties of the DTFT.
2. State the properties of z-Transform.
3. Determine the unit sample response of the system characterized by the difference equation $y(n) = 2.5y(n-1) - y(n-2) + x(n) - 5x(n-1) + 6x(n-2)$
4. A linear time-invariant system is characterized by the system function $H(z) = \frac{3 - 4z^{-1}}{1 - 3.5z^{-1} + 1.5z^{-2}}$.
   Specify the ROC of H (z) and determine h(n) for the following conditions: (a) The system is stable. (b) The system is causal. (c) The system is anticausal.

Course Outcome 3 (CO3)

1. Design a lowpass Butterworth filter satisfying the following requirements: a passband frequency of 200 Hz with a maximum passband attenuation of 0.5 dB, a stopband frequency of 400 Hz with a minimum stopband attenuation of 20 dB, and a sampling frequency of 2 kHz.
2. Design a lowpass FIR filter using the rectangular windows satisfying the following requirements: a passband frequency of 500 Hz with a maximum passband attenuation of 0.2 dB, a stopband frequency of 600 Hz with a minimum stopband attenuation of 40 dB, and a sampling rate of 4 kHz.
3. Illustrate Gibbs Phenomenon in causal FIR filters.

Course Outcome 4 (CO4

1. Describe Blackman-Tukey spectral estimation.

2. Draw the block diagram of optimum noise canceler using Wiener Filter.
3. With the help of a block diagram, explain the adaptive noise cancelling method in ECG monitoring.

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____ _	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIFTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT 303			
Course Name: BIOMEDICAL SIGNAL PROCESSING			
Max. Marks: 100			Duration: 3 Hours
PART A			
Answer all questions. Each question carries 3 marks			
1		Distinguish between a digital signal and a discrete signal.	
2		How do we obtain a causal discrete system from a non-causal discrete system?	
3		Mention the properties of ROC	
4		Distinguish between DIT and DFT FFT algorithm.	
5		Sketch the ideal characteristics of an ideal high pass filter.	
6		Illustrate Gibbs Phenomenon in causal FIR filters.	
7		Determine the order of a lowpass Butterworth filter that has a -3dB bandwidth of 500 Hz and an attenuation of 40 dB at 1000 Hz.	
8		State the desirable properties in converting an analog filter to a digital filter.	
9		Define Periodogram.	
10		State the objective of adaptive noise cancellation	
PART B			
11	a)	With the help of a block diagram explain an Analog-to-Digital Conversion system.	7
	b)	Give the classifications of Discrete-Time Systems.	7
		OR	
12	a)	Show that the energy (power) of real-valued energy (power) signal is equal to the sum of the energies (powers) od it's even and odd components.	6
	b)	Give examples of any four biomedical signals with their frequency ranges.	8
13	a)	Compute the 8-point DFT using FFT algorithm in decimation in frequency for the following frequency X[n]={0.5,0.5,0.5,0.5,0,0,0,0}	14

		OR	
14	a)	Consider the following system function $H(z) = z /(z-14)(z+14)(z-12)$ For different possible ROCs, determine the causality, stability and the impulse response of the system	14
15	a)	Design a high pass FIR filter using the rectangular window and satisfying the following requirements: a passband frequency of 600 Hz with a maximum passband attenuation of 0.1 dB, a stopband frequency of 500 Hz with a minimum stopband attenuation of 50 dB, and a sampling rate of 4 kHz	14
		OR	
16	a)	Show that ideal filters are not practically realizable.	6
	b)	Elucidate the design process of Linear-Phase FIR filters by frequency-sampling method.	8
17	a)	Investigate the implications of the mapping from s-plane to z-plane for IIR filter design by the impulse-invariant transformation.	6
	b)	Design a lowpass Butterworth filter satisfying the following requirements: a passband frequency of 200 Hz with a maximum passband attenuation of 0.5 dB, a stopband frequency of 400 Hz with a minimum stopband attenuation of 20 dB, and a sampling frequency of 2 kHz	8
		OR	
18	a)	Investigate the implications of the mapping from *s*-plane to *z*-plane for IIR filter design by the bilinear transformation.	6
	b)	Give the steps involved in designing an digital bandpass IIR filter using a Butterworth lowpass prototype filter. Support the steps with appropriate equations.	8
		OR	
19	a)	Analyse HRV using periodogram	7
	b)	Draw the block diagram of optimum noise canceler using Wiener Filter.	7
		OR	
20	a)	With the help of a block diagram, explain 50 Hz noise cancelling method in ECG monitoring.	7
	b)	Describe Blackman-Tukey spectral estimation	7

Syllabus

Module 1

Signals and Signal Processing-Characterization and Classification of Signals, Typical signal Processing Operations, Examples of Biomedical Signals and Analog-to-Digital Conversion (block diagram only)**Discrete-Time Signals -**Typical Sequences and Sequence. Representation, Discrete-Time Systems-Classification of Discrete-Time Systems

Module 2

Discrete-Time Fourier Transform (DTFT)-Definition, Properties, Discrete Fourier Transform-Definition, Properties, FFT-Decimation-in-Time, Decimation-in-Frequency.**The z-Transform**-Properties of the z-Transform, Poles and Zeros, Inversion of the z-Transform-Using partial fraction expansion, Analysis of Linear Time-Invariant Systems in the z-Domain-Transfer function, Frequency response

Module 3

LTI systems as frequency selective filters-Ideal filter characteristics-Simple Digital Filter Design**-**Preliminary Considerations, Design of linear-phase FIR Filter using windows (Bartlett, hamming, Hanning, Kaiser) and frequency sampling method-Applications of FIR filters in Biomedical systems - pre-processing of bio signals

Module 4

IIR Filter Design-Approximation of Derivatives, Impulse invariance, Bilinear Transform Method, Analog filter approximation-Butterworth approximation, Frequency Transformations (Analog and Digital domain), IIR digital filters for ECG analysis

Module 5

Periodogram-Averaged periodogram, Blackman-Tukey Spectral estimation, QRS detection in ECG, Analysis of Heart Rate Variability using periodogram**Adaptive Filters-**Principle of Wiener Filters**,** Principle of adaptive filtering, Principle of adaptive noise cancellation, Cancellation of 50-Hz interference in ECG

Textbooks:

1. Reddy, D. C. *Biomedical signal processing: principles and techniques*. McGraw-Hill, 2005.
2. John G Proakis& Dimitris G Manolakis: Digital Signal Processing Principles, Algorithms and Applications, Prentice Hall of India, 2005.
3. Akay, Metin. *Biomedical signal processing*. Academic press, 2012.
4. Tompkins, Willis J. "Biomedical digital signal processing." *Editorial Prentice Hall* (1993).

5. Oppenheim, Alan V., and Ronald W. Schafer. "Digital signal processing(Book)." *Research supported by the Massachusetts Institute of Technology, Bell Telephone Laboratories, and Guggenheim Foundation. Englewood Cliffs, N. J., Prentice-Hall, Inc., 1975. 598 p* (1975).

References:

1. Mitra, Sanjit Kumar, and YonghongKuo. *Digital signal processing: a computer-based approach*. Vol. 2. New York: McGraw-Hill, 2006.
2. Semmlow, John. *Signals and systems for bioengineers: a MATLAB-based introduction*. Academic Press, 2011..
3. Rangaraj M Rangayyan: Biomedical Signal Analysis, John Wiley, 2002

Course Contents and Lecture Schedule

No	Topic	No.of Lectures
1	**Module 1**	
1.1	Signals and Signal Processing	1
1.2	Characterization and Classification of Signals	1
1.3	Typical Signal Processing Operations	1
1.4	Examples of Biomedical Signals and Analog-to-Digital Conversion	2
1.5	Discrete-Time Signals-Typical Sequences and Sequence Representation	2
1.6	Discrete-Time Systems	2
2	**Module 2**	
2.1	The Discrete-Time Fourier Transform (DTFT)	1
2.2	Discrete Fourier Transform (DFT)	2
2.3	FFT	2
2.4	Properties of the z-Transform	1
2.5	Inversion of the z-Transform	1
2.6	Analysis of Linear Time-Invariant Systems in the z-Domain	2
3	**Module 3**	
3.1	LTI systems as frequency-selective filters	2
3.2	Ideal filter characteristics	2
3.3	Simple Digital Filter Design-Preliminary Considerations	1
3.4	Design of linear-phase FIR Filter using windows and frequency sampling method	3
3.5	Applications of FIR filters in Biomedical systems - pre-processing of bio signals	1
4	**Module 4**	
4.1	IIR Filter Design-Approximation of Derivatives	1
4.2	Impulse invariance	1

4.3	Bilinear Transform Method	3
4.4	Analog filter approximation-Butterworth approximation	1
4.5	Frequency Transformations	1
4.6	IIR digital filters for ECG analysis	2
5	**Module 5**	
5.1	The Periodogram	1
5.2	Blackman-Tukey Spectral estimation	1
5.3	Analysis of Heart Rate Variability using Periodogram	1
5.4	QRS detection in ECG	1
5.5	Principle of Wiener Filters	1
5.6	Principle of adaptive filtering	2
5.7	Principle of adaptive noise cancellation	2
5.8	Cancellation of 50-Hz interference in ECG	1

BMT305	BIOSENSORS & TRANSDUCERS	CATEGORY	L	T	P	CREDIT
		PCC	4	0	0	4

Preamble: The purpose of learning this course is to understand about the various sensors and receptors in the body and differentiate between transducers and biosensors. It analyses the working of various electrodes used for measuring physical quantities and to understand the concepts of nano sensors.

Prerequisite: Nil

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

CO 1	Interpret various sensors and receptors in the body.
CO 2	Explain the principle of transduction, classification and the characteristics of different transducers and Biosensors.
CO 3	Analyze the working and practical applications of electrodes used for measuring pH value, oxygen, CO2etc. in blood.
CO 4	Study various temperature and blood flow meter sensors.
CO 5	Differentiate between sensors used for the measurement of blood pressure and nano sensors.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1							2		2
CO2	3	2	1							2		2
CO3	3	2	1							2		2
CO4	3	2	1							2		2
CO5	3	2	1							2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	50
Apply	20	20	30
Analyze			
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 (2numbers) : 25marks
Assignment/Quiz/Course project :15marks

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 anyone. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are different the sensors of human body?
2. List the various receptors of human body.
3. Describe the working of various organs of the body.

Course Outcome 2 (CO2)

1. List out the differences between sensor and transducer.
2. What are the four classifications of transducers?
3. Explain the working of biosensor.

Course Outcome 3 (CO3):

1. Explain the role of chemical sensors in human body.
2. What are the different types of reference electrodes?
3. Explain the working of pH glass electrode.

Course Outcome 4 (CO4):

1. Explain the principle of thermocouple.
2. What are the two types of thermoresistive transducers?
3. Explain the working of blood flow meters.

Course Outcome 5 (CO5):

1. Explain the principle of resistive, capacitive, inductive transducers.
2. What are the transducers used for measuring blood pressure?
3. Explain the working of Hall effect transducers.

Model Question paper

			Total Pages: 3
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIFTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT 305			
Course Name: BIOSENSORS AND TRANSDUCERS			
Max. Marks: 100		Duration: 3 Hours	
PART A			
Answer all questions. Each question carries 3 marks			

1		List out the differences between somatic nervous system and autonomic nervous system.	
2		Write notes on hot receptors in our body.	
3		What are sensors and transducers.	
4		What is the principal of DNA sensors.	
5		Summarize on the properties of electrodes.	
6		Write notes on Reference electrodes	
7		Explain the principal of Chemical thermometry.	
8		Illustrate the working of sine wave flow meter.	
9		What are inductive transducers	
10		Write notes on potentiometer.	
PART B			
11	a)	Explain the senses of vision and taste in human body.	(14)
		OR	
12	a)	Explain thermo receptors and baro receptors in human body.	(14)
13	a)	What are biosensors? Explain the classification based on bio recognition	(14)

		element.	
		OR	
14	a)	What are active and passive transducers? Give an example of each one.	(14)
15	a)	Explain the working of Ion selective Field effect transistor.	(14)
		OR	
16	a)	Describe the construction and working of silver–silver chloride electrode.	(14)
17	a)	What are temperature transducers. Explain any two temperature transducers with diagram.	(14)
		OR	
18	a)	Explain ultrasonic blood flow meter with diagram.	(14)
19	a)	Explain the working of capacitive and piezo electric sensors	(14)
		OR	
20	a)	What are Nano biosensors. Explain its basic concepts, construction of Nano biosensors.	(14)

Syllabus

Module 1

Biological Sensors and physiological receptors: Study of biological sensors in human body and their basic mechanism of action. Organization of nervous system-neuronal mechanism and circuit processing. Study of various Chemo receptors, hot and cold receptors, baro receptors, Sensors for smell, sound, vision, osmolality and taste.

Module2

Biosensor and Transducers: Transducers–types and classification –primary and secondary-active and passive. Introduction to biosensor classification based on bio recognition element. Immobilization techniques- Enzymatic, DNA, antigen-antibody. Classification based on signal transduction–electrochemical, optical, colorimetric, piezoelectric

Module3

Chemical Biosensors: Blood –Gas and Acid –Based-Electrochemical sensors-Ion selective Field effect transistor –Reference electrodes-Hydrogen electrodes-Silver/silver chloride electrodes-Calomel electrodes. Measurement of pH-Glass pH electrodes-oxygen electrodes-CO_2 electrodes- Blood –Glucose sensor –Electronic Nose-Labon Chip.

Module4

Temperature sensors, blood flow and velocity measurement: Temperature sensors-principle of operation- construction details-characteristics of–thermo resistive transducers,-RTD-thermistor, thermoelectric transducers- thermocouple and its cold junction compensation-chemical thermometry-Liquid crystals-Solid liquid transition thermometers.

Blood flow and velocity measurement- Electromagnetic blood flowmeter and its types- Ultrasonic blood flowmeters- Doppler shift flow velocity meters.

Module5

Blood Pressure transducer and Nano biosensors: Resistive sensors-Potentiometric-resistive strain gauges, inductive sensors–LVDT- capacitive sensors–hall effect transducers-piezo electric sensors- measurement of blood pressure-sphygmomanometer-Indirect method-based on Korotk off sound, oscillometric method. Nano biosensors-basic concepts, construction of Nano biosensors, Nanomaterials for new bio sensing principles, optical nano biosensors-basics and applications of BioMEMS

Text Books

1. Brindley, Keith. Sensors and transducers. CRC Press ILlc, 1988.
2. Webster, John G., ed. Medical instrumentation: application and design. John Wiley & Sons, 2009.
3. RS CCobbold, Transducers for BiomedicalInstruments,JohnWiley&Sons,1974

Reference Books

1. Andrewg Webb, Principle of biomedical Instrumentation, Cambridge University Press 2018.
2. John E Hall -Guyton and Hall Textbook of Medical Physiology -13th edition- Saunders- 2013. Avraham Rasooly & KeithE. Herold, Biosensors and Bio detection, Vol.503.
3. Brown &Gann, Engineering Principles in Physiology Vol.I Academic Press,197
4. DLWise ,Applied BioSensors, Butterworth Publishers, London1989
5. Geddes&Becker, Principles of Applied Biomedical Instrumentation, JohnWiley,1989.
6. RSK handpur, Handbook of Biomedical Instrumentation, Tata McGrawHill,2004

Course Contents and Lecture Schedule

No	Topic	No.of Lectures
1	**Module 1**	
1.1	Study of biological sensors in human body and their basic mechanism of action. Organization of nervous system- neuronal Mechanism and circuit processing	3
1.2	Study of various Chemoreceptors, hot and cold receptors,baroreceptors	2
1.3	Sensors for smell, sound, vision, osmolality and taste.	4
2	**Module 2**	

2.1	Transducers–types and classification-primary and secondary-Active and passive.	2
2.2	Introduction to biosensor classification based on biorecognition element- Enzymatic, DNA, antigen-antibody.	3
2.3	Classification based on signal transduction-electrochemical, optical, colorimetric, piezoelectric	4
3	**Module 3**	
3.1	Blood–Gasand Acid –Based-Electro chemical sensors-Ionselective Field effect transistor	2
3.2	Reference electrodes- Hydrogen electrodes-Silver/ silver chloride electrodes- Calomel electrodes. Measurement of pH-Glass pH electrodes	3
3.3	Oxygen electrodes-CO_2 electrodes-Blood–Glucose sensor–Electronic Nose- Labon Chip.	4
4	**Module 4**	
4.1	Temperature sensors–thermo resistive transducers,-RTD-thermistor-thermo couple and its cold junction compensation	3
4.2	Chemical thermometry-Liquid Crystals-Solid liquid transition thermometers	2
4.3	Blood flow measurement-Electromagnetic blood flowmeter and its types-Ultrasonic blood flowmeters-Doppler shift flow velocity meters	4
5	**Module 5**	
5.1	Resistive sensors- Potentiometric -resistives train gauges, inductive sensors–LVDT-capacitive sensors	4
5.2	measurement of bloodpressure-sphygmomanometer-indirect method-based on Korotkoff sound, oscillometric method	2
5.3	Nano biosensors-basic concepts, construction of nano biosensors, Nano materials for new biosensing principles, optical nano biosensors-basics and applications of Bio MEMS	3

BMT307	SOFT COMPUTING TECHNIQUES	CATEGORY	L	T	P	CREDI T
		PCC	4	0	0	4

Preamble: Soft computing is an important branch of computational intelligence, where fuzzy logic, probability theory, neural networks, and genetic algorithms are synergistically used to mimic the reasoning and decision making of a human. It has massive applications in many application zones such as medical diagnosis, computer vision, machine intelligence, weather forecasting, network optimization, pattern recognition, etc.

Prerequisite: Nil

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

CO1	Apply Neural Networks - architecture, functions and various algorithms in relevant problem areas.
CO2	Develop Fuzzy logic systems for typical computational applications.
CO3	Employ Genetic algorithm concepts for solving simple computational problems.
CO4	Identify suitable Soft Computing techniques and implement solutions for typical biomedical engineering problems.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3					2		2
CO2	3	3	3	2	3					2		2
CO3	3	3	3	2	3					2		2
CO4	3	3	3	3	3					2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	5	5	10
Understand	15	15	40
Apply	30	30	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)

1. Obtain the output of the neuron for a network with inputs are given as [x1, x2, x3] = [0.6, 0.2, 0.6] and the weights are [w1, w2, w3] = [0.2, 0.5, -0.1] with bias= 0.25.
2. Explain the training algorithm for Hebb Network
3. Discuss different types of learning in ANN.
4. Draw the architecture of Back-Propagation network.
5. Explain the learning in perceptron networks.

Course Outcome 2(CO2):

1. Define Fuzzy set and write basic fuzzy set operations?
2. Discuss fuzzy equivalence relations and list out its properties?
3. State the relevance of fuzzification. Explain different types.
4. Explain the characteristics and different classifications of a neuro-fuzzy hybrid system

Course Outcome 3 (CO3):

1. Mention the stopping condition for genetic algorithm flow.
2. Explain different types of encoding techniques.
3. Mention the role of fitness function in GA

Course Outcome 4 (CO4):

1. Propose a suitable soft computing technique to implement a temperature control system for a room. Demonstrate the working of the system using suitable computing tool.
2. Given a dataset of mass spectrometry of normal and cancerous patients, identify a suitable classification methodology and implement the system in MATLAB/Python. Evaluate the system, varying the system parameters and comment on your inference.

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____ _____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIFTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT 307			
Course Name: SOFT COMPUTING TECHNIQUES			
Max. Marks: 100			Duration: 3 Hours
PART A			
Answer all questions. Each question carries 3 marks			
1		Compare and contrast biological neuron and artificial neuron	
2		Explain the different learning mechanisms used in Artificial Neural Networks with the help of necessary diagrams.	
3		State the concept of delta-rule used in Adaptive Linear Neurons.	
4		Draw the architecture of Back-Propagation network. Write its testing algorithm	
5		What is mean by pooling in CNN?	
6		Give the relevance of energy function in neural network design.	
7		With the help of a figure, explain the features of fuzzy membership functions	
8		List and explain the various operations that can be performed in fuzzy	

		relations.	
9		Distinguish between the processes of tuning and learning in genetic-fuzzy rule-based system	
10		Write any three advantages of Neuro- Genetic hybrid system.	
PART B			
11	a)	Implement ANDNOT function using McCulloch-Pitts neuron model.	7
	b)	Explain the training algorithm for Hebb Network.	7
		OR	
12	a)	With the help of an example explain Supervised, Unsupervised, Reinforcement learning.	7
	b)	Discuss McCulloch & Pitts model.	7
13	a)	Find the weights required to perform the following classification using perceptron. The vector (1, 1, 1, 1) and (-1, 1, -1, -1) are belonging to the class (so have target value 1), vectors (1, 1, 1, -1 ,) and (1, -1, -1, 1) are belonging to the class (so have target value -1). Assume learning rate as 1and initial weights as 0.	14
		OR	
14	a)	Explain architecture of back propagation network. Also discuss learning process with algorithm steps.	14
15	a)	What are the various applications of Neural Networks in Health care?	14
		OR	
16	a)	Discuss different associative memory networks.	14
17	a)	Explain different defuzzification methods.	10
	b)	Define Fuzzy set and write basic fuzzy set operations.	4
		OR	
18	a)	What is meant by Lambda cut of a fuzzy set? Show that Lambda cut relation of fuzzy relation is crisp.	7
	b)	State the relevance of fuzzification. Explain different types.	7
		OR	
19	a)	Using the intuition method develop fuzzy membership functions for the following shapes.	7

		Trapezoid (II) Gaussian function. (III) Isosceles triangle	
	b)	What is the concept of crossover in Genetic Algorithm?	7
		OR	
20	a)	What is the concept of crossover in Genetic Algorithm?	10
	b)	Explain different types of Encoding Techniques.	4

Syllabus

Module 1

Introduction to soft computing techniques: Neural networks, fuzzy logic, genetic algorithms. Artificial neural networks: Biological neural networks, model of an artificial neuron, architecture, activation functions, learning methods, McCulloch & Pitts model, Linear separability, Hebb net.

Module 2

Types of networks: Perceptron networks, ADALINE, MADALINE, Feedback Networks: Discrete Hopfield nets, Feed Forward Networks: Back Propagation Networks - architecture, training algorithm, Problems. Competitive net: Maxent.

Module 3

Associative memory networks: Hetero associative networks, Auto associative memory networks, Bidirectional associative memory networks, Energy Function, Problems.**Introduction to convolution neural networks**– convolution, pooling, architecture (Basic concepts only).**Applications of Neural networks** (case study / Assignment can be implementation of a network for an application in Biomedical field)

Module 4

Introduction to Fuzzy logic: Crisp and fuzzy sets - properties - operations on fuzzy sets, fuzzy relations- operations on fuzzy relations. Fuzzy membership functions. Fuzzification, Methods of membership value assignments – intuition – inference – rank ordering, Lambda – cuts for fuzzy sets, Defuzzification methods. Fuzzy Inference Systems – Mamdani and Sugeno types.

Module 5

Introduction to genetic algorithm: operators in genetic algorithm - coding - selection - cross over – mutation, stopping condition for genetic algorithm flow, Genetic - neuro hybrid systems, Genetic- Fuzzy rule-based system.

Text Books

1. Fausett, Laurene V. Fundamentals of neural networks: architectures, algorithms and applications. Pearson Education India, 2006

2. Rajasekaran, Sanguthevar, and GA Vijayalakshmi Pai. Neural networks, fuzzy logic and genetic algorithm: synthesis and applications (with cd). PHI Learning Pvt. Ltd., 2003..
3. CharuC.Aggarwal "Neural Networks and Deep learning" Springer International Publishing, 2018

Reference Books

1. Deepa, S. N., and S. N. Sivanandam. "Principles of soft computing." (2011): 133-205.
2. Ross, Timothy J. Fuzzy logic with engineering applications. Vol. 2. New York: Wiley, 2004.
3. Goldberg, David E. "Genetic algorithms in search." Optimization, and MachineLearning (1989).
4. S. Rajasekaran, G.A. VijayalakshmiPai, "Neural Networks, Fuzzy Logic and Genetic Algorithm, Synthesis and Applications ", PHI Learning Pvt. Ltd., 2017.
5. Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc,2004.
6. Driankov, Dimiter, Hans Hellendoorn, and Michael Reinfrank. An introduction to fuzzy control. Springer Science & Business Media, 2013

Course Contents and Lecture Schedule

No.	Topic	No .of Lectures
1	**Basics of soft computing**	
1.1	Introduction to soft computing techniques	1
1.2	Artificial neural networks: Biological neural networks	1
1.3	Model of an artificial neuron	1
1.4	Activation functions, architectures	1
1.5	Learning methods, brief history of ANN research	1
1.6	McCulloch & Pitts model	2
1.7	Linear separability	1
1.8	Hebb net	2
2	**Artificial Neural networks (ANN)**	
2.1	Perception networks	2

2.2	ADALINE	1
2.3	MADALINE	1
2.4	Discrete Hopfield nets	2
2.5	Back propagation networks	2
2.6	Maxnet	1
3	**Associative memory networks & CNN**	
3.1	Hetero associative networks	2
3.2	Auto associative memory networks	1
3.3	Bidirectional associative memory networks	2
3.4	Energy Function	1
3.5	Introduction to convolution neural networks- convolution, pooling	1
3.6	CNN architecture (Basic concept only)	1
3.7	Applications of Neural networks	1
4	**Fuzzy Logic (FL)**	
4.1	Fuzzy sets	1
4.2	Properties, operations on fuzzy sets	1
4.3	Fuzzy relations - operations on fuzzy relations	1
4.4	Fuzzy membership functions, Fuzzification	1
4.5	Methods of membership value assignments – intuition – inference – rankordering.	2
4.6	Lambda –cuts for fuzzy sets	1
4.7	Defuzzification methods	1
4.8	Fuzzy Inference Systems – Mamdani and Sugeno types	1
5	**Genetic Algorithm (GA)**	
5.1	Introduction to genetic algorithm, operators in genetic algorithm.	2
5.2	GA - selection - cross over.	2
5.3	Stopping condition for genetic algorithm flow.	2
5.4	Genetic - neuro hybrid systems.	1
5.5	Genetic-Fuzzy rule-based system.	2

BML331	MEDICAL COMPUTING & VIRTUAL NSTRUMENTATION LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: The Course deals with the study of basic concepts of processing on signal operations and the fundamentals of Virtual Instrumentation. Also to learn to acquire, analyse and present biomedical data. Acquire knowledge on biomedical signal processing and Soft Computing.

Prerequisite: Nil

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

CO 1	Implement the fundamental of virtual instrumentation.
CO 2	Apply the concept of operations of signals using offline data.
CO3	Implement soft computing using Fuzzy inference systems.
CO4	Develop soft computing applications using Neural networks.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3				3	3		3
CO2	3	3	3	3	3				3	3		3
CO3	3	3	3	3	3				3	3		3
CO4	3	3	3	3	3				3	3		3

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.

- Preliminary work : 15 Marks
- Implementing the work/Conducting the experiment : 10 Marks
- Performance, result and inference (usage of equipment and troubleshooting) : 25 Marks
- Viva voce : 20 marks
- Record : 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that 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 University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Perform the basic arithmetic operations using VI lab.
2. Analyse the Logical circuits using VI lab.
3. Design a Sub VI.
4. Design Arrays & Clusters using VI.
5. Analyse the signals using VI.

Course Outcome 2 (CO2)

1. Perform Convolution operations on simulated Discrete-time signals.
2. Perform FFT on simulated Discrete-time signals.
3. Obtain the Power spectrum of ECG.
4. Design a low pass Butterworth digital filter with following specification:
   a) Pass band frequency of 200Hz with attenuation of 0.5 db
   b) stop band frequency of 400Hz with stop band attenuation of 20db
   c) sampling frequency of 2 KHz.

Course Outcome 3 (CO3):

1. Design and implement a Fuzzy Washing machine with suitable mathematical relationship between amount of grease, dirt and washing time
2. Prove union and intersection property of fuzzy set A and B.
3. Find out the crisp relation for the given fuzzy set.

Course Outcome 4 (CO4):

1. Develop a neural network-based classification system for classifying Bradycardia and Tachycardia from a given heart rate data
2. Develop a neural network-based classification system for normal and abnormal respiration data. Let the feature inputs be mean amplitude and peak frequency of respiration. Compare the performance of the system for another network parameter and other possible signal features

LIST OF EXPERIMENTS

Cycle I (Any 5 Experiments)

1. Familiarization of virtual instrumentation environment using Labview.
2. VI for addition, subtraction, multiplication &division using Labview.
3. VI for Logical circuits using Labview.
4. Design of SubVI using Labview.
5. Arrays & Clusters inVI using Labview.
6. VI for acquisition & generation of signals using Labview.
7. VI for processing and analysis of signalsusing Labview.

Cycle II (Any 5 Experiments)

1. Perform (i) Addition (ii) Multiplication (iii) Scaling usingMATLAB.
2. Linear and Circular Convolution on simulated Discrete-timesignals.
3. DFT and FFT on simulated discrete-timesignals.
4. Implementation of FIR & IIR Butterworth filters.
5. FFT and power spectrum of ECG /EMG/EEG.
6. Implementation of Mc-Culloch pits Model using logic gates.
7. Classification using neural network.
8. Implementation of Fuzzy inference systems (such as Washing machine/Room temperature control).

(Include one open ended experiment from each cycle to make the students understand the concepts learned.)

Reference Books

1. JovithaJerome: Virtual Instruments using LabView -PHI -30 January 2010

2. Sanjay Gupta: -"Virtual Instrumentation using LABVIEW" - Tata McGraw Hill India -2009

3. Rangaraj&Rangayyan: Biomedical signal processing -Wiley-IEEE Press-24 April 2015

4. John L. SemmlowBenjamin Griffel- :-Bio signal and Medical Image Processing – CRCPress 2014 -Published March 17, 2014

5. S. N. Sivanandam and S. N. Deepa, Principles of soft computing – Wiley India Pvt. Limited - 1 January 2011

BML333	CLINICAL INSTRUMENTATION LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: Clinical instrumentation laboratory helps the students to get familiarize with the instrumentation and operation of Biomedical Medical Equipment such as ECG, patient monitor, ESU, colorimeter etc. This laboratory course provides hands-on experience on design and implementation of electronic circuits used in various analytical, monitoring and signal acquisition devices. The skills acquired through the design and troubleshooting of experiments help the students to do their projects, testing, troubleshooting and calibration of medical equipment and also to enhance their knowledge on the latest biomedical technologies.

Prerequisite: Students undergoing the course are expected to have a thorough understanding and hands-on expertise on simple Analog Electronic circuits and basic electronic instrumentation for Medical devices.

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

CO 1	Describe the working principle and operation of different types of medical equipment's
CO 2	Design and implement the instrumentation modules of clinical equipment's
CO 3	Conduct testing and calibration procedure of different medical equipment's
CO 4	Simulate the electronic instrumentation of common clinical equipment's

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2							3	3		3
CO2	3		3	3	3				3	3		3
CO3	3			3	3				3	3		3
CO4	3		3	3	3				3	3		3

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 equipment and troubleshooting) : 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that 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 University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Referring to the technical manual, identify the instrumentation of ECG machine and demonstrate its various lead configurations
2. Demonstrate the working principle of SpO2 sensing and monitoring
3. Describe the effects of high frequency current on human body and demonstrate the working principle of ESU
4. Demonstrate the working and operation of mufti-parameter Patient Monitor

Course Outcome 2 (CO2)

1. Design and implement a circuit to dive chart of medical equipment such as ECG
2. Design and implement a circuit to demonstrate the Time Gain Compensation. Justify your choice of design a parameter
3. Describe the working of an ultrasound machine. Design and implement a circuit to demonstrate the Automatic Gain Compensation

Course Outcome 3 (CO3):

1. Justify the importance of calibration by demonstrating the performance of a syringe pump and infusion pump
2. Demonstrate the calibration procedure of analytical devices such as flame photometer and colorimeter.

3. Demonstration calibration procedure of diagnostic devices such as ECG machine and spirometer

Course Outcome 4 (CO4):

1. Design a circuit to generate the Cut and Coagulation waveform using simulation software
2. Design a circuit to demonstrate concept of Time Gain Compensation using simulation software
3. Design a circuit using a simulation software to demonstrate the heart rate measurement through PQRS detection

LIST OF EXPERIMENTS (Minimum 10 Mandatory)

1. Power amplifier circuit for Stylus movement
2. Chart Drive circuit
3. QRS Detector circuit
4. Automatic gain compensation circuit
5. Time gain compensation circuit
6. ESU waveform generator
7. Study of basic sensor circuits to acquire and display the physiological parameter: Volumetric measurement using Photoplethysmography or plethysmography / monitoring of body temperature, heart rate and blood pressure / measuring the oxygen saturation using Photoplethysmography / Electronic Stethoscope for characterization of physiological acoustic signals
8. Study of monitoring device - Multiparameter physiological recorders – instrumentation and operation
9. Study of analytical device – Semi-auto analyser / colorimeter / flame photometer - instrumentation, operation and calibration.
10. Study of therapeutic equipment – Ventilator / Dialysis machine (model kit or demo) / Defibrillator / Heart lung Machine (model kit or demo) - demonstration
11. Study of diagnostic equipment - ECG Machine / Spirometer – instrumentation, operation and calibration.
12. Study of general surgery assisting device - Electrosurgical unit – instrumentation, operation
13. Study of drug delivery devices – Infusion pump / syringe pump – Instrumentation and and operation
14. Study of simulators and analysers – Electrical safety analyser, ECG simulator, and defibrillator analyser
15. Testing and calibration of medical equipment - Field visit - Engineering department of hospital (any one equipment)

(Include two open ended experiments to make the students understand the concepts learned.)

Text Books:

1. Ramakanth A Gayakwad, Op-Amps and Linear Integrated Circuits, 4th edition, Pearson Education, 2015.

2. Robert B. Northrop, Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation, 1st edition, CRC Press, 2003

3. Boylestead& Neshelsky, Electronic Devices & Circuit Theory, Prentice Hall of India, 2003.

4. R.S. Khandpur, Handbook of Biomedical Instrumentation, Second Edition, McGraw-Hill Publishing Company Limited, 2002

Reference Books:

1. Encyclopaedia of medical devices and instrumentation, volume 1, John G Webster, Published by John Wiley & Sons, Inc., Hoboken, New Jersey, 2006

2. Dr. Vibhav Kumar Sachan, Principles of Transducers & Biomedical Instrumentation: Designs and Applications, Sachan Books, 2019

3. Tatsuo Togawa, Toshiyo Tamura, P. Ake Oberg, Biomedical Transducers and Instruments, CRC Press, 1997.

SEMESTER V

MINOR

BMT381	MEDICAL IMAGING TECHNIQUES	CATEGORY	L	T	P	CREDIT
		PCC	4	0	0	4

Preamble: The course introduces the principles of biomedical imaging modalities such as Ultrasonic imaging, X-Ray-Computed tomography, Magnetic Resonance Imaging, Molecular imaging - SPECT & PET, Hybrid imaging- PET-CT, PET-MR, Cath Lab, Infrared imaging, Tactile and Photo acoustic imaging.

Prerequisite: The students should have a thorough understanding of BMT206 Biophysics.

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

CO 1	Describe the operating principle, instrumentation and imaging techniques of diagnostic Ultrasound.
CO 2	Discuss the operating principle, instrumentation and imaging techniques of Magnetic Resonance Imaging
CO 3	Analyse the operating principle, instrumentation and imaging techniques of X-Ray Computed Tomography, Cath Lab, and molecular imaging modalities
CO 4	Explain the concept of Infrared, Tactile and Photoacoustic imaging modalities.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3				2			2	2		2
CO2	3	3				2				2		2
CO3	3	3				2	3		2	2		2
CO4	3									2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	10	10	35
Apply	10	10	20

Analyse	30	30	45
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):

1. Explain the significance of acoustic impedance in ultrasound imaging. What is the difference between acoustic impedance and acoustic absorption?
2. Discuss the Stefan-Boltzmann law.
3. List the basic principles of ultrasound propagation in tissue. Describe at least 5 with suitable equations
4. Explain why bone and gas limit the areas of clinical application of ultrasound
5. What are the essential elements of a complete B-mode system, and describe how the B-mode amplitude information can be processed?
6. List the sources of errors in US systems
7. Justify the suitability of ultrasound in gynaecology. Identify the procedure for PNDT approval and its relevance in Indian scenario.

Course Outcome 2 (CO2):

1. Describe the components of a clinical MRI system. Give detailed description of the functions of individual components.

2. Illustrate the instrumentation of a typical MRI machine with the help of a block diagram
3. Consider an emergency situation where a patient is sandwiched between the main superconducting magnet of an MRI and a metal wheelchair with “missile effect”. Identify the emergency rescue system arranged in an MRI room for such a situation and illustrate the working of the same. Also estimate the approximate financial loss for the imaging centre to operate the rescue system with proper justification.
4. Discuss the proton density weighted imaging and compare the image obtained with T1 weighted and T2 weighted images

Course Outcome 3(CO3):

1. Referring appropriate literature, prepare a write up about the parameters to be checked in the quality assurance of Computed Tomography equipment for ensuring compliance with respective standards and specifications. Also, describe the test procedures and significance of such tests.
2. Analyse iterative reconstruction techniques versus filtered back projection in CT image reconstruction.
3. Illustrate the fan beam algorithm in spiral CT.
4. Discuss the working of a gamma camera.
5. Identify relevant standards and prepare a rough sketch and a project report for a room to install PET-CT Machine based on AERB regulations in India.

Course Outcome 4 (CO4):

1. Justify the purpose of Cath Lab
2. Illustrate the principles of Tactile Imaging
3. List out the applications of Photoacoustic Imaging
4. Differentiate the thermal and photon detectors in infrared imaging.

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____	

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__

Course Code: BMT381

Course Name: MEDICAL IMAGING TECHNIQUES

Max. Marks: 100		Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks

1		Discuss the relation between frequency of the ultrasound and resolution of imaging.	
2		Differentiate the concept of A, B and M scans in Ultrasound imaging.	
3		Explain the sequence of events which occur in spin echo imaging.	
4		Explain CT number used in computed tomography.	
5		Tabulate the differences between the T1 and T2 weighted imaging.	
6		Discuss the Radon transform for CT image reconstruction	
7		Describe the working of technetium generators.	
8		Discuss the working of pulse height analysers.	
9		Discuss the operation principles of pyroelectric detectors	
10		Detail the clinical applications of thermography in rheumatology.	
		PART B	
11	a)	With a neat sketch, explain the block diagram of the ultrasound machine. Also discuss the functions of each part.	10
	b)	Investigate the suitability of ultrasound scan in obstetrics and gynaecology	4
		OR	
12	a)	What is the doppler effect? Derive the equations to analyse blood velocity with Doppler effect.	14

13	a)	Discuss the principles of sectional imaging CT.	14
		OR	
14	a)	Explain the working of spiral and multislice CT.	14
15	a)	Discuss the T1, T2 and T2* Relaxation processes with suitable diagrams	14
		OR	
16	a)	With the help of suitable diagrams explain the Image acquisition and reconstruction techniques in MRI	14
17	a)	Explain the principles of PET imaging.	14
		OR	
18	a)	Discuss the advantages of PET and SPECT imaging. List some radiotracers used in PET imaging and their applications.	14
		OR	
19	a)	What is the principle of thermography? Explain the constructional details of a vidicon camera.	14
		OR	
20	a)	Discuss the working of thermal infrared detectors.	14

Syllabus

Module 1

Diagnostic Ultrasound Imaging: Basic physics of ultrasound (Review Only): Wave nature, frequency, speed, wavelength, phase, pressure and intensity-acoustic pressure and intensities within the beam, power, acoustic impedance, reflection, diffuse reflection, scattering, refraction, absorption, interference, diffraction, Attenuation-dependence on frequency. Diagnostic Ultrasound Imaging: A-mode, B-mode and M-mode, Principle of B-Mode Image formation, B-mode formats, Transducers and Beam forming, B-Mode Instrumentation, B-mode image properties, limitations and artifacts, B-Mode Measurements, Doppler Ultrasound, Spectral Ultrasound, colour imaging, advanced techniques for flow and tissue motion, Three-Dimensional Ultrasound, 4D measurements, ultrasound contrast studies, Elastography, Quality assurance and safety of diagnostic ultrasound.

Module 2

Magnetic resonance imaging: Physics of the Dynamics of the Spin (Review Only). MRI Principle-Magnetisation-Excitation-Relaxation-T1 and T2 phase relaxation and relaxation curves – Acquisition-Bloch Equations. MRI Instrumentation and Block Diagram - Main Magnet, Gradient System, Shim System, RF System, Console, MRI Suite, Magnet Quench system. Signal formation and imaging- Free induction decay, Echoes, Signal Coding- Slice

Encoding, Phase Encoding, Frequency Encoding, slice thickness, 2D and 3D imaging- Spatial resolution and Field of View-K Space-MRI Fourier Reconstruction, Acceleration methods. Image Contrast- T1 Contrast, T2 Contrast, Proton Density Contrast. MR Sequence Parameters (TR,TE,FA,TI), Image Artifacts. MRI Pulse Sequences - Spin Echo Sequence, Multi Echo Sequence, Turbo Spin Echo Sequence, Fast Advanced Spin Echo Sequence, Gradient Echo Sequence, Inversion Recovery Sequence. Principles of Functional MRI, MR Angiography and Diffusion MRI.

Module 3

X-Ray Computed Tomography: Basic concepts of X-ray Generation, Components involved, Properties of X-rays, Different X-Ray Instruments, Impact of mA and KV. **Principle of Computed Tomography**- Geometries, First, Second, Third, Fourth generation Scanners- Multislice CT Scanners, CT Scanning in Spiral-Helical Geometry, Fifth-Generation Scanners, Sixth-Generation Scanners- The Dual-Source CT Scanner, Seventh-Generation Scanners- Flat-Panel CT Scanners. Slip-Ring Technology, System components- Gantry, Collimation, X-Ray tubes for CT applications - Pencil beam and Cone beam projections. CT Detector Technology, Detector Characteristics, Types, Design Innovations, Multirow/Multislice Detectors, Area Detectors, Image reconstruction algorithms, Image characteristics, Image matrix, CT numbers, Spatial resolution, System noise, Image Artifacts. Introduction to CT Angiogram and DSA

Module 4

Radiology and Hybrid imaging: Radio-isotopes in medical diagnosis, Interaction of nuclear particles with matter. Radionuclide generators, nuclear radiation detectors, rectilinear scanner, Gamma camera, Single photon Emission Computed Tomography, Positron Emission Tomography, Biological effects. Hybrid Imaging instrumentation MR-PET Instrumentation-Mutual interference between MR and PET, MR Compatible PET detector technology, MR-PET system architecture. PET-CT, SPECT-CT. Radiation protection.

Module 5

Infrared imaging and new imaging types: Infrared Imaging - Physics of thermography – IR Detectors - photon & thermal detectors - thermal uncooled IR detectors: resistive micro bolometers, pyroelectric and ferroelectric detectors, thermoelectric detectors. Pyroelectric vidicon camera - camera characterization - thermographic image processing - clinical applications of thermography in rheumatology, neurology, oncology and physiotherapy. Introduction to Principles of Tactile Imaging and Photoacoustic Imaging. **Catheterization Laboratory**- Theory, Purpose, Types of Cath labs, CT angio vs Cat Lab Angio.

Text Books

1. Hoskins, Peter R., Kevin Martin, and Abigail Thrush, eds. Diagnostic ultrasound: Physics and equipment. CRC Press, 2019.
2. M Flower, Webb's Physics of Medical Imaging, Taylor & Francis, 2016.

3. Shah, N. Jon, ed. Hybrid MR-PET Imaging: Systems, Methods and Applications. Royal Society of Chemistry, 2018.
4. Seeram, Euclid. Computed Tomography e Book: Physical Principles, Clinical Applications, and Quality Control. Elsevier Health Sciences, 2015.
5. Webb, The Physics of Medical Imaging, IOP Publishing Ltd., 1988
6. Andrew Webb, Introduction to Biomedical Imaging, John Wiley & Sons, Inc., 2003

Reference Books

1. Avinash C Kak, Malcolm Slaney, Principles of Computerized Tomographic Imaging, 2001.
2. Hans H Schild, MRI Made easy…Well almost, H. HeenemannGmBH, 2012.
3. Fenster, Aaron, and James C. Lacefield, eds. Ultrasound imaging and therapy. Taylor & Francis, 2015.
4. DuccioVolterrani Paola Anna ErbaIgnasiCarrió H. William Strauss Giuliano Mariani, Nuclear Medicine Tex t book, Methodology and Clinical Applications, Springer, 2019.
5. Christian, Paul E., and Kristen M. Waterstram-Rich, eds. nuclear medicine and PET/CT: technology and techniques. Mosby/Elsevier, 2007.
6. Douglas A Christensen: Ultrasonic Bioinstrumentation, John Wiley, New York, 1988.
7. AtamDhavan, Medical Image Analysis,Wiley IEEE Press, 2003.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.2	Basic physics of ultrasound (Review Only): Wave nature, frequency, speed, wavelength, phase, pressure and intensity-acoustic pressure and intensities within the beam, power, acoustic impedance, reflection, diffuse reflection, scattering, refraction, absorption, interference, diffraction, Attenuation-dependence on frequency.	2
1.3	Diagnostic Ultrasound Imaging: A-mode, B-mode and M-mode, Principle of B-Mode Image formation, B-mode formats, Transducers and Beam forming, B-Mode Instrumentation, B-mode image properties, limitations and artifacts, B-Mode Measurements	3
1.4	Doppler Ultrasound, Spectral Ultrasound, colour imaging, advanced techniques for flow and tissue motion,	2
1.5	Three-Dimensional Ultrasound, 4D measurements, ultrasound	2

	contrast studies, Elastography	
1.6	Quality assurance and safety of diagnostic ultrasound.	1
2	**Module 2**	
2.1	Physics of the Dynamics of the Spin (Review Only).	1
2.2	MRI Principle-Magnetisation-Excitation-Relaxation-T1 and T2 phase relaxation and relaxation curves – Acquisition-Bloch Equations.	2
2.3	MRI Instrumentation and Block Diagram - Main Magnet, Gradient System, Shim System, RF System, Console, MRI Suite, Magnet Quench system.	2
2.4	Signal formation and imaging- Free induction decay, Echoes, Signal Coding- Slice Encoding, Phase Encoding, Frequency Encoding, slice thickness, 2D and 3D imaging- Spatial resolution and Field of View-K Space-MRI Fourier Reconstruction, Acceleration methods.	2
2.5	Image Contrast- T1 Contrast, T2 Contrast, Proton Density Contrast. MR Sequence Parameters (TR, TE, FA, TI), Image Artifacts.	1
2.6	MRI Pulse Sequences - Spin Echo Sequence, Multi Echo Sequence, Turbo Spin Echo Sequence, Fast Advanced Spin Echo Sequence, Gradient Echo Sequence, Inversion Recovery Sequence.	2
2.7	Principles of Functional MRI, MR Angiography and Diffusion MRI.	1
3	**Module 3**	
3.1	Basic concepts of X-ray Generation, Components involved, Properties of X-rays, Different X-Ray Instruments, Impact of mA and KV.	1
3.2	Principle of Computed Tomography- Geometries, First, Second, Third, Fourth generation Scanners- Multislice CT Scanners, CT Scanning in Spiral-Helical Geometry	1
3.3	Fifth-Generation Scanners, Sixth-Generation Scanners- The Dual-Source CT Scanner, Seventh-Generation Scanners- Flat-Panel CT Scanners. Slip-Ring Technology	2
3.4	System components- Gantry, Collimation, X-Ray tubes for CT applications - Pencil beam and Cone beam projections.	2
3.5	CT Detector Technology, Detector Characteristics, Types, Design Innovations, Multirow/Multislice Detectors, Area Detectors	1

3.6	Image reconstruction algorithms, Image characteristics, Image matrix, CT numbers, Spatial resolution, System noise, Image Artifacts.	2
3.7	Introduction to CT Angiogram and DSA	1
4	**Module 4**	
4.1	Radio-isotopes in medical diagnosis, Interaction of nuclear particles with matter. Radionuclide generators, nuclear radiation detectors	1
4.2	Rectilinear scanner, Gamma camera	1
4.3	Single photon Emission Computed Tomography, Positron Emission Tomography, Biological effects.	2
4.4	Hybrid Imaging instrumentation MR-PET Instrumentation-Mutual interference between MR and PET, MR Compatible PET detector technology	2
4.5	MR-PET system architecture. PET-CT, SPECT-CT. Radiation protection	1
5	**Module 5**	
5.1	Infrared Imaging - Physics of thermography – IR Detectors - photon & thermal detectors - thermal uncooled IR detectors: resistive micro bolometers, pyroelectric and ferroelectric detectors, thermoelectric detectors.	2
5.2	Pyroelectric vidicon camera - camera characterization - thermographic image processing - clinical applications of thermography in rheumatology, neurology, oncology and physiotherapy.	2
5.3	Introduction to Principles of Tactile Imaging and Photoacoustic Imaging	2
5.4	Catheterization Laboratory - Theory, Purpose, Types of Cath labs, CT Angio vs Cat Lab Angio.	1

BMT383	REHABILITATION ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	4	0	0	4

Preamble: The objective of this course is to understand the field of rehabilitation engineering in general and apply the acquired knowledge to implement such systems in practice appropriately.

Prerequisite: Nil.

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

CO 1	Understand the engineering principles applied in various settings of human rehabilitation
CO 2	Apply the design concepts of wheel chairs and auxiliary devices for assisting personal transportation
CO 3	Analyse the components of Robotic rehabilitation and Neuro- rehabilitation
CO4	Recognise the application of AR/VR in rehabilitation and concepts of Tele-rehabilitation technique

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3				3	3	3		2		2
CO2	3	3	3	3	3	3	3	3		2		2
CO3	3	3	3	3	3	3	3	3		2		2
CO4	3	3	3	3	3	3	3	3		2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	15	15	30
Apply	20	20	40
Analyse	15	15	30
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):

1. Discuss the principle of rehabilitation engineering.
2. List major limb prosthetic devices.
3. Identify the disease conditions that require considerations of seating and positioning of an individual with disabilities. Design an assistive device and give its characteristics.

Course Outcome 2 (CO2):

1. List the wheel chair selection factors.
2. Discuss the concepts of wheelchair safety, standards and testing.
3. Describe finite-element modelling applied to wheelchair design and testing

Course Outcome 3(CO3)

1. Design a robot as a manipulation aid in the rehabilitation process.
2. How neuro modulation is done in case of Parkinson disease.
3. Identify the signal processing methods commonly employed for prosthetic control of upper limb

Course Outcome 4 (CO4):

1. With the help of an example explain the concept of virtual reality in rehabilitation.

2. What are the facilities required for offering tele-rehabilitation? Conduct a literature review and identify the healthcare centre offering tele-rehabilitation in your locality.
3. Propose the design of an ergonomic rehabilitation method using head mounted devices and other accessories that improves the static and dynamic balance to prevent falling.

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIFTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT383			
Course Name: REHABILITATION ENGINEERING			
Max. Marks: 100		Duration: 3 Hours	
PART A			
Answer all questions. Each question carries 3 marks			
1		Define rehabilitation.	
2		List the principle of rehabilitation engineering.	
3		List the classes of manual wheelchairs.	
4		List the major components of a powered wheelchair	
5		Differentiate between an industrial robot and a rehabilitation robot	
6		Draw the simplified block diagram of a robotic system and explain.	
7		What do you mean by context aware BCI?	
8		Describe the conditions of Cerebral paralysis and Multiple Sclerosis	
9		Compare evoked potentials with voluntary activity	
10		List the advantages, limitations and application areas of tele-rehabilitation.	
PART B			
11		Discuss the role of the rehabilitation engineering in a clinical setting	14
		OR	
12		Write a note on the design factors that form the guideline for the design of assistive technology	14
13		Explain electrical systems and controls for a power wheelchair.	14
		OR	
14		Discuss the design considerations for a manual wheel chair for indoor use	14
15	a	List the advantages of robot-assisted therapy over the conventional therapy	5

	b	Describe the architecture of a Head-mounted control system for tele-operation of a robotic system.	9
		OR	
16		Propose a set of sensing technologies which provide substantially better performance for robot used in rehabilitation	14
17	a	Write a note on implantable electrodes for neural interface	7
	b	Give an overview of diseases and injuries causing sensory-motor impairment.	7
		OR	
18		Draw the architecture of brain computer interface for controlling a hand orthosis and describe the signals and of interest	14
19		Describe the components of tele-rehabilitation with the help of neat diagrams	14
		OR	
20		Justify the statement – Computer based motor rehabilitation can improve static and dynamic postural balance during walking.	14

Syllabus

Module 1

Scope of Rehabilitation Engineering: Measurement and analysis of human movement, disability associated with aging in the workplace and their solutions, clinical practice of rehabilitation engineering. Fundamentals of rehabilitation engineering design: design considerations, total quality management in rehabilitation engineering, steel as a structural material, Aluminium for assistive technology design, use of composites for assistive technology design.

Module 2

Manual wheelchair design: classes of manual wheelchairs; Frame design; materials; wheelchair and rider; Wheels and casters; Components; human factors design considerations. **Power wheelchair design:** classes of power wheelchairs; motor selection; servo amplifiers; Microprocessor control, shared control; fault-tolerant control; integrated controllers, electromagnetic compatibility; batteries; gear boxes; user interfaces; Postural support and seating- Seating Pressure Measurement- Control Interface Integration- Multi-Configuration Seating and Postural Support Systems.

Module 3

Rehabilitation robotics: Introduction; components and configurations of robots; robot kinematics; robot motion; robot control; robot sensors; human interfaces to robotic systems; recreational devices and vehicles, racing wheelchairs; arm-powered bicycles and tricycles; off-road vehicles; water sports; Adaptive ski equipment; recreational vehicles

Module 4

Neuro rehabilitation: Overview of diseases and injuries causing sensory-motor impairment, spinal cord and deep brain stimulation for neurological deficits, introduction to brain computer interfaces, myoelectric control of prosthesis, peripheral neural interfaces, gait analysis for movement.

Module 5

Computer applications in Rehabilitation Engineering: Virtual reality in rehabilitation - Upper extremity function rehabilitation by imitation, Augmented reality application for rehabilitation, Examples- GenVirtual and ARToolkit, Virtual reality augmented training for improving walking and reducing fall risk in patients with neurodegenerative disease Telerehabilitation.

Text Books

1. Rory A Cooper, HisaichiOhnabe, Douglas A. Hobson, An introduction to rehabilitation engineering, CRC Press, 2007.
2. Farina D, Jensen W & Akay M. Introduction to Neural Engineering for Motor Rehabilitation. John Wiley & Sons, 2013
3. Joseph D.Bronzino , “The Biomedical Engineering Handbook: Four volume set” , CRC Press, Fourth edition revised, 2018.
4. Tan Yen Kheng, "Rehabilitation Engineering", In-Tech, 2009.

Reference Books

1. Cooper, Rory A. Rehabilitation engineering applied to mobility and manipulation. CRC Press, 1995.
2. Weiss, Patrice L., Emily A. Keshner, and Mindy F. Levin, eds. Virtual reality for physical and motor rehabilitation. New York:: Springer, 2014.
3. Bronzino, Joseph D. Biomedical Engineering Handbook 2. Vol. 2. Springer Science & Business Media, 2000.
4. Smith, Raymond V., and John H. Leslie Jr. Rehabilitation engineering. CRC Press, 1990
5. Cifu, David X. Braddom's physical medicine and rehabilitation E-book. Elsevier Health Sciences, 2020.
6. Robinson C.J., Rehabilitation Engineering, CRC Press, 1995.
7. Szeto, Andrew. "Rehabilitation engineering and assistive technology." In Introduction to biomedical engineering, pp. 211-254. Academic Press, 2005.
8. Ballabio E., et al., Rehabilitation Technology, IOS Press, 1993

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Scope of Rehabilitation Engineering	1
1.2	Measurement and analysis of human movement	1
1.3	Disability associated with aging in the workplace and their solutions	1
1.4	Clinical practice of rehabilitation engineering.	1
1.5	Fundamentals of rehabilitation engineering design: design considerations total quality management in rehabilitation engineering.	3
1.6	Steel as a structural material, aluminium for assistive technology design, use of composites for assistive technology design.	2
2	**Module 2**	
2.1	Manual wheelchair design: classes of manual wheelchairs; Frame design; materials; wheelchair and rider; Wheels and casters; Components; human factors design considerations.	2
2.2	Power wheelchair design: classes of power wheelchairs; motor selection; servo amplifiers	2
2.3	Microprocessor control, shared control; fault-tolerant control; integrated controllers, electromagnetic compatibility; batteries; gear boxes; user interfaces	2
2.4	Postural support and seating- Seating Pressure Measurement	2
2.5	Control Interface Integration- Multi-Configuration Seating and Postural Support Systems.	2
3	**Module 3**	
3.1	Rehabilitation robotics: Introduction; components and configurations of robots	2
3.2	Robot kinematics; robot motion; robot control; robot sensors	2
3.3	Human interfaces to robotic systems	2
3.4	Recreational devices and vehicles, racing wheelchairs	1
3.5	Arm-powered bicycles and tricycles; off-road vehicles	1
3.6	Water sports; Adaptive ski equipment; recreational vehicles	1
4	**Module 4**	
4.1	Neuro Rehabilitation: Overview of diseases and injuries causing sensory-motor impairment	1

4.2	Spinal cord and deep brain stimulation for neurological deficits	2
4.3	Introduction to brain computer interfaces	2
4.4	Myoelectric control of prosthesis	2
4.5	Peripheral neural interfaces	1
4.6	Gait analysis for movement.	1
5	**Module 5**	
5.1	Computer applications in Rehabilitation Engineering: Virtual reality in rehabilitation - Upper extremity function rehabilitation by imitation	2
5.2	Augmented reality application for rehabilitation, Examples- GenVirtual and ARToolkit	2
5.3	Virtual reality augmented training for improving walking and reducing fall risk in patients with neurodegenerative disease	2
5.4	Telerehabilitation.	2

BMT385	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING TECHNIQUES	CATEGORY	L	T	P	CREDIT
		VAC	4	0	0	4

Preamble: The course deals with the study of different algorithms and models. It helps the students to develop intelligent information systems.

Prerequisite: Students should have a basic knowledge of Probability and statistical concepts, coding and data analysis.

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

CO 1	Extend the scope and limits of artificial intelligence.
CO 2	Apply the concepts of AI techniques in problem solving.
CO 3	Differentiate between different learning approaches.
CO 4	Apply Different classifier models for problem solving.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	2	3	3	1		3	3	3
CO2	3	3	3		2		2	1		3		3
CO3	3	3	3	2		2	2	1		3		3
CO4	3	3	3	3	2					3		3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	10	10	20
Apply	20	20	40
Analyse	15	15	30

Evaluate	5	5	10
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 contains 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):

1. Appreciate the scope and limits of the artificial intelligence (AI) field.
2. Interpret the role of knowledge representation, problem solving, and learning.

Course Outcome 2 (CO2)

1. Assess the applicability strengths, and weaknesses of the basic knowledge representation.
2. Explain uninformed algorithm problem solving.

Course Outcome 3(CO3):

1. Differentiate various learning approaches, and to interpret the concepts of supervised Learning
2. Compare the different dimensionality reduction techniques

Course Outcome 4 (CO4):

1. Illustrate the working of SVM.
2. Explain Hidden Markov Model.

Model question paper

			Total Pages: 3
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY			
FIFTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT 385			
Course Name: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING TECHNIQUES			
Max. Marks: 100			Duration: 3 Hours
PART A			
Answer all questions. Each question carries 3 marks			

1		Discuss the history of Artificial Intelligence.	
2		Define the component of 8 puzzle problems with suitable examples.	
3		Illustrate the problem of underestimation and overestimation.	
4		List the categories for actions in conceptual dependency	
5		List out the difference between the two quantifiers in the logics?	
6		What do you mean by unification? How is it useful in logic?	
7		Describe principal learning analysis?	
8		Illustrate Learning Multiple classes.	
9		Explain Support Vector Machine.	
10		What are the three basic problems of HMMs?	
11	a)	Explaining Different types of hill climbing and issues in hill climbing.	(14)
		OR	

12	a)	(i)You are given a 4-litre jug and a 3-litre jug. Neither has a measuring mark on it. You have to measure exactly 2 litres of water in the 4-litre jug. Define the production rules for solving the problem. (ii) Define uninformed search. Which kind of problems can use uninformed search?	(9) (5)
13	a)	Explain A* algorithm with example.	(14)
		OR	
14	a)	Write steps in converting to clause form.	(14)
15	a)	How do you represent the following sentences in predicate logic? Every student who studies three hours a day pass the exam. Everyone in Kerala is hard working. Students who are regularly late for the first hour classes are hostellers	(9)
	b)	(ii) Prove R from the facts: P→Q, Q→R, and P.	(5)
		OR	
16	a)	Convert the following sentences to logic and then to clause form. All Romans were either loyal to Caesar or hated him. Everyone is loyal to someone. People only try to assassinate rulers they are not loyal to.	(9)
	b)	Illustrate with example conversion of well-formed formula to clause form.	(5)
17	a)	Explain two classification methods with examples.	(14)
		OR	
18	a)	What is the use of dimensionality reduction? Explain about PCA.	(14)
19	a)	How SVM classified data point into two different categories using hyper plane.	(14)
		OR	
20	a)	Define Hidden Markov Model. Illustrate evaluation problem and how is this solved?	(14)

Syllabus

Module 1

Introduction: What is AI, The foundations of AI, History and applications, Production systems. Structures and strategies for state space search. Informed and Uninformed searches. Searching strategies – Generate and Test, Heuristic Search Techniques- Hill climbing– issues in hill climbing

Module 2

Search methods-Best first search-The A* algorithm, Problem Reduction-AND-OR Graphs, The AO* algorithm, Constraint Satisfaction, MINIMAX search procedure, Alpha-Beta pruning. **AI representational schemes**- Semantic nets, conceptual dependency, scripts, frames.

Module 3

Knowledge representation - Using Predicate logic - representing facts in logic, functions and predicates, Conversion to clause form, Resolution in propositional logic, Resolution in predicate logic, Unification. Representing Knowledge Using Rules: Procedural Versus Declarative knowledge, Logic Programming, forward versus Backward Reasoning

Module 4

Introduction to Machine Learning, Examples of Machine Learning applications - Learning associations, Classification, Regression, Unsupervised Learning, Reinforcement Learning.Supervised learning- Input representation, Hypothesis class, space, Vapnik-Chervonenkis (VC) Dimension. **Probably Approximately Learning (PAC)**, Noise, Learning Multiple classes, Model Selection and Generalization, Dimensionality reduction-Subset selection, Principle Component Analysis

Module 5

Kernel Machines- Support Vector Machine- Optimal Separating hyperplane, Soft-margin hyperplane, Kernel trick, Kernel functions. Discrete Markov Processes, Hidden Markov models, three basic problems of HMMs- Evaluation problem, finding state sequence, Learning model parameters. Combining multiple learners, Ways to achieve diver

Text Book

1. Elaine Rich and Kevin Knight, “Artificial Intelligence”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, Third Edition, ISBN: 13:978-0-07-008770-5, 2010.

2. Stuart Russell, Peter Norvig, "Artificial Intelligence- A modern approach", Pearson Education Asia, Second Edition, ISBN:81-297-0041-7.
3. EthemAlpaydın, *Introduction to Machine Learning* (Adaptive Computation and Machine Learning), MIT Press, 2004

Reference Books

1. D. Poole and A. Mackworth. Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, 2010 Available online: http://artint.info/
2. Dan W Patterson, Introduction to Artificial Intelligence, Pearson,2009
3. Deepak Khemeni,A First course in Artificial Intelligence,Tata McGraw Hill,2013
4. Maja J. Mataric ,RoboticsPrimer,MIT press, 2007
5. Patrick Henry Winston,Artificial intelligence, Addisson wessley,1992
6. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
7. EthemAlpaydın, *Introduction to Machine Learning* (Adaptive Computation and Machine Learning), MIT Press, 2004.
8. Ryszard S. Michalski, Jaime G. Carbonell, and Tom M. Mitchell, *Machine Learning : An Artificial Intelligence Approach*, Tioga Publishing Company.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	What is AI, The foundations of AI, History and applications, Production systems.	**2**
1.2	Structures and strategies for state space search. Informed and Uninformed searches.	**3**
1.3	Searching strategies – Generate and Test, Heuristic Search Techniques- Hill climbing– issues in hill climbing.	**3**
2	**Module 2**	
2.1	Search methods-Best first search-The A* algorithm, Problem Reduction-AND-OR Graphs.	**3**
2.2	The AO* algorithm, Constraint Satisfaction, MINIMAX search procedure, Alpha-Beta pruning.	**3**
2.3	AI representational schemes- Semantic nets, conceptual dependency, scripts, frames.	**2**

3	**Module 3**	
3.1	Knowledge representation - Using Predicate logic - representing facts in logic, functions and predicates, Conversion to clause form.	**3**
3.2	Resolution in predicate logic, Unification. Representing Knowledge, Using Rules: Procedural Versus Declarative knowledge.	**3**
3.3	Logic Programming, forward versus Backward Reasoning.	**3**
4	**Module 4**	
4.1	Introduction to Machine Learning Examples of Machine Learning applications - Learning associations.	**2**
4.2	Classification, Regression, Unsupervised Learning, Reinforcement Learning. Supervised learning.	**3**
4.3	Input representation, Hypothesis class, space, Vapnik-Chervonenkis (VC) Dimension.	**3**
4.4	Probably Approximately Learning (PAC), Noise, Learning Multiple classes, Model Selection and Generalization, Dimensionality reduction-Subset selection, Principle Component Analysis.	**3**
5	**Module 5**	
5.1	Support Vector Machine.	**1**
5.2	Optimal Separating hyper plane, soft margin hyperplane, Kernel. Trick	**2**
5.3	Kernel functions. Discrete Markov Processes, Hidden Markov Models.	**2**
5.4	Three basic problems of HMMs- Evaluation problem, finding state sequence, Learning model parameters.	**2**
5.5	Combining multiple learners, Ways to achieve diver.	**1**

SEMESTER V

HONOURS

BMT393	DIGITAL SIGNAL PROCESSORS	CATEGORY	L	T	P	CREDIT
		VAC	4	0	0	4

Preamble: Digital Signal Processor (DSP) is being used widely in applications that include telecommunication equipment, multimedia systems, electronic and biomedical instrumentation, automotive systems and many military and weapon systems. DSP chips, general processors or dedicated ASIC chips, are now able to process wide bandwidth signal of all sorts in real-time. The application of DSP is only limited by our imagination instead of DSP technology itself.

Prerequisite: Students learning this course are expected to have strong foundation in Signals and systems, Biomedical Signal Processing, and good programming skills along with a knowledge in system architecture of computing platforms.

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

CO 1	Apply the techniques of digital signal processing that are fundamental to various industrial applications.
CO 2	Describe the architecture of DSP processors
CO 3	Analyse signal processing algorithms in DSP processor-based systems
CO4	Identify the control instructions, interrupts, and pipeline operations of TMS320C54XX
CO 5	Interpret about interfacing of DSP programmable devices and peripherals.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3					2		2
CO2	3	2								2		2
CO3	3	2	2		3					2		2
CO4	3	2	2	2	3					2		2
CO5	3	2	2	2	3					2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	20	20	20
Apply	20	20	20
Analyse	30	30	30
Evaluate	30	30	30
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):

1. With a neat diagram explain the scheme of the DSP system.
2. What is DSP? What are the important issues to be considered in designing and implementing a DSP system? Explain in detail.
3. Define decimation and interpolation process. Explain them using block diagrams and equations. With a neat diagram explain the scheme of a DSP system.

4. For the FIR filter y(n)=(x(n)+x(n-1)+x(n-2))/3. Determine i) System Function ii) Magnitude and phase function iii) Step response iv) Group Delay.

Course Outcome 2 (CO2):

1. Explain implementation of 8- tap FIR filter, (i) pipelined using MAC units and (ii) parallel using two MAC units. Draw block diagrams.
2. Identify the addressing modes of the operands in each of the following instructions & their operations i)ADD B ii) ADD #1234h iii) ADD 5678h iv) ADD +*addreg
3. Explain guard bits in a MAC unit of DSP. Consider a MAC unit whose inputs are 24-bit numbers. How many guard bits should be provided if 512 products have to be added in the accumulator to prevent overflow condition? What is the overall size of the accumulator required?
4. The 256 unsigned numbers, 16 bit each are to be summed up in a processor. How many guard bits are needed to prevent overflow.

Course Outcome 3 (CO3):

1. Describe the importance of Q-notation in DSP algorithm implementation with examples. What are the values represented by 16- bit fixed point number N=4000h in Q15, Q10, Q7 notations?
2. What is the drawback of using linear interpolation for implementing of an FIR filter in TMS320C54XX processor? Show the memory organization for the filter implementation.
3. Determine the number of stages and number of butterflies in each stage and the total number of butterflies needed for the entire computation of 512 point FFT.
4. A DSP has a circular buffer with the start and the end addresses as 0200h and 020Fh respectively. What would be the new values of the address pointer of the buffer if, in the course of address computation, it gets updated to a. 0212h b. 01FCh Buffer Length= (EAR-SAR+1) = 020F-0200+1=10h a. New Address Pointer= Updated Pointer-buffer length = 0212-10=0202h b. New Address Pointer= Updated Pointer+ buffer length = 01FC+10=020Ch

Course Outcome 4(CO4):

1. Explain an interface between an A/D converter and the TMS320C54XX processor in the programmed I/O mode.
2. Describe DMA with respect to TMS320C54XX processors.
3. What are interrupts? How interrupts are handled by C54xx DSP Processors
4. Describe the pipelining operation of TMS320C54XX processors.

Course Outcome 5(CO5):

1. Explain with a neat diagram, the synchronous serial interface between the C54xx and a CODEC device. Explain the operation of pulse position modulation (PPM) to encode two biomedical signals.
2. Draw the I/O interface timing diagram for read – write read sequence of operation
3. Design a data memory system with address range 000800h – 000fffh for a c5416 processor using 2kx8 SRAM memory chips

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____ __	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIFTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT393			
Course Name: Digital Signal Processors			
Max. Marks: 100			Duration: 3 Hours
PART A			
Answer all questions. Each question carries 3 marks			
1		With a neat diagram explain the scheme of the DSP system	
2		Why signal sampling is required? Explain the sampling process	
3		With an example explain the need for the low pass filter in decimation process	
4		Why circular buffers are required in DSP processor? How they are implemented?	
5		Describe Host Port Interface and explain its signals	
6		Write the subroutine for bit reversed address generation.	
7		Explain, how scaling prevents overflow conditions in the butterfly computation	
8		Describe DMA with respect to TMS320C54XX processors	
9		Draw the I/O interface timing diagram for read – write read sequence of operation. Draw the block diagram of JPEG algorithm	

10		With a neat diagram explain the scheme of the DSP system	
PART B			
11	a)	Assuming X(K) as a complex sequence determine the number of complex real multiplies for computing IDFT using direct and Radix-2 FT algorithms.	8
	b)	Explain the two method of sampling rate conversions used in DSP system, with suitable block diagrams and examples. Draw the corresponding spectrum	6
		OR	
12	a)	Explain how to simulate the impulse responses of FIR and IIR filters.	5
	b)	Define decimation and interpolation process. Explain them using block diagrams and equations. With a neat diagram explain the scheme of a DSP system	9
13	a)	Explain the operation used in DSP to increase the sampling rate. The sequence x(n)=[0,2,4,6,8] is interpolated using interpolation sequence bk =[1/2,1,1/2] and the interpolation factor is 2.find the interpolated sequence y(m).	10
	b)	Define decimation and interpolation process. Explain them using block diagrams and equations	4
		OR	
14	a)	Compare architectural features of TMS320C25 and DSP6000 fixed point digital signal processors	14
15	a)	Explain the direct addressing mode of the TMS320C54XX processor with the help of a block diagram	14
		OR	
16	a)	Describe any four data addressing modes of TMS320c54xx processor	7
	b)	Why circular buffers are required in DSP processor? How they are implemented?	7
17	a)	Describe the pipelining operation of TMS320C54XX processors.	7
	b)	Explain the operation of serial I/O ports and hardware timer of TMS320C54XX on chip peripherals.	7
		OR	
18	a)	Describe the operation of the following instructions of TMS 320c54xx processor, with example Describe the operation of hardware timer with neat diagram	7
	b)	Determine the number of stages and number of butterflies in each stage and the total number of butterflies needed for the entire computation of 512 point	7

		FFT.	
		OR	
19	a)	Explain how the bit reversed index generation can be done in 8 pt FFT. Also write a TMS320C54xx program for 8 pt DIT-FFT bit reversed index generation	14
		OR	
20	a)	Explain DSP based biotelemetry receiver system, with the help of a block schematic diagram	7
	b)	Explain PCM3002 CODEC, with the help of neat block diagram	7

Syllabus

Module 1

Introduction To Digital Signal Processing: Introduction, A Digital Signal Processing System, The Sampling Process, Discrete Time Sequences, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), Linear Time-Invariant Systems, Digital Filters, Decimation and Interpolation. Number formats for signals and coefficients in DSP systems, Dynamic Range and Precision, Sources of error in DSP implementations, A/D Conversion errors, DSP Computational errors, D/A Conversion Errors, Compensating filter.

Module 2

Architectures for Programmable DSP Devices: Basic Architectural features, DSP computational Building Blocks, Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit, Programmability and Program Execution, Speed issues Features for External interfacing.

Module 3

Programmable Digital Signal Processors: Commercial Digital signal-processing Devices, Data Addressing modes of TMS320C54XX DSPs, Data Addressing modes of TMS320C54XX Processors, Memory space of TMS320C54XX Processors, Program Control, TMS320C54XX instructions and Programming, On-Chip peripherals, Interrupts of TMS320C54XX processors, Pipeline Operation of TMS320C54XX Processors.

Module 4

Implementation of Basic DSP Algorithms: The Q-notation, FIR Filters, IIR Filters, interpolation Filters, Decimation filters, PID Controller, Adaptive Filters, 2-D Signal Processing. An FFT Algorithm for DFT Computation, Overflow and Scaling, Bit-Reversed Index Generation & Implementation on the TMS32OC54xx

Module 5

Interfacing Memory and I/O Peripherals to Programmable DSP Devices: Memory space organization, External bus interfacing signals, Memory interface, parallel I/O interface, Programmed I/O, Direct Memory access (DMA). Multichannel buffered serial port (McBSP), McBSP Programming, a CODEC interface circuit, DSP Based Bio-telemetry Receiver

Text Books

1. S. Salivahanan, A. Vallavaraj. C. Gnanpriya, Digital signal processing -TMH-2nd, 2001.
2. Rabiner, Lawrence R., Bernard Gold, and C. K. Yuen. *Theory and application of digital signal processing*. Prentice-Hall, 2016.
3. Hinamoto, Takao, and Wu-Sheng Lu. *Digital Filter Design and Realization*. River Publishers, 2017.
4. Singh, Avtar, and Srini Srinivasan. *Digital signal processing implementations: using DSP microprocessors with examples from TMS320C54xx*. Cl-Engineering, 2004 .

Reference Books

1. Digital Signal Processing: A practical approach, Ifeachor E. C., Jervis B. W Pearson Education, PHI/ 2002
2. "Digital Signal Processors", B Venkataramani and M Bhaskar TMH, 2002
3. "Architectures for Digital Signal Processing", Peter Pirsch John Weily, 2007
4. Mitra, Sanjit Kumar, and YonghongKuo. *Digital signal processing: a computer-based approach*. Vol. 2. New York: McGraw-Hill, 2006.
5. Oppenheim, Alan V., John R. Buck, and Ronald W. Schafer. *Discrete-time signal processing. Vol. 2*. Upper Saddle River, NJ: Prentice Hall, 2001.
6. John G. Proakis, Digital signal processing principles – algorithms and applications - PHI-3rd edition 2002.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction, A Digital Signal Processing System,	1
1.2	The Sampling Process, Discrete Time Sequences, Discrete Fourier Transform(DFT) and Fast Fourier Transform (FFT)	1
1.3	Linear Time-Invariant Systems, Digital Filters	1
1.4	Decimation and Interpolation	1
1.5	Number formats for signals and coefficients in DSP systems, Dynamic Range and Precision, Sources of error in DSP	3

	implementations	
1.6	A/D Conversion errors, DSP Computational errors, D/A Conversion Errors, Compensating filter	2
2	**Module 2**	
2.1	Basic Architectural features, DSP computational Building Blocks,	2
2.2	Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit	3
2.3	Programmability and Program Execution	2
2.4	Speed issues Features for External interfacing.	2
3	**Module 3**	
3.1	Commercial Digital signal-processing Devices	1
3.2	Data Addressing modes of TMS320C54XX DSPs, Data Addressing modes of TMS320C54XX Processors,	2
3.3	Data Addressing modes of TMS320C54XX Processors, Memory space of TMS320C54XX Processors	2
3.4	Program Control, TMS320C54XX instructions and Programming,	2
3.5	On-Chip peripherals, Interrupts of TMS320C54XX processors	1
3.6	Pipeline Operation of TMS320C54XX Processors	1
4	**Module 4**	
4.1	The Q-notation	1
4.2	FIR Filters, IIR Filters	1
4.3	Interpolation Filters, Decimation filters	1
4.4	PID Controller, Adaptive Filters,2-D Signal Processing.	2
4.5	An FFT Algorithm for DFT Computation, Overflow and Scaling	2
4.6	Bit-Reversed Index Generation & Implementation on the TMS32OC54xx	2
5	**Module 5**	
5.1	Memory space organization, External bus interfacing signals	2
5.2	Memory interface, parallel I/O interface, Programmed I/O, Direct Memory access(DMA)	2
5.3	Multichannel buffered serial port (McBSP), McBSP Programming	2
5.4	CODEC interface circuit	1
5.5	DSP Based Bio-telemetry Receiver	1

BMT395	BIOMEDICAL NANOTECHNOLOGY IN SENSOR DEVELOPMENT	CATEGORY	L	T	P	CREDIT
		VAC	4	0	0	4

Preamble: Nanotechnology holds a great potential for revolutionizing the sensor arena. Traditional sensors are being re-engineered and recast from the nanotechnology perspective, and new sensor designs are being introduced. Sensitivity, detection range and response time of sensors have been remarkably ameliorated by using nanotechnological methods. Faster, better, cheaper and smaller sensors are becoming available. Sensor development in the nanotechnology age is highly significant. This course describes nano sensor development from the viewpoints of materials, fabrication techniques, and tools, nanodevices, and functionalities.

Prerequisite: A basic knowledge of physics, chemistry, biology, and nanotechnology is preferred and a understanding of nano sensors development.

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

CO 1	Appraise the new opportunities provided by nanotechnologies and the nanotechnology-enabled advancements in the field of sensors.
CO 2	Illustrate the fundamental properties at play in the structure and behaviour of nanomaterials used in the development of sensors
CO 3	Describe the challenges in effective integration and bio detection using novel nanomaterials and nano sensors.
CO 4	Comprehend the materials utilized for the fabrication of nano sensors and categorize nano sensors for biomedical applications

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3							2		3
CO2	3	3	3							2		3
CO3	3	3	3							2		3
CO4	3	3	3							2		3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	20	20	20
Apply	40	40	40
Analyse	40	40	40
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 contains 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):

1. What are nanoparticles, nanotubes, and nanoplates?
2. Describe the applications and challenges in nanotechnologies
3. Write a note on thin-films properties and their typical applications

Course Outcome 2 (CO2)

1. How nanomaterials are classified into different types on the basis of their dimensions?

2. Calculate the wavelength of a photon when the momentum of a fast-moving electron with a speed of 2:01 3 105m=s is equal to the momentum of the photon
3. Describe the techniques for the deposition of thin films

Course Outcome 3(CO3):

1. Why in the family of nanocarbon materials, graphene has emerged as a subject of enormous scientific interest?
2. Differentiate graphene-based enzymatic biosensors and graphene-based non enzymatic biosensors
3. Write a note on Biosensors based on carbon nanotubes and their hybrids

Course Outcome 4 (CO4):

1. Write a note on metals utilized for the fabrication of nano sensors
2. Define and Classification of Nano sensors for Biomedical applications
3. Describe the measurands for physical, chemical, and biological sensors

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____ ___	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIFTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT395			
Course Name: BIOMEDICAL NANOTECHNOLOGY IN SENSOR DEVELOPMENT			
Max. Marks: 100			Duration: 3 Hours
PART A			
Answer all questions. Each question carries 3 marks			
1		What is nanoscience and nanotechnology?	
2		How are nanoparticles classified?	
3		Describe Nitride-Based Nanomaterial	
4		Differentiate graphene-based enzymatic biosensors and graphene-based non enzymatic biosensors	
5		How does transmission electron microscope (TEM) differ from SEM in	

		producing an image?	
6		What is micro injection moulding?	
7		List the techniques for synthesis of nanoparticles	
8		Differentiate surface and bulk micromachining processes	
9		What are the applications of QCM?	
10		How is a nanosized thermocouple junction made?	
PART B			
11	a)	Write a note on various types of nanoparticles	14
		OR	
12	a)	Describe the application areas of Nanotechnology	14
13	a)	Describe the biosensing application of Nitride-based nanomaterials	14
		OR	
14	a)	What are the desirable characteristics of Metal and Metal Oxide Nanostructure for the development of a biosensor?	14
15	a)	What are the distinguishing features of AFM in relation to other microscopes?	14
		OR	
16	a)	How does a scanning electron microscope (SEM) produce the picture of the surface of an object?	14
17	a)	What does LIGA stand for? What are the uses of micro/ nanostructures produced by the LIGA process?	14
		OR	
18	a)	Describe the features, advantages and disadvantages of different silicon etchants for bulk micromachining	14
19	a)	Draw the cross-sectional view of PZT-transducer cantilever for mass sensing and explain the working principle.	14
		OR	
20	a)	With the help of neat sketches, describe the steps in the fabrication of colloidal gold sensor ship	14

Module 1

Introduction to nanoscience and nanotechnology- an overview of biomedical applications of nanotechnology, introduction to nanomaterials - Nanometre scale, nanoparticles and types of nanoparticles, nanomaterials, classification of nanomaterials, quantum effects, quantum dots, surfaces and interfaces of nanomaterials.

Module 2

Novel nanomaterials for Biosensor development - Introduction, Graphene and Its Composites Based Biosensor, Carbon Nanotubes - types, carbon nanotubes as biosensors, Nitride-Based materials and Biosensors, Metals and Metal Oxide Nanoparticles, semiconductor materials for Biosensors - fundamental characteristics of metallic nanoparticles and metal oxide nanostructures. polymeric nanomaterials for biosensors - types, basic properties and applications. Inorganic Nanowires and nano porous materials.

Module 3

Introduction to nano sensor - fundamentals of physical, chemical and biological nano sensors, definition, classifications, basics of semiconductor electronics, Microcantilever and Nanocantilever based nano sensors, Analytical and Characterization tools - principles and applications of STM, AFM, Auger Electron Spectroscopy, X-Ray Diffraction spectroscopy.

Module 4

Fundamental techniques and processes in nano sensor developments - synthesis of nanoparticles - gold nanoparticles, silver nanoparticles, semiconductor nanoparticles and carbon nanotubes. Fundamentals of MEMS and NEMS - LIGA process, micro injection moulding, micromachining, photolithography, ion implantation, etching process - types and applications.

Module 5

Types of nano sensors - mechanical nano sensors - types of displacement sensors, basics of Fabry–PerotElectron.Tunneling Displacement Nano sensor and Magnetomotive Displacement Nano sensor, Thermal nano sensors - types and applications, principles of Nano calorimetry - Optical nano sensors- Fabry–Perot concept, fibre optic nano sensors and it's applications, - Types and biomedical applications of Magnetics nano sensors - basics of nano biosensor and applications.

Text Books

1. Tahir Iqbal Awan, Almas Bashir, Aqsa Tahseen, “Chemistry of Nanomaterials: Fundamentals and Applications”, Elsevier, Year: 2020, ISBN: 0128189088,9780128189085

2. Aiguo Wu, Waheed S. Khan, “Nano biosensors: From Design to Applications “, Vch Pub, Year: 2019, ISBN: 3527345108,9783527345106
3. Vinod Kumar Khanna, “Nano sensors: Physical, Chemical, and Biological”, CRC Press, 2021

Reference Books

1. Neelina H. Malsch, “BIOMEDICAL, NANOTECHNOLOGY”, CRC PRESS,2005
2. Ezzat G. Bakhoum, “Micro- and Nano-Scale Sensors and Transducers”, CRC PRESS,2015

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction to nanoscience and nanotechnology,	2
1.2	Overview of biomedical applications of nanotechnology	1
1.3	Introduction to nanomaterials - nano meter scale, nanoparticles and types of nanoparticles	1
1.4	Nanomaterials, classification of nanomaterials	1
1.5	Quantum effects, quantum dot	2
1.6	Surfaces, and interfaces of nanomaterials.	2
2	**Module 2**	
2.1	Novel nanomaterials for Biosensor development - Introduction	1
2.2	Graphene and Its Composites Based Biosensor	1
2.3	Carbon Nanotubes - types, carbon nanotubes as biosensors, Nitride-Based materials and Biosensors	1
2.4	Metals and Metal Oxide Nanoparticles, semiconductor materials for Biosensors	2
2.5	Fundamental characteristics of metallic nanoparticles and metal oxide nanostructures	2
2.6	Polymeric nanomaterials for biosensors - types, basic properties and applications. Inorganic Nanowires and nano porous materials.	2
3	**Module 3**	

3.1	Introduction to nano sensor - fundamentals of physical, chemical and biological nano sensors, definition, classifications	2
3.2	Basics of semiconductor electronics, Microcantilever and Nanocantilever based nano sensors	3
3.3	Analytical and Characterization tools - Principles and applications of STM, AFM, Auger Electron Spectroscopy, X-Ray Diffraction spectroscopy	4
4	**Module 4**	
4.1	Fundamental techniques and processes in nano sensor developments	1
4.2	Synthesis of nanoparticles - gold nanoparticles, silver nanoparticles, semiconductor nanoparticles and carbon nanotubes.	2
4.3	Fundamentals of MEMS and NEMS	2
4.4	LIGA process, micro injection moulding, micromachining	2
4.5	Photolithography, ion implantation, etching process - types and applications.	2
5	**Module 5**	
5.1	Types of nano sensors - mechanical nano sensors - types of displacement sensors, basics of Fabry–PerotElectron.Tunneling Displacement	1
5.2	Nano sensor and Magnetomotive Displacement Nano sensor,	1
5.3	Thermal nano sensors - types and applications, principles of nano calorimetry	2
	Thermal nano sensors - types and applications	2
5.4	Principles of Optical nano sensors- Fabry–Perot concept, fibre optic nano sensors and it's applications, -	2
5.5	Types and biomedical applications of Magnetics nano sensors - basics of nano biosensor and applications.	1

BMT397	PROGRAMING USING PYTHON	CATEGORY	L	T	P	CREDI T
		VAC	4	0	0	4

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Preamble: The main objective of this course focuses on developing the python programming to do a variety of programming tasks where the students are encouraged to develop applications using python. At the end of the course the student will be developing adequate skills in programming and will be able to implement various applications using python.

Prerequisite: Nil

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

CO 1	Design programs with interactive Input and Output, utilizing arithmetic expression repetitions, decision making and arrays.
CO 2	Design modular Python programs using functions and develop recursive solutions.
CO 3	Develop programs using strings.
CO 4	Extend the Object-oriented concept and the file functions in Python.
CO 5	Interpret the multithread and synchronization.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1							3
CO2	2	3	3	3	2							3
CO3	3	3	3	3	2							3
CO4	3	3	3	3	2							3
CO5	3	3	3	3	2							3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	10	10	20
Apply	20	20	40
Analyse	15	15	30
Evaluate	5	5	10
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

Internal Examination Pattern: Each of the two internal examinations has to be conducted out of 50 marks. First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

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 a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Course Level Assessment

Questions Course Outcome

Course Outcome (CO1)

1. Explain about various data types used in python.
2. Differentiate between while and do while.
3. Explain control statements with examples

Course Outcome 2(CO2):

1. What is recursion?
2. Write a python function to generate prime numbers up to n.
3. Describe type conversion and coercion.

Course Outcome 3 (CO3):

1. Explain various methods of dictionary types.
2. Write a python code to check whether two strings are equal or not.
3. Write a python code to add two matrices using list

Course Outcome 4 (CO4):

1. Write notes on Class, Attributes and Instances with suitable examples.
2. Describe the use of try-except method in Python with suitable illustration.
3. List out the functions used for file related operations in Python.

Course Outcome 5 (CO5):

1. Explain the various types of concurrencies.
2. Write a program that calculates the squares and cubes of first 6 odd numbers through functions that are executed sequentially. Incorporate a delay of 0.5 sec. after calculation of each square/cube value. Report the time required for execution of the program.
3. Write a program that runs a recursive factorial () function in 2 threads.

Model Question paper

			Total Pages: 3
Reg No.:_____		Name:_____ _____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY			
FIFTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT 397			
Course Name: PROGRAMING USING PYTHON			
Max. Marks: 100			Duration: 3 Hours
PART A			
Answer all questions. Each question carries 3 marks			

1		Define Keywords and Identifiers with examples	
2	a)	Which of the following is a valid variable name in python? 12xyz ii) break ii) A_123 iv) A? B? C?	
	b)	Evaluate the expression x**y**z given x=2, y=3, z=2	
3		Differentiate between type conversion and coercion	
4		Write a python programme to find the area of a circle using functions	
5		Discuss the following functions	
	a)	Len()	
	b)	sum ()	
	c)	any ()	
6		Differentiate between tuple and list	
7		What is the support provided by Python to handle exceptions	
8		What do you mean by Pickling in Python? Explain its significance with the help of example	
9		What is the difference between multi-processing and multi-threading?	
10		What is the difference between a Lock and RLock?	

		PART B	
11	a)	Describe various Operators in Python.	(7)
	b)	Explain the basic data types available in Python with examples	(7)
		OR	
12	a)	Write Python Program to reverse a number and also find the Sum of digits in the reversed number.	(8)
	b)	Explain the need for **continue** and **break** statements. Write a program to check whether a number is prime or not	(6)
13	a)	Explain the function arguments in python.	(6)
	b)	Write a Python program to insert a new item before the second element in an existing array.	(8)
		OR	
14	a)	Define recursion with an example.	(7)
	b)	Write a python programme using function to generate first N prime numbers	(7)
15	a)	Enlist the salient features of python.	(7)
	b)	Describe the various components of health care analytics.	(7)
		OR	
16	a)	Write a Python program to input a string and perform the following operations. Reverse the string without using reverse () function. Check for a substring in the string. Find all the occurrences of a particular character in the string and print the indices at which the character appears.	(7)
	b)	What is a dictionary? With an example explain any five dictionary operations in python	(7)
17	a)	Explain the use of join () and split () string methods with examples.	(7)
	b)	Explain the various methods of Dictionary type with examples	(7)
		OR	
18	a)	What are the basic file operations and operating modes in Python? Explain.	(5)

	b)	Define a class in Python to store the details of students (roll Number, Mark1, Mark2), with the following methods: Read Data ()- to assign values to class attributes Compute Total ()– find the total marks Print details ()-to display the attribute values and the total marks Create an object of the class and invoke the methods.	(9)
19	a)	Write a python programme to read two matrices from two files, find the sum and display the resultant matrix	(14)
		OR	
20	a)	Write a program that reads the contents of 3 files a.txt, b.txt and c.txt sequentially and converts their contents in to uppercase and writes them into files aa.txt, bb.txt and cc.txt respectively. The program should report the time required in carrying out this conversion. The files a.txt, b.txt and c.txt should be added to the project and filled with some text. The program should receive the file names as command – line-arguments. Suspend the program for 0.5 seconds after reading a line from any file.	(11)
	b)	What is the purpose of the Semaphore synchronization primitive?	(3)

Syllabus

Module 1

Introduction to *Python*– Variables, Data types, Keywords, Literals, Input and Output Statements Operators, expressions and statements, evaluation of expressions, precedence, string operations, Control statements-If, if else, nested if, conditional statements-for loop, while, do-while, break and continue, tables

Module 2

Functions, calling functions, type conversion and coercion, composition of functions, mathematical functions, built in functions, user-defined functions, local variable, global variable, lambda functions, recursion, parameters and arguments, Python Module

Module 3

Python packages, Strings and lists– string traversal and comparison with examples. List operations with examples, tuples and dictionaries – operations and examples

Module 4

Files and exceptions - text files, directories Introduction to classes and objects - attributes,

instances, Python Constructors, Python Inheritance, Python Polymorphism, Python Abstraction. Python Encapsulation. Iterators and Generators

Module 5

Multi-threading – Types of Concurrencies, Types of Multi- threading, when to use Concurrency, Thread Properties, Launching Threads, Passing Parameters to a Thread Synchronization – Examples of sharing resources, Example of communication between threads, Mechanisms for sharing resources', lock, RLock, Semaphore, Mechanisms for inter thread communication, Event.

Text Books:

1. Downey, A. et al., How to think like a Computer Scientist: Learning with Python, John Wiley, 2015.
2. YashavantKanetkar and Aditya Kanetkar, Let Us Python 2nd Edition, Bpb publication. Jan 2020
3. Yashwant Kanetkar, AdityaKanetkar Lambert K. A., Let us python
4. Rajaraman, V. *Computer Basics and C Programming*. PHI Learning Pvt. Ltd., 2008.

References Books:

1. Barry, Paul. *Head first Python: A brain-friendly guide*. " O'Reilly Media, Inc.", 2016.
2. Dromey, R. Geoff. *How to Solve it by Computer*. Prentice-Hall, Inc., 1982.
3. Guzdial, Mark, and Barbara Ericson. *Introduction to computing and programming in python*. Pearson, 2016.
1. Perkovic, L., Introduction to Computing Using Python, 2/e, John Wiley, 2015
2. Sprankle, Maureen, and Jim Hubbard. *Problem solving & programming concepts*. Upper Saddle River, NJ: Pearson Prentice Hall,, 2012.
3. Venit, Stewart, and Elizabeth Drake. *Prelude to programming: concepts and design*. Pearson Education India, 2014.
4. Zelle, John M. *Python programming: an introduction to computer science*. Franklin, Beedle & Associates, Inc., 2004.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction to *Python*	1
1.2	variables, Keywords, Literals	1
1.3	Data types	1
1.4	Input and Output Statements	1
1.5	Operators	1
1.6	Evaluation of expressions, precedence of operator	1

1.7	String operations	1
1.8	Control statements-If, If else, Nested if	1
1.9	conditional statements- for loop, *while,* Do-while, Break and	1
2	**Module 2**	
2.1	Tables	1
2.2	Functions- calling functions	1
2.3	Type conversion and coercion.	1
2.4	composition of functions	1
2.5	mathematical functions	1
2.6	Built in functions	1
2.7	user-defined functions	1
2.8	Local variable, Global Variable	1
2.9	parameters and arguments	1
3	**Module 3**	
3.1	Python modules	1
3.2	Python packages	1
3.3	Strings and lists	1
3.4	String traversal and comparison with examples.	1
3.5	List operations with examples	1
3.6	Tuples	1
3.7	dictionaries operations and examples	1
4	**Module 4**	
4.1	Files, exceptions	1
4.2	text files, directories	1
4.3	Introduction to classes and objects	1
4.4	Attributes and instances	1
4.5	Python Constructors	1
4.6	Python Polymorphism,	1
4.7	Python Abstraction, Python Encapsulation	1
4.8	Python Inheritance	1
4.9	Iterators and Generators	1
5	**Module 5**	
5.1	Multi-threading – Types of Concurrencies	1
5.2	Types of Multi-threading, when to use Concurrency,	1
5.3	Thread Properties, Launching Threads	1
5.4	Passing Parameters to a Thread	1
5.5	Synchronization – Examples of sharing resources, Example of	1
5.6	Mechanisms for sharing resources', lock, RLock	1
5.7	Semaphore	1
5.8	Mechanisms for inter thread communication	1
5.9	Event	1

SEMESTER VI

BMT302	BIOMECHANICS	CATEGORY	L	T	P	CREDIT
		PCC	4	0	0	4

Preamble: Biomechanics uses the principles of mechanics for solving problems related to the structure and function of living organisms. This course aims to provide an overall exposure about Human Biomechanics and encourage understanding of physiological systems quantitatively for facilitating the development of Biomedical Systems.

Prerequisite: Concepts of Engineering Mechanics, Human Anatomy and Physiology

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

CO 1	Apply a broad and coherent knowledge of the underlying principles and concepts of Basic Biomechanics of Human Bone, Skeletal articulations, spine and upper-lower extremity movements.
CO 2	Analyse the Biomechanics of Human Skeletal Muscles.
CO 3	Apply bio-fluid mechanics knowledge to systematically analyse the blood-vascular system.
CO 4	Investigate the Biomechanics of Human Systems using Models of Physiological Systems.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2						2		3
CO2	3	3	3	2						2		3
CO3	3	3	3	2						2		3
CO4	3	3	3	2						2		3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	20	20	60
Apply	20	20	20
Analyse	10	10	20
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 (case study/problem solving) /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.

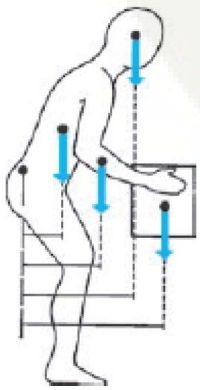
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. How much compressive stress is present on the L1, L2 vertebral disc of a 625 N woman, given that approximately 45% of body weight is supported by the disc (a) when she stands in anatomical position and (b) when she stands erect holding a 222 N suitcase? (Assume that the disc is oriented horizontally and that its surface area is 20 cm^2.)

2. Briefly describe about joint architecture

3. How much tension must be developed by the erector spinae with a moment arm of 6 cm from the L5-S1 joint center to maintain the body in a lifting position with segment moment arms as specified? (Segment weights are approximated for a 600 N (135 lb) person.)



SEGMENT	WT	MOMENT ARM	
head	50 N	22 m	
trunk	280 N	12 cm	
arms	65 N	25 cm	
box	100 N	42 cm	
Fm		6 cm	

4. How much tension must be developed by the erector spinae with a moment arm of 6 cm from the L5-S1 joint center to maintain the body in a lifting position with segment moment arms as specified? (Segment weights are approximated for a 600 N (135 lb) person.). Segment weight and distance from center of mass can be estimated by referring to the studies of Harless.

Course Outcome 2 (CO2)

1. Discuss pennate muscles. Why are they called pennate? How are pinnation angles determined? How can pinnated muscles be further classified? What is a pinnation plane? Give examples of pinnated muscles.

2. Draw a typical stress versus strain plot. Label the toe region, linear region, and plastic region. Describe internal behaviour as it passes through each region. What is the difference between tendon deformation in the toe region and in the linear region?

3. Define musculoskeletal redundancy. Define kinematic redundancy. Give example

Course Outcome 3(CO3):

1. Explain five attributes of the flow of fluids

2. The internal pressure of an elastic vessel, such as an artery, vein, eyeball, aneurysm, or balloon, can be estimated by pushing down on it with your finger; this method is called palpation: (a) Show that the pressure felt by the finger is affected by the tension in the vessel wall. (b) Show that the pressure you feel equals the pressure internal to the vessel when you push down on it so that the vessel wall is flat.

3. Why is blood pressure measured using major arteries in the upper arm, rather than those in the lower arm or leg?

4. Analyse blood flow rates and speeds in the circulatory system.

Course Outcome 4 (CO4):

1. Analyse the model for Heart-Lung pumping unit and illustrate equations which characterize the heart-lung-unit for Cardiac Output determined by RV Function, RV Saturates and LV limits C.O. (LV failure).

2. Elaborate about modelling the intact cardiovascular system by considering normal functioning of the cardiovascular system and cardiac output under abnormal conditions.

3. Examine the Electrical Circuit Model of the Ventricle and analyse the system during each phase of the cardiac cycle.

Model Question paper

			Total Pages: 2
Reg No.:_____		Name: _____	

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__

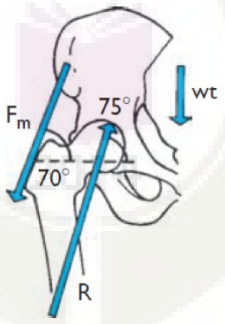
Course Code: BMT 302

Course Name: BIOMECHANICS

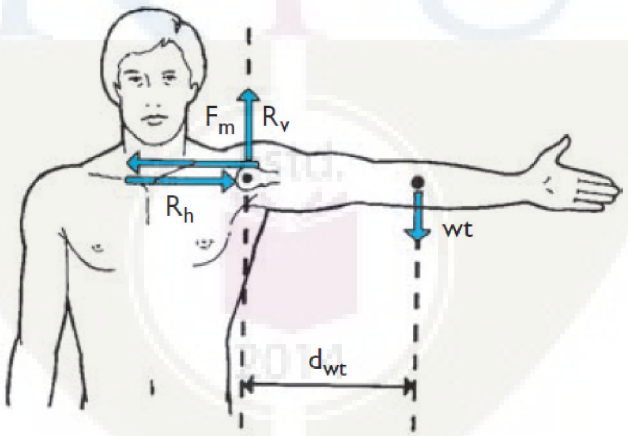
Max. Marks: 100		Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks

1		The tibia is the major weight-bearing bone in the lower extremity. If 88% of body mass is proximal to the knee joint, how much compressive force acts on each tibia when a 600 N person stands in anatomical position? How much compressive force acts on each tibia if the person holds a 20 N sack of groceries?	
2		Illustrate the biomechanics of Bone Modelling and Remodelling	
3		Muscles are sometimes considered composite material, explain. Provide an example of nonorganic composite material comparable to muscle	
4		Define and compare PCSA and anatomical cross-sectional area of a muscle. How is the PCSA of a muscle determined?	
5		Explain about Lordosis, Kyphosis and Scoliosis.	
6		How much compression acts on the hip during two-legged standing, given that the joint supports 250 N of body weight and the abductor muscles are producing 600 N of tension? 	
7		List-out the properties of blood.	
8		Assuming no viscosity and no changes in height, determine how the flow speed in a vessel changes if its diameter decreases by a factor of 4.	
9		Explain the concept of Vascular Resistance and Vascular Capacitance	
10		Interpret the Effect of Intrathoracic Pressure by Incorporation of Transthoracic Pressure into Variable Capacitor Model.	

PART B

11	a)	Analyse composition and structure of bone tissue. Illustrate biomechanics of bone growth and development	14
		OR	
12	a)	Derive and compare Maxwell, Voigt and Kelvin Models of viscoelasticity	14
13	a)	Discuss Hill's force velocity curve (parametric force-velocity relation). Write Hill's equation and explain its meaning	14
		OR	
14	a)	Analyse force transmission and associated internal deformations in muscle fibres.	14
15	a)	Explain in detail about human GAIT Cycle with descriptions about Components of the Swing and Stance Phase of walking, temporal factors, centre of mass displacement, Range of motion at the joints and Gait Cycle for running.	14
		OR	
16	a)	Using the simplifying assumptions of Poppen and Walker, a free body diagram of the arm and shoulder can be constructed as shown below. If the weight of the arm is 33 N, the moment arm for the total arm segment is 30 cm, and the moment arm for the deltoid muscle (Fm) is 3 cm, how much force must be supplied by the deltoid to maintain the arm in this position? What is the magnitude of the horizontal component of the joint reaction force (Rh)? 	14
17	a)	Analyse Pressure Drops in Arteries and Resistive Vessels.	14
		OR	
18	a)	Illustrate modelling Flow in Blood Vessels	14
19	a)	Demonstrate a Lumped Parameter Model of the Peripheral Circulation and develop Windkessel model.	14
		OR	

20	a)	Examine the Variable Capacitor Model and analyse the Electrical Circuit Model of the Ventricle for each phase of the cardiac cycle.	14

Syllabus

Module 1

Introduction to Biomechanics: Definition and perspective- Statics of the Body and Total body equilibrium- equilibrium of individual body components -Kinematic Concepts for Analysing Human Motion -Kinetic Concepts for Analysing Human Motion – Anthropometry. Models of viscoelasticity of tissues (Maxwell, Voigt, Kelvin).**Human Bone Biomechanics:** Composition and structure of bone tissue- Bone Growth and Development- Modelling and Remodelling of bones (Wolfe's law of bone remodelling) – Biomechanics of Bone Fractures and fixation (External and Internal fixation). **Biomechanics of human skeletal articulations**- joint architecture- joint flexibility- neuromuscular response to stretch- joint injuries and pathologies

Module 2

Muscle mechanics: Muscle architecture and mechanics ; Muscle fascicles and their arrangement – Fiber architecture in fascicles – Muscle as a fibre reinforced composite – Muscle centroids – Muscle Cross sectional areas (Physiological & Anatomical) – Properties of tendons and passive muscles; Viscoelastic behaviour of tendons – Tendon interaction with surrounding tissues – Mechanical properties of passive muscles-Mechanics of Active muscle; Muscle force production and transmission – Functional relations (Force - length, Force – Velocity curves), History effects in muscle mechanics – Hill's model– Sliding filament theory -Muscle coordination – Problem of motor redundancy – Approach to studying muscle force production using optimization (forward and inverse)

Module 3

Biomechanics of the Human Upper and Lower Extremity: loads on the shoulder - loads on the elbow- loads on the hip - loads on the knee- loads on the foot –GAIT Cycle (Components of the Swing and Stance Phase of walking, temporal factors, centre of mass displacement, Range of motion at the joints, Gait Cycle for running). **Biomechanics of the Human Spine**: structure of the spine- spinal curves and abnormal spinal curvatures (lordosis, kyphosis, scoliosis) - loads on the spine - stress fractures.

Module 4

Fluid Mechanics Principles (Review only): Law of Laplace- Fluids in Motion- Equation of Continuity- Bernoulli's Equation- Interactions among the Flow Parameters- Viscous Flow and Poiseuille's Law- Approach to Steady Flow- Flow of Objects in Fluids: Drag and Lift.**Basic Bio fluid Mechanics**: Properties of Blood- Structure of Blood Vessels- Blood Pressure- Flow in Curving Tubes such as Arteries- Measuring Flow in Blood Vessels-

Modelling Flow in Blood Vessels- Pressure Drops in Arteries and Resistive Vessels - Blood Flow Rates and Speeds.

Module 5

Models of the Cardiovascular System: Vascular Resistance & Capacitance - Lumped Parameter Model of the Peripheral Circulation- Windkessel Simplification- Heart as a Pump - Variable Capacitor Model of the Heart - Modelling the Intact Cardiovascular System for Normal Functioning and Under Abnormal Conditions.

Text Books

1. Vladimir M. Zatsiorsky and Boris I. Prilutsky, Biomechanics of Skeletal Muscles, Human Kinetics, 2012.
2. Susan J. Hall, Basic Biomechanics, McGraw-Hill, 6th ed, 2012.
3. Irving P. Herman, Physics of the Human Body, Springer-Verlag Berlin Heidelberg, 2007.

Reference Books

1. Caro, L.G., et al. The Mechanics of the Circulation, Oxford University Press, Second Edition, 2012
2. Fung, Y.C., Biodynamics: Circulation. Springer-Verlag, 1984.
3. Holt, J.P., Flow through collapsible tubes and through in situ veins. Trans. Biomed. Eng. BME-16: 274-283, 1969.
4. Sagawa, K. Comparative models of overall circulatory mechanics. Advances in Biomedical Engineering JHU Brown and J. Dickson. Academic Press Vol. 3, ed., pp. 1-95, 1973.
5. Sunagawa, K. and Sagawa, K. Models of ventricular contraction based on time-varying elastance. CRC Critical Reviews in Biomedical Engineering, vol. 7, issue 3, 1982.
6. Fung, Y.C., Biomechanics: Mechanical Properties of Living Tissues, Springer-Verlag, 2nd ed, 2020
7. Fung, Y.C., Biomechanics: Motion, Flow, Stress, and Growth, Springer-Verlag, 1998
8. Fung, Y.C., Biomechanics: Circulation, Springer-Verlag, 2nd ed, 1998

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Definition and perspective- Statics of the Body and Total body equilibrium- equilibrium of individual body components (problems)	1
1.2	Kinematic Concepts for Analysing Human Motion Kinetic Concepts for Analysing Human Motion – Anthropometry	1
1.3	Models of viscoelasticity of tissues (Maxwell, Voigt, Kelvin)	1
1.4	Composition and structure of bone tissue- Bone Growth and Development	1
1.5	Modelling and Remodelling of bones (Wolfe's law of bone remodelling)	1
1.6	Biomechanics of Bone Fractures and fixation (External and Internal fixation)	2
1.7	joint architecture- joint flexibility- neuromuscular response to stretch- joint injuries and pathologies	2
2	**Module 2**	
2.1	Muscle architecture and mechanics; Muscle fascicles and their arrangement – Fiber architecture in fascicles – Muscle as a fiber reinforced composite – Muscle centroids – Muscle Cross sectional areas (Physiological & Anatomical)	3
2.2	Properties of tendons and passive muscles; Viscoelastic behaviour of tendons – Tendon interaction with surrounding tissues – Mechanical properties of passive muscles-Mechanics of Active muscle;	3
2.3	Mechanics of Active muscle; Muscle force production and transmission- Functional relations (Force - length, Force – Velocity curves), History effects in muscle mechanics	3
2.4	Hill's model	1
2.5	Muscle coordination – Problem of motor redundancy – Approach to studying muscle force production using optimization (forward and inverse)	2
3	**Module 3**	
3.1	loads on the shoulder(problems)- loads on the elbow (problems)	2
3.2	loads on the hip(problems) - loads on the knee(problems)- loads on the foot(problems)	2
3.3	GAIT Cycle (Components of the Swing and Stance Phase of walking, temporal factors, centre of mass displacement, Range of motion at the joints, Gait Cycle for running)	2
3.4	structure of the spine- spinal curves and abnormal spinal curvatures	1

3.5	loads on the spine(problems) - stress fractures	2
4	**Module 4**	
4.1	Law of Laplace- Fluids in Motion- Equation of Continuity- Bernoulli's Equation- Interactions among the Flow Parameters- Viscous Flow and Poiseuille's Law- Approach to Steady Flow- Flow of Objects in Fluids: Drag and Lift.	2
4.2	Properties of Blood- Structure of Blood Vessels- Blood Pressure	2
4.3	Flow in Curving Tubes such as Arteries- Measuring Flow in Blood Vessels- Modelling Flow in Blood Vessels	3
4.4	Blood Flow Rates and Speeds.	2
5	**Module 5**	
5.1	Vascular Resistance & Capacitance - Lumped Parameter Model of the Peripheral Circulation- Windkessel Simplification	2
5.2	Heart as a Pump - Variable Capacitor Model of the Heart	2
5.3	Modelling the Intact Cardiovascular System for Normal Functioning and Under Abnormal Conditions	2

BMT304	THERAPEUTIC EQUIPMENTS	CATEGORY	L	T	P	CREDIT
		PCC	4	0	0	4

Preamble: To acquire knowledge about various therapeutic equipment's and their applications in the field of medical science.

Prerequisite: NIL

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

CO 1	Describe the working principle of therapeutic devices for cardiac assistance
CO 2	Analyzelife-support equipments in clinical field
CO 3	Describe the current stimulated therapeutic equipment's
CO 4	Analyze the working of drug delivery systems
CO 5	Describe specialized instruments to view and operate on the internal organs and vessels

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1							2		1
CO2	3	2	1							2		1
CO3	3	2	1							2		1
CO4	3	2	1							2		1
CO5	3	2	1							2		1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	10	10	20
Apply	20	20	40
Analyse	20	20	40
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):

1. What are the need for a cardiac pacemaker?
2. Explain pacer- cardioverter defibrillator.
3. Define IABP.

Course Outcome 2 (CO2):

1. Explain different ventilator modes.
2. List the different types of oxygenator.
3. Describe anesthesia machine.

Course Outcome 3(CO3):

1. Describe the working of neuro drills.
2. What are applications of TMS.
3. Explain about deep brain simulators.

Course Outcome 4(CO4):

1. Explain drug delivery.
2. What are the drug infusion devices?
3. Illustrate the working of dialysis machine.

Course Outcome 5(CO5):

1. Define stroboscope
2. What are the different cryotherapy techniques.
3. Explain about fibre optic endoscope.

Model Question paper

			Total Pages: 3
Reg No.: _____		Name: _____	

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__

Course Code: BMT 304

Course Name: THERAPEUTIC EQUIPMENTS

Max. Marks: 100		Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks

1		What are the two types of pacemaker?	
2		Define defibrillator.	
3		Define HLM.	
4		What is the purpose of flow sensor?	
5		Define TENS.	
6		Mention the use of neuro drills.	
7		What is eelastomericiinfusers?	
8		Mention the basic principle of surgical diathermy.	
9		What is a capsule endoscope?	
10		Define arthroscopy.	
		PART B	
11	a)	What is cardiac pacemaker. Explain the two types of cardiac pacemaker with block diagram.	(14)
		OR	
12	a)	Explain external defibrillator in detail.	(7)
	b)	Describe in detail about Catheterization lab.	(7)
13	a)	Illustrate heart lung machine with a neat block diagram. Mention the operating principle.	(14)
		OR	
14	a)	With a neat diagram explain anaesthesia machine.	(14)
15	a)	Illustrate the working neuro navigation systems.	(14)
		OR	
16	b)	Explain	(14)

		I. Transcutaneous electrical nerve stimulation II. Electro surgical analysers	
17	a)	Explain the different approaches in drug delivery system.	(14)
		OR	
18	a)	Illustrate the working of dialysis machine with block diagram.	(14)
19	a)	What is endoscope? Explain fibre optics endoscopy with diagram.	(14)
		OR	
20	a)	Explain in detail I. Cryotherapy techniques II. Operating microscope	(14)

Syllabus

Module 1

Cardiac pacemakers: different modes of operation, external and implantable pacemakers, pacemaker standard codes. Need for cardiac pacemaker.**Defibrillator:** AC and DC defibrillator – Need for defibrillator – basic principle. Implantable defibrillator and automated external defibrillator (AED) – functional block diagram. Pacer- cardioverter defibrillator – block diagram, defibrillator analysers. Catheterization - IABP, Stents.

Module 2

Ventilators: Types of ventilators, Differentventilator operational and therapy modes. Flow sensors and FiO2 sensor. Heart lung machine (HLM) – principle of operation-functional block diagram - types of oxygenators. Extracorporeal membrane oxygenation (ECMO) machine.**Anaesthetic machines:** Block diagram and working. Need of anaesthesia, gas used and their sources, Gas blending and vaporizers, Anaesthesia delivery system, breathing circuit. Computer aided anaesthesia control.

Module 3

Surgical diathermy unit: Basic principle and working,electrodes and safety aspects in electrosurgical units, Electro-surgical analysers, Neuro drills, Neuro navigation systems, Intra operative nerve monitors, Deep brain simulators. Laser surgery applications in ophthalmology, Short wave diathermy, Ultrasonic therapy unit, Interferential current therapy, Transcutaneous electrical nerve stimulation (TENS) - applications. Transcranial magnetic stimulation- applications.

Module 4

Drug delivery systems: Different approaches for drug delivery, Drug infusion devices - Gravity Drip Systems, Infusion pump, Syringe pump, Implantable pumps, Patient Controlled Analgesia (PCA) Pumps, Elastomeric Infusers. Recent developments in drug infusion systems.
Dialysis machine: Block diagram and working.

Module 5

Endoscopy: Principles, types &applications. Block diagram of a fibre optic endoscope with integral TV cameras. Laparoscopes,Gastro endoscope, Bbronchoscope, Stroboscope, Capsule endoscopy, Cryo-surgery techniques and application. Operating microscope, arthroscopy. Modern lithotripter system, laser lithotripsy.
Photo therapy unit

Text Books

1. Bronzino, Joseph D., and Donald R. Peterson. Biomedical engineering fundamentals. CRC press, 2014.
2. Kramme, Rüdiger, Klaus-Peter Hoffmann, and Robert Steven Pozos, eds. Springer handbook of medical technology. Springer Science & Business Media, 2011.
3. Lei, Yuan. Medical Ventilator System Basics: A Clinical Guide. Oxford University Press, 2017.
4. Khandpur, Raghbir Singh. Handbook of biomedical instrumentation. McGraw-Hill Education, 2004
5. Webster, John G. Encyclopaedia of medical devices and instrumentation. Vol. 4. Wiley-Interscience, 1988.

Reference Books

1. Webster, John G., ed. Medical instrumentation: application and design. John Wiley & Sons, 2009.
2. Mushin, William Woolf. "Automatic ventilation of the lungs." (1980).
3. Joseph J. Carr, John M. Brown, Introduction to Biomedical Equipment Technology, Pearson Education (Singapore) Pvt. Ltd., 2001.
4. Geddes & Baker, Principles of Applied Biomedical Instrumentation Wiley, 1989 Biomedical Engineering Handbook, CRC Press, 1995

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Cardiac pacemakers: different modes of operation, external and implantable pacemakers, pacemaker standard codes. Need for cardiac pacemaker.	3
1.2	Defibrillator: AC and DC defibrillator – Need for defibrillator – basic principle. Implantable defibrillator and automated external defibrillator (AED) – functional block diagram.	3
1.3	Pacer- cardioverter defibrillator – block diagram, defibrillator analysers. Catheterization - IABP, Stents.	3
2	**Module 2**	
2.1	Ventilators: Types of ventilators, Differentventilator operational and therapy modes. Flow sensors and FiO2 sensor. Extracorporeal membrane oxygenation (ECMO) machine.	2
2.2	Heart lung machine (HLM) – principle of operation-functional block diagram - types of oxygenator.	1
2.3	Anaesthetic machines: block diagram and working. Need of anaesthesia, gas used and their sources, Gas blending and vaporizers	3
2.4	Anaesthesia delivery system, breathing circuit. Computer aided anaesthesia control	3
3	**Module 3**	
3.1	Surgical diathermy unit. –Basic principle and working, electrodes and safety aspects in electrosurgical units, Electro-surgical analysers	2
3.2	Neuro drills, Neuro navigation systems, Intra operative nerve monitors, Deep brain simulators.	2
3.3	Laser surgery applications in ophthalmology, Short wave diathermy, Ultrasonic therapy unit, Interferential current therapy	3
3.4	Transcutaneous electrical nerve stimulation (TENS) - applications. Transcranial magnetic stimulation- applications.	2
4	Module 4	
4.1	Drug delivery systems – Different approaches for drug delivery, Drug infusion devices - Gravity Drip Systems, Infusion pump, Syringe pump, Implantable pumps	4
4.2	Patient Controlled Analgesia (PCA) Pumps, Elastomeric Infusers. Recent developments in drug infusion systems.	3
4.3	Dialysis machine – Block diagram and working.	1
5	**Module 5**	
5.1	Endoscopy – Principles, types & applications.	2
5.2	Block diagram of a fibre optic endoscope with integral TV cameras.	2
5.3	Laparoscopes,Gastro endoscope, bronchoscope, Stroboscope,	3

	Capsule endoscopy, Cryotherapy techniques and application.	
5.4	Operating microscope, arthroscopy. Modern lithotripter system- laser lithotripsy.	2
5.5	Photo therapy unit	1

BMT306	PRINCIPLES OF MEDICAL IMAGING	CATEGORY	L	T	P	CREDIT
		PCC	4	0	0	4

Preamble: The course introduces the principles of biomedical imaging modalities such as Ultrasonic imaging, X-Ray-Computed tomography, Magnetic Resonance Imaging, Molecular imaging - SPECT & PET, Hybrid imaging- PET-CT, PET-MR, Cath Lab, Infrared imaging, Tactile and Photoacoustic imaging.

Prerequisite: The students should have a knowledge in Biophysics.

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

CO 1	Describe the operating principle, instrumentation and imaging techniques of diagnostic Ultrasound.
CO 2	Discuss the operating principle, instrumentation and imaging techniques of Magnetic Resonance Imaging
CO 3	Analyse the operating principle, instrumentation and imaging techniques of X-Ray Computed Tomography, Cath Lab, and molecular imaging modalities
CO 4	Outline the concept of Infrared, Tactile and Photoacoustic imaging modalities.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3				2			2	2		2
CO2	3	3				2				2		2
CO3	3	3				2	3		2	2		2
CO4	3									2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	10	10	35
Apply	10	10	20
Analyse	30	30	45
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):

1. Justify the suitability of ultrasound in gynaecology. Identify the procedure for PNDT approvaland its relevance in Indian scenario.
2. Explain the significance of acoustic impedance in ultrasound imaging. What is the difference between acoustic impedance and acoustic absorption?
3. Discuss the Stefan-Boltzmann law.
4. List the basic principles of ultrasound propagation in tissue. Describe at least 5 with suitable equations
5. Explain why bone and gas limit the areas of clinical application of ultrasound
6. What are the essential elements of a complete B-mode system, and describe how the B-mode amplitude information can be processed?
7. List the sources of errors in US systems

Course Outcome 2 (CO2):

1. Describe the components of a clinical MRI system. Give detailed description of the functions of individual components.
2. Illustrate the instrumentation of a typical MRI machine with the help of a block diagram

3. Consider an emergency situation where a patient is sandwiched between the main superconducting magnet of an MRI and a metal wheelchair with “missile effect”. Identify the emergency rescue system arranged in an MRI room for such a situation and illustrate the working of the same. Also estimate the approximate financial loss for the imaging center to operate the rescue system with proper justification.

4. Discuss the proton density weighted imaging and compare the image obtained with T1 weighted and T2 weighted images.

Course Outcome 3(CO3):

1. Referring appropriate literature, prepare a write up about the parameters to be checked in the quality assurance of Computed Tomography equipment for ensuring compliance with respective standards and specifications. Also, describe the test procedures and significance of such tests.

2. Analyse iterative reconstruction techniques versus filtered back projection in CT image reconstruction.

3. Illustrate the fan beam algorithm in spiral CT.

4. Discuss the working of a gamma camera.

5. Identify relevant standards and prepare a rough sketch and a project report for a room to install PET-CT Machine based on AERB regulations in India.

Course Outcome 4 (CO4):

1. Justify the purpose of Cath Lab

2. Illustrate the principles of Tactile Imaging

3. List out the applications of Photoacoustic Imaging

4. Differentiate the thermal and photon detectors in infrared imaging.

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____ ___	

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__

Course Code: BMT306

Course Name: PRINCIPLES OF MEDICAL IMAGING

Max. Marks: 100		Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks

1		Discuss the relation between frequency of the ultrasound and resolution of imaging.	
2		Differentiate the concept of A, B and M scans in Ultrasound imaging.	
3		Explain the sequence of events which occur in spin echo imaging.	
4		Explain CT number used in computed tomography.	
5		Tabulate the differences between the T1 and T2 weighted imaging.	
6		Discuss the Radon transform for CT image reconstruction	
7		Describe the working of technetium generators.	
8		Discuss the working of pulse height analysers.	
9		Discuss the operation principles of pyroelectric detectors	
10		Detail the clinical applications of thermography in rheumatology.	
PART B			
11	a)	With a neat sketch, explain the block diagram of the ultrasound machine. Also discuss the functions of each part.	10
	b)	Investigate the suitability of ultrasound scan in obstetrics and gynaecology	4
		OR	
12	a)	What is the doppler effect? Derive the equations to analyse blood velocity with Doppler effect.	14
13	a)	Discuss the principles of sectional imaging CT.	14
		OR	
14	a)	Explain the working of spiral and multislice CT.	14
15	a)	Discuss the T1, T2 and T2* Relaxation processes with suitable diagrams	14
		OR	
16	a)	With the help of suitable diagrams explain the Image acquisition and reconstruction techniques in MRI	14

17	a)	Explain the principles of PET imaging.	14
		OR	
18	a)	Discuss the advantages of PET and SPECT imaging. List some radiotracers used in PET imaging and their applications.	14
		OR	
19	a)	What is the principle of thermography? Explain the constructional details of a vidicon camera.	14
		OR	
20	a)	Discuss the working of thermal infrared detectors.	14

Syllabus

Module 1

Diagnostic Ultrasound Imaging: Basic physics of ultrasound (Review Only): Wave nature, frequency, speed, wavelength, phase, pressure and intensity-acoustic pressure and intensities within the beam, power, acoustic impedance, reflection, diffuse reflection, scattering, refraction, absorption, interference, diffraction, Attenuation-dependence on frequency.**Diagnostic Ultrasound Imaging**: A-mode, B-mode and M-mode, Principle of B-Mode Image formation, B-mode formats, Transducers and Beam forming, B-Mode Instrumentation, B-mode image properties, limitations and artifacts, B-Mode Measurements, Doppler Ultrasound, Spectral Ultrasound, colour imaging, advanced techniques for flow and tissue motion, Three-Dimensional Ultrasound, 4D measurements, ultrasound contrast studies, Elastography, Quality assurance and safety of diagnostic ultrasound.

Module 2

Magnetic resonance imaging: Physics of the Dynamics of the Spin (Review Only).MRI Principle-Magnetisation-Excitation-Relaxation-T1 and T2 phase relaxation and relaxation curves – Acquisition-Bloch Equations. MRI Instrumentation and Block Diagram - Main Magnet, Gradient System, Shim System, RF System, Console, MRI Suite, Magnet Quench system. Signal formation and imaging- Free induction decay, Echoes, Signal Coding- Slice Encoding, Phase Encoding, Frequency Encoding, slice thickness, 2D and 3D imaging-Spatial resolution and Field of View-K Space-MRI Fourier Reconstruction, Acceleration methods. Image Contrast- T1 Contrast, T2 Contrast, Proton Density Contrast. MR Sequence Parameters (TR, TE, FA, TI), Image Artifacts. MRI Pulse Sequences - Spin Echo Sequence, Multi Echo Sequence, Turbo Spin Echo Sequence, Fast Advanced Spin Echo Sequence, Gradient Echo Sequence, Inversion Recovery Sequence. Principles of Functional MRI, MR Angiography and Diffusion MRI.

Module 3

X-Ray Computed Tomography: Basic concepts of X-ray Generation, Components involved, Properties of X-rays, Different X-Ray Instruments, Impact of mA and KV.**Principle of Computed Tomography**- Geometries, First, Second, Third, Fourth generation Scanners- Multislice CT Scanners, CT Scanning in Spiral-Helical Geometry, Fifth-Generation Scanners, Sixth-Generation Scanners- The Dual-Source CT Scanner, Seventh-Generation Scanners- Flat-Panel CT Scanners. Slip-Ring Technology, System components- Gantry, Collimation, X-Ray tubes for CT applications - Pencil beam and Cone beam projections. CT Detector Technology, Detector Characteristics, Types, Design Innovations, Multirow/Multislice Detectors, Area Detectors, Image reconstruction algorithms, Image characteristics, Image matrix, CT numbers, Spatial resolution, System noise, Image Artifacts. Introduction to CT Angiogram and DSA

Module 4

Radiology and Hybrid imaging: Radio-isotopes in medical diagnosis, Interaction of nuclear particles with matter. Radionuclide generators, nuclear radiation detectors, rectilinear scanner, Gamma camera, Single photon Emission Computed Tomography, Positron Emission Tomography, Biological effects. Hybrid Imaging instrumentation MR-PET Instrumentation-Mutual interference between MR and PET, MR Compatible PET detector technology, MR-PET system architecture. PET-CT, SPECT-CT. Radiation protection.

Module 5

Infrared imaging and new imaging types: Infrared Imaging - Physics of thermography – IR Detectors - photon & thermal detectors - thermal uncooled IR detectors: resistive micro bolometers, pyroelectric and ferroelectric detectors, thermoelectric detectors. Pyroelectric vidicon camera - camera characterization - thermographic image processing - clinical applications of thermography in rheumatology, neurology, oncology and physiotherapy.Introduction to Principles of Tactile Imaging and Photoacoustic Imaging. **Catheterization Laboratory**- Theory, Purpose, Types of Cath labs, CT Angio vs Cat Lab Angio.

Text Books

1. Hoskins, Peter R., Kevin Martin, and Abigail Thrush, eds. Diagnostic ultrasound Physics and Equipment CRC Press 2019

2. M Flower, Webb’s Physics of Medical Imaging, Taylor & Francis, 2016.

3. Shah, N. Jon, ed. Hybrid MR-PET Imaging: Systems, Methods and Applications, Royal Society of Chemistry 2018.

4. Seeram Euclid Computed Tomography e Book: Physical Principles, ClinicalApplications and Quality control Elsevier Health Sciences, 2015.

5. Webb, The Physics of Medical Imaging, IOP Publishing Ltd., 1988.

6. Andrew Webb, Introduction to Biomedical Imaging, John Wiley & Sons, Inc., 2003

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1. AvinashiC KakMalcolm Slaney, Principles of Computerized Tomographic Imaging, 2001.

2. Hans H Schild, MRI Made easy…Well almost, H. HeenemannGmBH, 2012.

3. Fenster, Aaron, and James C. Lacefield, eds. Ultrasound imaging and therapy. Taylor & Francis, 2015

4. DuccioVolterrani Paola Anna ErbaIgnasiCarrió H. William Strauss Giuliano Mariani, Nuclear Medicine Tex t book, Methodology and Clinical Applications, Springer, 2019.

5. Christian, Paul E., and Kristen M. Waterstram-Rich, eds. Nuclear medicine and PET/CT: technology and techniques. Mosby/Elsevier, 2007.

6. Douglas A Christensen: Ultrasonic Bioinstrumentation, John Wiley, New York, 1988.

7. AtamDhavan, Medical Image Analysis,Wiley IEEE Press, 2003

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.2	Basic physics of ultrasound (Review Only): Wave nature, frequency, speed, wavelength, phase, pressure and intensity-acoustic pressure and intensities within the beam, power, acoustic impedance, reflection, diffuse reflection, scattering, refraction, absorption, interference, diffraction, Attenuation-dependence on frequency.	2
1.3	Diagnostic Ultrasound Imaging: A-mode, B-mode and M-mode, Principle of B-Mode Image formation, B-mode formats, Transducers and Beam forming, B-Mode Instrumentation, B-mode image properties, limitations and artifacts, B-Mode Measurements	3
1.4	Doppler Ultrasound, Spectral Ultrasound, colour imaging, advanced techniques for flow and tissue motion,	2
1.5	Three-Dimensional Ultrasound, 4D measurements, ultrasound contrast studies, Elastography	2
1.6	Quality assurance and safety of diagnostic ultrasound.	1
2	**Module 2**	

2.1	Physics of the Dynamics of the Spin (Review Only).	1
2.2	MRI Principle-Magnetisation-Excitation-Relaxation-T1 and T2 phase relaxation and relaxation curves – Acquisition-Bloch Equations.	2
2.3	MRI Instrumentation and Block Diagram - Main Magnet, Gradient System, Shim System, RF System, Console, MRI Suite, Magnet Quench system.	2
2.4	Signal formation and imaging- Free induction decay, Echoes, Signal Coding- Slice Encoding, Phase Encoding, Frequency Encoding, slice thickness, 2D and 3D imaging- Spatial resolution and Field of View- K Space-MRI Fourier Reconstruction, Acceleration methods.	2
2.5	Image Contrast- T1 Contrast, T2 Contrast, Proton Density Contrast. MR Sequence Parameters (TR,TE,FA,TI), Image Artifacts.	1
2.6	MRI Pulse Sequences - Spin Echo Sequence, Multi Echo Sequence, Turbo Spin Echo Sequence, Fast Advanced Spin Echo Sequence, Gradient Echo Sequence, Inversion Recovery Sequence.	2
2.7	Principles of Functional MRI, MR Angiography and Diffusion MRI.	1
3	**Module 3**	
3.1	Basic concepts of X-ray Generation, Components involved, Properties of X-rays, Different X-Ray Instruments, Impact of mA and KV.	1
3.2	Principle of Computed Tomography- Geometries, First, Second, Third, Fourth generation Scanners- Multislice CT Scanners, CT Scanning in Spiral-Helical Geometry	1
3.3	Fifth-Generation Scanners, Sixth-Generation Scanners- The Dual-Source CT Scanner, Seventh-Generation Scanners- Flat-Panel CT Scanners. Slip-Ring Technology	2
3.4	System components- Gantry, Collimation, X-Ray tubes for CT applications - Pencil beam and Cone beam projections.	2
3.5	CT Detector Technology, Detector Characteristics, Types, Design Innovations, Multirow/Multislice Detectors, Area Detectors	1
3.6	Image reconstruction algorithms, Image characteristics, Image matrix, CT numbers, Spatial resolution, System noise, Image Artifacts.	2
3.7	Introduction to CT Angiogram and DSA	1
4	**Module 4**	
4.1	Radio-isotopes in medical diagnosis, Interaction of nuclear particles with matter. Radionuclide generators, nuclear radiation detectors	1
4.2	Rectilinear scanner, Gamma camera	1
4.3	Single photon Emission Computed Tomography, Positron Emission Tomography, Biological effects.	2
4.4	Hybrid Imaging instrumentation MR-PET Instrumentation-Mutual interference between MR and PET, MR Compatible PET detector technology	2

4.5	MR-PET system architecture. PET-CT, SPECT-CT. Radiation protection	1
5	**Module 5**	
5.1	Infrared Imaging - Physics of thermography – IR Detectors - photon & thermal detectors - thermal uncooled IR detectors: resistive micro bolometers, pyroelectric and ferroelectric detectors, thermoelectric detectors.	2
5.2	Pyroelectric vidicon camera - camera characterization - thermographic image processing - clinical applications of thermography in rheumatology, neurology, oncology and physiotherapy.	2
5.3	Introduction to Principles of Tactile Imaging and Photoacoustic Imaging	1
5.4	Catheterization Laboratory - Theory, Purpose, Types of Cath labs, CT Angio vs Cat Lab Angio.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
BMT308	COMPREHENSIVE COURSE WORK	PCC	1	0	0	1

Preamble:

The course Comprehensive Course work is designed to assess the knowledge gained by the students in the core courses in the B Tech programme in Biomedical Engineering. The core subjects identified in the area of study is listed in the Prerequisite section of the syllabus. The course shall have an objective type written test of 50 marks similar to comprehensive examination like GATE. The pass minimum for this course is 25. The course will help the students in preparing for comprehensive examinations and improve the confidence in answering questions in objective mode. The course will be mapped to a faculty. The hour allotted for the course may be used by the students for practicing questions in core courses, library reading and for oral assessment if needed.

Prerequisite:

The students must have gone through the following courses before attending the comprehensive examination.

1.	BMT 201	ANATOMY & PHYSIOLOGY FOR BIOMEDICAL ENGINEERS
2	BMT 206	BIOPHYSICS
3	BMT 301	ANALYTICAL & DIAGNOSTIC EQUIPMENTS
4	BMT 303	BIOMEDICAL SIGNAL PROCESSING
5	BMT 305	BIOSENSORS & TRANSDUCERS

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

CO No.	Course Outcome (CO)
CO 1	Explain the core concepts in the courses listed in the prerequisite section (BMT201, BMT206, BMT301, BMT303, BMT305)
CO 2	Interpret questions asked and answer them with confidence
CO 3	Practice the comprehensive knowledge gained in basic courses in the field of Electronics and Biomedical Engineering to build confidence for appearing for a competitive examination

Mapping of course outcomes with program outcomes

POs COs	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	-	-	1	-	-	1	-	3
CO 2	3	-	-	2	-	-	1	-	-	1	-	3
CO 3	3	1	1	-	-	2	-	-	-	-	-	-

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
50	-	50	1 Hour

End Semester Examination Pattern:

written examination will be conducted by the University at the end of the sixth semester. The written examination will be of objective type similar to the competitive examination like GATE. Syllabus for the comprehensive examination consists of 5 modules based on following five core courses in the curriculum.

1.	BMT 201	ANATOMY & PHYSIOLOGY FOR BIOMEDICAL ENGINEERS
2	BMT 206	BIOPHYSICS
3	BMT 301	ANALYTICAL & DIAGNOSTIC EQUIPMENTS
4	BMT 303	BIOMEDICAL SIGNAL PROCESSING
5	BMT 305	BIOSENSORS & TRANSDUCERS

The written test will be of 50 marks with 50 multiple choice questions (10 questions from each module) with 4 choices of 1 mark each covering all the five core courses. There will be no negative marking. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed above.

Written examination : 50marks

Total : 50 marks

Course Level Assessment and Sample Questions:

1. Sensitivity of a differential capacitive transducer is proportional to

   A) 1/distance between plates

   B) Area^2

   C) 1/distance between plates^2

   D) 1/Area^2

2. A thermistor has ----------temperature coefficient of resistance

   A) positive

   B) negative

   C) zero

   D) None of the above

3. Distance can be measured by ----------

   A) capacitive transducer

   B) LVDT

   C) Strain gauge

   D) All of the above

4. The system represented by y(n)=x(n)+ x(n-1) is

   A) static
   B) time invariant
   C) time variant
   D) none of the above

5. An example of a non-polarizable electrode is_____.

   A) Platinum electrode
   B) Zinc-Zinc Sulphate electrode
   C) Ag-AgCl electrode
   D) None of the above

6. Fourier transform of a discrete time aperiodic signal is

   A) discrete and periodic with period 2π
   B) continuous and aperiodic with period 2π
   C) discrete and aperiodic
   D) continuous and periodic with period 2π

7. A natural pacemaker of heart is

   A) SA Node

   B) A V Node

   C) Bundle of His

   D) Purkinje fiber

8. The greatest volume of gas that can be inspired by voluntary effort after maximum expiration, irrespective of time

A) vital capacity

B) functional residual capacity

C) tidal volume

D) residual volume

9. Blood flow velocity can be measured by utilizing----------

A) Doppler effect

B) Nuclear magnetic resonance

C) Electromagnetic induction

D) All of the above

10. Depolarization of ventricles is represented in ECG as _____.

A) P wave

B) QRS complex

C) T wave

D) U wave

11. A ramp signal is ----------

A) Energy signal

B) Power signal

C) Neither energy signal nor power signal

D) Both energy and power signal

14. Second heart sound is caused by the closing of the_____.

A) Tricuspidvalve

B) Aorticvalve

C) Bicuspidvalve

D) Mitralvalve

15. Largest organ in the human body is _____.

A) Skin

B) Kidneys

C) Heart

D) Liver

Syllabus

Module 1: ANATOMY & PHYSIOLOGY FOR BIOMEDICAL ENGINEERS

Structural & functional organization of human body – cells, tissues, organs & systems -their functions. Organization and functioning of nervous system, Special senses, Muscular System, endocrine system, Cardiovascular system, heart, Circulatory systems, Respiratory system and Urinary System

Module 2: BIOPHYSICS

Cell Potentials: Resting membrane potential, Action potential (muscle and nerve) Nernst potential, Goldman Hodgkin Katz equation Electrode-tissue interfaces - electrode-electrolyte and electrolyte skin interface Generation of ECG, ECG leads, recording of ECG, arrhythmias, Generation of EEG, 10-20 electrode system, measurement of EEG, electrodes, clinical applications of EEG, EMG- Generation of EMG signal, measurement of EMG, electrodes applications. Radioactivity - half-life period, detection of radioactivity - interaction of radiation with matter, applications. Xrays – Production – discharge tube and Coolidge tube methods, x-ray spectra Electromagnetic radiation and applications. Radiation therapies

Module 3: ANALYTICAL AND DIAGNOSTIC EQUIPMENTS

Principle and operation of analytical and diagnostic equipment used in the clinical environment, Spectrophotometers: Electrolyte Analysers Automated clinical analysers Electrophoresis- Principles, Chromatography Coulter Counters, Blood Gas Analysers
Instrumentation of ECG, EEG, EMG, NIBP, PPG-Temperature measurements, Arrhythmia monitors, Ambulatory recorders- Holter monitors, Sleep apnoea monitors. Bipolar and tetrapolar circuits Audiometers Respiratory Measurements Blood flowmeters

Module 4: BIOMEDICAL SIGNAL PROCESSING

Signal representation, Aliasing-Sampling theorem. Classification of discrete signals Properties of. LTI system- convolution- correlation - difference equation representation of discrete systems Fourier Analysis: Fourier Analysis of discrete time signals - DFT-properties FFT algorithms. Spectrum analysis & Z Transform: parametric & non parametric methods. Z transform –Properties, Inverse Z transform, Digital filters: FIR, IIR filter design Applications of biomedical signal processing

Module 5: BIOSENSORS & TRANSDUCERS

Biological Sensors and physiological receptors: Study of various Chemo receptors, hot and cold receptors, baro receptors, Sensors for smell, sound, vision, osmolality and taste. Biosensor and Transducers: Transducers– types and classification-. Biosensor classifications Chemical Biosensors: Blood –Gas and Acid –Based-Electrochemical sensors-Hydrogenelectrodes-Silver/silverchlorideelectrodes-Calomelelectrodes.

pHelectrodes- oxygen electrodes-CO_2electrodes. Temperature sensors, transducers for blood flow and velocity measurement, Blood Pressure transducer, nano biosensors optical nano biosensors, applications of BioMEMS

Reference Books

1. Mahin Basha - Analytical Techniques in Biochemistry-Springer US_Humana (2020)
2. RüdigerKramme, Heike Kramme, Springer Handbook of Medical Technology, Springer-Verlag Berlin Heidelberg, Year: 2011
3. Khandpur R S, Handbook of Bio-Medical Instrumentation, Tata McGraw Hill, 2nd Ed., 2003
4. Guyton and Hall: Text book of Medical Physiology,Saunders, an imprint of Elsevier Inc.12thedn, 2011
5. Richard Aston: Principles of Biomedical Instrumentation and measurements
6. Tagawa, Tatsuo, Toshiyo Tamura, and P. Ake Oberg. Biomedical sensors and instruments. CRC press, 2019.
7. John G Proakis& Dimitris G Manolakis, Digital Signal Processing-Principles, Algorithms and Applications, PHI, 4 th Edition, 2016
8. Rangaraj M Rangayyan: Biomedical Signal Analysis, John Wiley, 2 nd Edition, 2015.
9. Suresh R Devasahayam , Signals & Systems in Biomedical Engineering , Springer 2 nd Edition, 2013
10. P. Ramesh Babu: Digital Signal Processing, Scitech Publications, India, 6th Edition, 2014.

BML332	BIOMEDICAL EQUIPMENT DISSECTION LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble:

The lab aims to impart industry ready skills for Biomedical Engineers. The experiments in the lab are arranged in three categories. Part A, Part B and Part C, based on various learning outcomes expected. The objectives of each category are listed as follows.

PART A: Testing and Calibration of Biomedical Equipment

1. Perform electrical safety testing on biomedical equipment's (minimum two) using Electrical Safety Analyser and generate a standard (IEC/ANSI/AAMI) safety, quality and performance test report for following tests.

    a. Voltage Test
    b. Current Test
    c. Leakage Current Test
    d. Earth Resistance Test
    e. Insulation Resistance Test

2. Test and verify the basic operation of Vital signs devices or systems used to monitor various physiological parameters of a patient, including ECG, respiration, invasive blood pressure, and non-invasive blood pressure and Oxygen Saturation using simulators and generate a standard (IEC/ANSI/AAMI) safety, quality and performance test report for following tests.

    a. ECG Functions and Arrhythmia
    b. Respiration
    c. Invasive and non-invasive Blood Pressure

3. Test an Electrosurgical Unit (ESU) using an Electro Surgical Analyzer for all critical ESU functions with precise power, current, frequency, crest factor and load resistance ranges. Generate a standard (IEC/ANSI/AAMI) safety, quality and performance test report for following tests

    a. Generator output: Power, RMS Current, RMS Voltage, peak to peak Crest Factor
    b. Vessel Sealing Loop Current
    c. HF Leakage Current in various configurations
    d. Contact Quality Monitor (CQM) test
    e. Power Distribution test

4. Test a Defibrillator using a Defibrillator Analyzer and verify that machine is performing within their performance specifications through measurement of energy output. Generate a standard (IEC/ANSI/AAMI) safety, quality and performance test report for following tests

    a. Energy test
    b. Synchronization test
    c. Charge time test
    d. Pulse width
    e. Pulse amplitude

5. Test an Infusion Pump using an Infusion Pump Analyzer and verify that machine is performing within their performance specifications through measurement of flow and pressure. Generate a standard (IEC/ANSI/AAMI) safety, quality and performance test report for following tests

    a. Instantaneous and average flow measurement test
    b. Volume measurement test
    c. end flow measurement

PART B: Biomedical Equipment Dissection

Perform dissection on Biomedical Equipment (probably decommissioned) and carry out following studies

a. Perform disinfection protocol of the equipment
b. Classify (A/B/C/D) the medical device according to Medical Device Rule 2017
c. Label and list out various modules of the equipment. Analyze the functional/structural roles of each mechanical/ electromechanical module
d. Analyse the product architecture and design features of the equipment under study through reverse engineering (block diagram approach)

Equipment can be arranged in the category of analytical equipment, Diagnostic equipment, therapeutic equipment, imaging Equipment, critical care equipment and any device under the definition of medical device by Medical Device Rule 2017 /drugs and cosmetics act, Govt. of India.

PART C: Field Study

Each student is expected to study (visit recommended) a hospital department (e.g. Radiology) and understand the workflow, regulatory requirements (e.g. AERB) for the installation and maintenance of biomedical equipment/systems at the department. Generate a report about the study with facility layout.

Prerequisite: Students should have a strong theoretical foundation in Analytical & Diagnostic Equipment, Biosensor sand Transducer, Clinical Instrumentation Lab.

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

CO 1	Perform the experiments to analyse patient safety, equipment performance and calibration of Biomedical Equipment's by using standard test equipment and simulators
CO 2	Apply engineering dissection to learn product design and architecture of a Medical device
CO 3	Explain the functional roles of mechanical/electromechanical units in a medical device through dissection and familiarize the vocabulary of medical systems.
CO 4	Familiarize standardized protocols for installation, maintenance and regulatory control of Biomedical Engineering systems in a hospital workflow through field visits

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	2	3	3	3		3
CO2	3	3	3	3		2		2	3	3		3
CO3	3	3	3	3		2		2	3	3		3
CO4	3	3	3	3	3	2	2	3	3	3	2	3

Assessment Pattern

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 equipment's and troubleshooting) : 25 Marks
(d) Viva voce (*Include questions based on Medical Device Rule 2017*) : 20 marks
(e) Record : 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering the entire syllabus given below. Evaluation is a serious process that 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 University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Analyse the electrical safety of given biomedical equipment as per IEC 60601.1 standard and generate Biomedical Engineers electrical safety report with parameters measured in test and its limits.
2. Investigate the functioning of a physiological monitoring system by simulating Hypotensive, hypertensive and normal patient condition for HR, respiration, NIBP and IBP. Also investigate functioning of ECG module for the arrhythmias - asystole, ventricular fibrillation and ventricular tachycardia and generate a biomedical engineers test report for physiological monitoring system.
3. Inspect functioning of a defibrillator using a defibrillator analyser for various energy dut set value and measure the test equipment energy values. Also perform charge time test, sync time test at 100J and generate biomedical engineers test report for defibrillator.
4. Examine the given Electrosurgical Unit using Electrosurgical Analyzer for various dut set power and measuring the power/ current of test gadget for cutting and coagulation mode. Also perform REM test as well as leakage current test and generate biomedical engineers test report for ESU.

Course Outcome 2 (CO2)

1. Perform dissection on given analytical equipment and identify the product architecture using reverse engineering approach.
2. Perform dissection on given therapeutic equipment and identify the design of the equipment using reverse engineering approach.
3. Perform dissection on given diagnostic equipment and identify the design features of the equipment using reverse engineering approach.

Course Outcome 3(CO3):

1. Perform dissection on given medical imaging equipment and analyse the functional/structural role of each electro-mechanical module.

2. Perform dissection on given rehabilitation equipment and analyse the functional/structural role of each electro-mechanical module.
3. Perform dissection on given biomedical equipment and suggest a new cost-effective design by analysing the functions of each module under study.

Course Outcome 4 (CO4):

1. Design a facility layout for a hospital for the installation of a PET scanner.
2. Design a facility layout for a hospital ICU for the installation of critical care equipment and systems in an ICU facility.
3. Perform Classification of Medical Devices used in an operating theatre under your study, according to the Medical Device Rule 2017 with its latest amendments and prepare a risk classification report in compliance with MDR 2017. Also define the scope of regulatory control for each medical device.

LIST OF EXPERIMENTS (Minimum 10 mandatory)

1. Familiarisation of Electrical Safety Analyser and Perform electrical safety testing on any two biomedical equipment using Electrical Safety Analyser and generate a standard (IEC/ANSI/AAMI etc.) safety, quality and performance test report for any two biomedical equipment.

2. Familiarisation of Vital Signs Simulator for patient monitor performance checks/ troubleshooting and standards (IEC/ANSI/AAMI etc.) for safety, quality and performance test of ECG, respiration, invasive blood pressure, non-invasive blood pressure and Oxygen Saturation.

3. Test and verify the basic operation of Vital signs devices or systems used to monitor various physiological parameters of a patient, including ECG, respiration, invasive blood pressure, non-invasive blood pressure and Oxygen Saturation using simulators and generate a standard (IEC/ANSI/AAMI) safety, quality and performance test report.

4. Familiarisation of Electro Surgical Analyser, Defibrillator Analyser and safety, quality and performance test standards (IEC/ANSI/AAMI etc.) for ESU/Defibrillator functions.

5. Test an Electrosurgical Unit using an Electro Surgical Analyser for all critical ESU functions. Generate a standard (IEC/ANSI/AAMI etc.) safety, quality and performance test report.

6. Test a Defibrillator using a Defibrillator Analyser and verify that machine is performing within their performance specifications. Generate a standard (IEC/ANSI/AAMI etc.) safety, quality and performance test report.

7. Test an Infusion Pump using an Infusion Pump Analyzer and verify that machine is performing within their performance specifications. Generate a standard (IEC/ANSI/AAMI etc.) safety, quality and performance test report.
8. Perform dissection study on basic biomedical equipment (ECG machine/Automatic BP Machine)
9. Perform dissection study on analytical equipment
10. Perform dissection study on diagnostic equipment
11. Perform dissection study on therapeutic equipment
12. Perform dissection study on Biomedical Imaging equipment
13. Perform dissection study on rehabilitation equipment
14. Perform dissection on any implantable medical device
15. Hospital department facility layout for installation and maintenance of biomedical equipment/systems in reference to regulatory guidelines.

(Include two open ended experimentsto make the students understand the concepts learned.)

Reference Books

1. John G. Webster, Encyclopaedia of Medical Devices and Instrumentation, Wiley-Interscience, 2006.
2. Bich, Walter, Maurice G. Cox, and Peter M. Harris. "Evolution of the 'Guide to the Expression of Uncertainty in Measurement'." *Metrologia* 43, no. 4 (2006): S161.
3. World Health Organization. "Decommissioning medical devices." (2019).
4. Gupta, Kavita. *A practical guide to needs assessment*. John Wiley & Sons, 2011.
5. Introduction to Medical Equipment Inventory Management- WHO Medical Device Technical Series.
6. Medical Equipment Maintenance Programme Overview -WHO Medical Device Technical Series.
7. Computerized Maintenance Management System -WHO Medical Device Technical Series.
8. Safe use of medical devices- WHO Medical device technical series.
9. Procurement Process Resource Guide -WHO Medical Device Technical Series.
10. AERB, Department of Atomic Energy, Guidelines for preparation of radiotherapy (Nuclear Medicine) site and layout drawings
11. AERB, Department of Atomic Energy, Layout and shielding guidelines: Sample layout plans Computed Tomography, Interventional Radiology facility, Radiography Facility, Mammography & BMD.
12. Paul H hing, Richard C Fries, Arthur T Johnson, Design of biomedical devices and systems third edition, CRC Press, 2014.

13. Justin Cooperand Alex Dahinten; Medical Equipment Troubleshooting Flowchart Handbook Engineering World Health version 6, 2013.
14. Medical devices are regulated in India vide Medical Devices Rules 2017 on those devices notified by central government under section 3 (B)(IV) of Drugs and Cosmetics act 1940 and S.O. 648 (E) dated 11.2.2020 specifies intended uses .

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
BMD334	MINIPROJECT	PWS	0	0	3	2

Preamble: This course is designed for enabling the students to apply the engineering knowledge they have imbibed to address the real-world situations/problems and find solutions. The course is also intended to estimate the ability of the students in transforming theoretical knowledge studied as part of the curriculum so far in to a working model. The students are expected to design and develop a software/hardware or hybrid project to innovatively solve a real-world problem preferably related to healthcare.

Prerequisites: Understanding on the basic concepts of electronic circuits, programming, biomedical instruments and the requirements of healthcare sector.

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

CO No.	Course Outcome (CO)
CO 1	Make use of acquired knowledge within the selected area of technology for project development.
CO 2	Identify, discuss and justify the technical aspects and design aspects of the project with a systematic approach.
CO 3	Interpret, improve and refine technical aspects for engineering projects.
CO 4	Associate with a team as an effective team player for the development of technical projects.
CO 5	Report effectively the project related activities and findings.

Mapping of course outcomes with program outcomes

POs / COs	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	3	3	3	-	-	-	3
CO 2	3	3	3	3	3	-	2	3	-	3	2	3
CO 3	3	3	3	3	3	2	3	3	-	2	3	3
CO 4	3	3	2	2	-	-	-	3	3	3	3	3
CO 5	3	-	-	-	2	-	-	3	2	3	2	3

Assessment Pattern

The End Semester Evaluation (ESE) will be conducted as an internal evaluation based on the prototype developed, the report prepared and a viva- voce examination, conducted by a 3-member committee appointed by Head of the Department comprising of a senior faculty member of the department, project coordinator and project guide. The Committee will be evaluating the level of completion and demonstration of functionality/specifications,

presentation, oral examination, working knowledge and involvement of the student as an individual and a team member.

The Continuous Internal Evaluation (CIE) is conducted by evaluating the progress of the mini project through minimum of TWO reviews. At the time of the 1st review, students are supposed to propose a new system/design/idea, after completing a thorough literature study of the existing systems under their chosen area. In the 2nd review students are expected to highlight the implementation details of the proposed solution. The review committee should assess the extent to which the implementation reflects the proposed design. A well coded, assembled and completely functional product is the expected output at this stage. The final CIE mark is the average of 1st and 2nd review marks.

A zeroth review may be conducted before the beginning of the project to give a chance for the students to present their area of interest or problem domain or conduct open brain storming sessions for innovative ideas. Zeroth review will not be a part of the CIE evaluation process.

Marks Distribution

Total Marks	CIE	ESE
150	75	75

Continuous Internal Evaluation Pattern:
Attendance : 10 marks
Marks awarded by Guide : 15 marks
Project Report : 10 marks
Evaluation by the Committee : 40 Marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks.
(a) Demonstration: 50 Marks
(b) Project report : 10 Marks
(d) Viva voce : 15marks

Course Plan

In this course, each group consisting of three/four members is expected to design and develop a moderately complex software/hardware system with practical application preferably related to healthcare sector. The basic concept of product design may be taken into consideration while developing the working model.

Students should identify a topic of interest in consultation with Faculty-in-charge of mini project/Advisor. After the zeroth review project guide should be allotted for each project

batch and project guide should be present for the 1st and 2nd review. The major steps in the course plan are

1. Review the literature and gather information pertaining to the chosen topic. ‘
2. State the objectives and develop a methodology to achieve the objectives.
3. Carryout the design/fabrication or develop codes/programs to achieve the objectives.
4. Demonstrate the novelty of the project through the results and outputs.

The progress of the mini project is evaluated based on a minimum of two reviews**.** The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The product has to be demonstrated for its full design specifications. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care in the project shall be given due weightage.

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SEMESTER VI

PROGRAM ELECTIVE I

BMT312	CONTROL SYSTEMS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Control Engineering is concerned with techniques that are used to solve the problems in all fields of engineering in an efficient manner. Control theory is equally applicable to biomedical, aeronautical, chemical, mechanical, environmental, civil, and electrical engineering fields. The ability to understand, design and analyse the performance of a control system through various mathematical domains is one of the key engineering skills a student undergoing this course is expected to attain.

Prerequisite: Basic skill in applying Laplace transform would be desirable. Students are also expected to have basic skill in applying laws pertaining to Electrical and mechanical systems.

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

CO 1	Characterize a control system in Laplace domain and model it in simpler forms.
CO 2	Employ time domain analysis to predict and investigate transient and steady state performance parameters of the system for standard test signals.
CO 3	Formulate different types of analysis in frequency domain to explain the nature of stability of the system.
CO 4	Develop and analyse state space models

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3							2		3
CO2	3	3	3	3	3					2		3
CO3	3	3	3	3	3					2		3
CO4	3	3	3							2		3

Assessment Pattern

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

Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

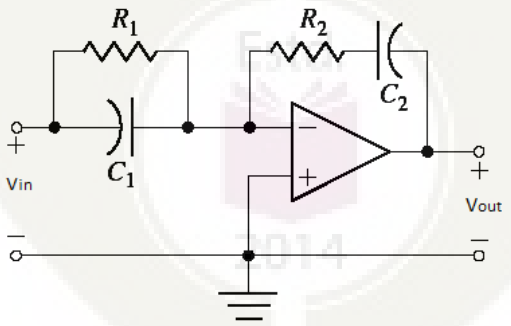
Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 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.

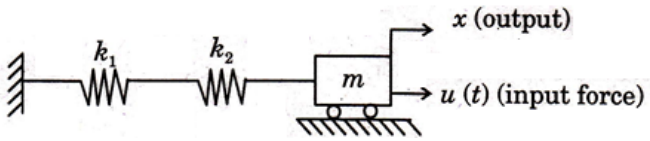
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Derive the transfer function of the following circuit.



2. Obtain the mathematical model and transfer function of the following mechanical system



Design an electrical control system which produces sustained oscillations at 10 rad/sec and an amplitude of 20 V

3. Conduct a literature review of systems for pathological tremor suppression. Identify a simple mechanical system and applying techniques of mathematical modelling, find out the expression for its response in time domain for a step input.

Course Outcome 2 (CO2):

1. Review appropriate literature and identify how humans respond to a visual cue with a physical response, with a transfer function that relates the output physical response, P(s), to the input visual command, V(s).

   Do the following:

   a. Evaluate the output response for a unit step input using the Laplace transform.

   b. Represent the transfer function in state space.

   c. Use MATLAB to simulate the system and obtain a plot of the step response.

2. For the given system with unity feedback, find out an expression for time response. Find rise time, peak time and percentage overshoot.$G(S) = \frac{25}{S(S+5)}$

3. Find out the position, velocity and acceleration error constants of the following open loop system $G(S) = \frac{100}{(0.5S+1)(1+2S)}$with unity feedback.

4. Draw the Root locus for the unity feedback system$G(S) = \frac{K}{S(S+4)(S+2)}$ Also find the value of K for the system damping ratio to be 0.5

Course Outcome 3 (CO3):

1. An electric ventricular assist device (EVAD) helps pump blood concurrently to a defective natural heart in sick patients. Identify the mathematical model representing the second order transfer function approximation in the closed-loop configuration. Let the input be Em(s), the controlling motor's armature voltage, and the output Pao(s), the aortic blood pressure. Do the following.

   a. Using Frequency domain approach, design a phase lag compensator to achieve a tenfold improvement in the steady-state error to step inputs without appreciably affecting the transient response of the uncompensated system.

b. Use MATLAB to simulate the uncompensated and compensated systems for a unit step input.

2. Find the value of K so that, the system will be stable with Kg = 2dB and ϒ= 45º

$$G(S) = \frac{Ke^{-0.2S}}{S(S+2)(S+8)}$$

3. Draw the Bode plot for $G(S) = \frac{KS^2}{(1+0.2S)(1+0.02S)}$ Find the value of K for the system to produce a gain of 0 dB at 5 rad/sec.

4. Draw the bode plot for $G(S) = \frac{1}{(S+5)}$. If the cutoff frequency is changed 10 times, what is the difference in performance noticed?

Course Outcome 4 (CO4):

1. An electric ventricular assist device (EVAD) has been designed to help patients with diminished but still functional heart pumping action to work in parallel with the natural heart. The device consists of a brushless dc electric motor that actuates on a pusher plate. The plate movements help the ejection of blood in systole and sac filling in diastole. System dynamics during systolic mode have been found to be:

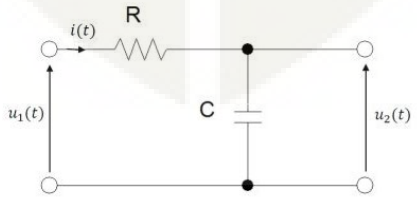
$$\begin{bmatrix} \dot{x} \\ \dot{v} \\ \dot{P}_{ao} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -68.3 & -7.2 \\ 0 & 3.2 & -0.7 \end{bmatrix} \begin{bmatrix} x \\ v \\ P_{ao} \end{bmatrix} + \begin{bmatrix} 0 \\ 425.4 \\ 0 \end{bmatrix} e_m$$

2. The state variables in this model are x, the pusher plate position, v, the pusher plate velocity, and Pao, the aortic blood pressure. The input to the system is em, the motor voltage.

   a. Use MATLAB/similar computing tool to find a similarity transformation to diagonalize the system.

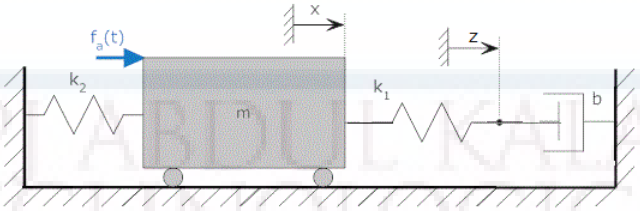
   b. Use MATLAB/similar computing tool and the obtained similarity transformation of Part a to obtain a diagonalized expression for the system.

3. Obtain the state space representation of the circuit shown below.



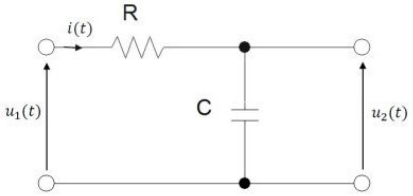
4. Explain the concept of duality in state space representation, with the help of Controllable and Observable canonical forms.

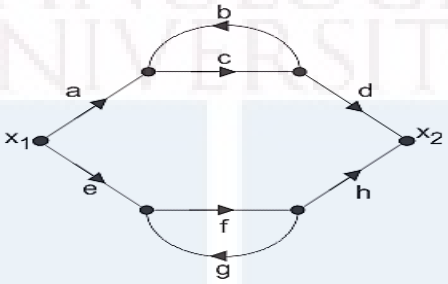
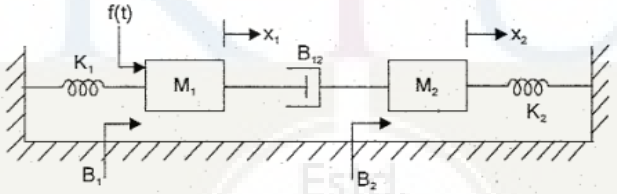
5. Represent the transfer function in any 3 different state space forms. $G(S)H(S) = \frac{K}{S(S+2)(S+4)}$



6. Obtain the state space representation for the following mechanical system

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____ _____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT312			
Course Name: CONTROL SYSTEMS			
Max. Marks: 100			Duration: 3 Hours
PART A			
Answer all the questions. Each question carries 3 marks.			
1		Obtain the response of a first order RC circuit for an impulse signal	
2		What do you mean by the term transfer function of a control system?	
3		What are test signals? Represent the test signals graphically and mathematically.	
4		Derive the expression for the unit ramp response of a first order system.	
5		Draw the bode plot for $G(S) = \frac{1}{(S+10)}$.	
6		Explain how the root locus of a system can be used for the analysis of stability of a system.	
7		Obtain the state space representation of the circuit shown below. 	

8		Convert the system state given as A = $\begin{matrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -6 & -11 & -6 \end{matrix}$ **B** = $\begin{matrix} 0 \\ 0 \\ 1 \end{matrix}$ and C = $\begin{matrix} 1 & 0 & 0 \end{matrix}$ into the transfer function model.	
9		What are the properties of state transition matrices?	
10		Define controllability and observability	
		PART B *(5x14 = 70 marks)*	
11	a)	Using Masons Gain formula, find the transfer function for the given flow graph 	14
		OR	
12	a)	Obtain the differential equation governing the system and find out the transfer functions $\frac{X_1(S)}{F(S)}$ and $\frac{X_2(S)}{F(S)}$ 	14
13	a)	Sketch the time domain response and mark the values of time domain specifications for the system with unity feedback and open loop transfer function$G(S) = \frac{1+0.4S}{S(S+0.6)}$ if excited with a unit step input.	14
		OR	
	a)	The forward path transfer function is given by $G(S) = \frac{2}{S(S+3)}$ Obtain an expression for unit step response of the system.	8
14	b)	Derive the expression for unit step response of an under damped second order system	6
15	a)	Draw the Nyquist plot for the unity feedback system, whose open loop transfer function is$G(S) = \frac{K}{S(S+2)(S+10)}$ Find the range of K for system will be stable	14
		OR	

16	a)	Draw the Root locus for the unity feedback system $G(S) = \frac{K}{S(S+2)(S+4)}$ Also find the value of K for the system damping ratio to be 0.5	14
17	a)	Explain how an n^{th} order linear time invariant differential equation with constant coefficients can be represented in the state space form?	14
		OR	
18	a)	Obtain the state space representation of a dc motor whose speed is controlled by varying the armature voltage	14
19	a)	Explain the concept of duality in state space representation, with the help of Controllable and Observable canonical forms.	14
		OR	
20	a)	Determine the matrix exponential, and hence the state transition matrix, and the homogeneous response to the initial conditions $x_1(0) = 2$, $x_2(0) = 3$ of the system with state equations: $\dot{x}_1 = -2x_1 + u$ $\dot{x}_2 = x_1 - x_2$.	14

Syllabus

Module 1

Introduction to Control Systems - Definition, Examples (including physiological control systems), History, System configurations, Design considerations, Control system design process. Review of Laplace Transforms, Transfer function of LTI system, Model of simple electrical, mechanical and electromechanical systems. Concept of feedback, Reduction of Block diagrams, Signal flow graph- Use of Mason's gain formula.

Module 2

Time domain analysis- Standard test signals, Time response specifications, First order system response, S-plane root location and transient response, impulse and step response of second order systems, performance and characteristics in the time domain, Steady state response- Steady state error and static error coefficients.

Module 3

Frequency domain analysis - Frequency response techniques - frequency response specifications, bodeplots, gain margin and phase margin via Bode plots Nyquist stability criterion, Nyquist Plot, Routh - Hurwitz criterion, Root Locus techniques, Concepts of relative stability. Overview of compensators for design improvement.

Module 4

State space models - Introduction to the state variable concept, State model of mechanical and electrical systems. Converting transfer function into state space, converting state space

into transfer function, state transition matrix properties various forms of representing state space systems.

Module 5

Solution of continuous time state equations - Homogeneous and non-homogeneous cases, Transfer function from State Variable Representation, state transition matrix - properties of state transition matrix, Controllability, Observability.

Text Books

1. Norman S. Nise, Control System Engineering, Sixth Edition, John Wiley & Sons, Inc, 2019
2. Gopal, Control Systems, 4/e, McGraw Hill Education India Education, 2012.
3. Ogata K, Modern Control Engineering, 4th Ed., Prentice-Hall India Ltd Pearson Education
4. Rehabilitation Robotics, Kommu S.S. (ed.), 2007, ISBN: 978-3-902613-01-1
5. Gopal, Control Systems, 4/e, McGraw Hill Education India Education, 2012.

Reference Books

1. Richard C Dorf and Robert H. Bishop, Modern Control Systems, 9/e, Pearson Education, 2001.
2. Ogata K., Modern Control Engineering, Prentice Hall of India, 4/e, Pearson Education, 2002.
3. Kuo B. C, Automatic Control System, Prentice-Hall India Ltd, 8th ed.
4. NagoorKani, Control Systems, RB Publishers, 1998

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Control System Definition, Examples (including physiological control systems), History, System configurations, Design considerations (Using a case study), Control system design process.	2
1.2	Review of Laplace Transforms, Transfer function of linear system, Model of simple electrical, mechanical and electromechanical systems.	2
1.3	Concept of feedback, Reduction of Block diagrams,	2
1.4	Signal flow graph- Mason's gain formula.	1
2	**Module 2**	
2.1	Standard test signals, Time response specifications, First order system response, S-plane root location and transient response	3
2.2	Impulse and step response of second order systems, performance and characteristics in the time domain	2
2.3	Steady state response- Steady state error and static error coefficients.	2

3	**Module 3**	
3.1	Routh - Hurwitz criterion, Root Locus techniques	2
3.2	Frequency domain analysis - Frequency response techniques - frequency response specifications	1
3.3	Bode plots, gain margin and phase margin via Bode plots	2
3.4	Nyquist stability criterion, Nyquist plots.	2
3.5	Concepts of relative stability. Overview of Compensators for design improvement	1
4	**Module 4**	
4.1	State space models - Introduction to the state variable concept,	1
4.2	State model of mechanical and electrical systems.	1
4.3	Converting transfer function into state space, Converting state space into transfer function, state transition matrix properties	3
4.4	Various forms of representing state space systems	2
5	**Module 5**	
5.1	Solution of continuous time state equations - Homogeneous and non-homogeneous cases,	2
5.2	Transfer function from State Variable Representation, state transition matrix - properties of state transition matrix	3
5.3	Controllability, Observability	1

BMT322	MEDICAL INFORMATICS	CATEGORY	L	T	P	CREDIT
		PEC	3	0	0	3

Preamble: This course is meant for familiarizing the basics of medical informatics.

Prerequisite: Nil

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

CO 1	Describe the fundamentals of health information systems.
CO 2	Discuss the benefits and foundational role of electronic health records.
CO 3	Assess the role, benefits and challenges of health information exchanges and healthcare analytics.
CO 4	Appraise the security and privacy risks of healthcare data.
CO 5	Describe the fundamentals of bioinformatics and m- Health care informatics.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3					2	3	2
CO2	3	2	3	3	3					2	3	2
CO3	3	2	3	3	3					2	3	2
CO4	3	2	3	3	3					2	3	2
CO5	3	2	3	3	3					2	3	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	50
Apply	20	20	30

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3hours

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)

1. State the definition & origin of health informatics.
2. Discuss on the basic theories & models involved in healthcare informatics.

Course Outcome 2 (CO2)

1. State the definition of Electronic Health Records.
2. List the key components of Electronic Health Records

Course Outcome 3 (CO3)

1. Explain the basic data standards used in health care informatics
2. Describe the 2 main components of HIPAA Act.

Course Outcome 4 (CO4)

How Privacy, Security & confidentiality of patient medical information is maintained.

2. What are the external & internal Vulnerabilities associated with security of healthcare data.

Course Outcome 5 (CO5)

1. What is bioinformatics?
2. Describe the opportunities & obstacles in adoption of m-health.

Model Question paper

			Total Pages: 3
Reg No.:_____			Name:_____ ___
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT 322			
Course Name: MEDICAL INFORMATICS			
Max. Marks: 100			Duration: 3 Hours
PART A			

Answer all questions. Each question carries 3 marks			
			3
1		Why informatics is needed in healthcare.	3
2		Write a short note on learning theory.	3
3		Compare and contrast the electronic health record & electronic medical record.	3
4		What is the use of technology to provide healthcare at a distance?	3
5		Explain the role of analytics in healthcare.	3
6		What is health information exchange & why is it important?	3
7		Why privacy & confidentiality is important in healthcare?	3
8		What is healthcare information security?	3
9		Discuss on the benefits of m-health.	3
10		Write a short note on ChIP-Chip and ChIP-Seq.	3
PART B			
11	a)	Discuss on Staggers & Nelson System life cycle model.	(10)
	b)	Illustrate the ACE star model of knowledge transformation.	(4)
		OR	
12	a)	Why change theory is used as effective tool in planning & implementing change in social systems & organizations.	(9)
	b)	Explain the 5 internal organizational characteristics that can be used to understand how an organization will respond to an innovation	(5)
13	a)	List the key components of electronic health record.	(10)
	b)	Identify the benefits of electronic health record.	(4)
		OR	
14	a)	Describe the benefits &challenges of computerized order entry &clinical decision support systems.	(10)
	b)	Describe the obstacles implementing in electronic health record.	(4)
15	a)	Enlist the salient features of python.	(7)
	b)	Describe the various components of health care analytics.	(7)
		OR	
16	a)	Define SOA &its benefits?	(7)
	b	Explain the linear regression model with an example.	(7)

	)		
	a)	Explain the External & Internal Vulnerabilities that occurs in healthcare system.	(10)
17	b)	Write notes on use of ICT in healthcare.	(4)
		OR	
18	a)	Describe the various physical, administrative &technical security controls for information security in healthcare	(14)
19	a)	Explain the opportunities & obstacles in the adoption of m-health	(9)
	b)	With the help of a diagram explain the basic building block of m health.	(5)
		OR	
20	a)	Explain the following principles of genetics i) Mendel and Morgan's Legacy, ii) Disease Gene Mapping in the Genomic Era	(14)

Syllabus

Module 1:

Overview of health informatics: healthcare data & analytics - Definition of health informatics, Theories & models underlying health informatics-Systems Theory, Chaos's Theory, Complexity Theory, Information Theory, Diffusion of innovation theory, Learning Theory, Change Theory, System Life cycle models, Staggers & Nelson system Life cycle model, Evidence based practice & Informatics-Evidence based practice models, ACE star model of knowledge transformation, Knowledge ,Data mining & Practice based medicine

Module 2:

Information system in healthcare delivery - Electronic health Records– Definition, Electronic medical Record versus Electronic Health Record, EHR: components, Functions & Attributes, EHR applications used in clinical settings, benefits, Barriers to EHR adoption. Telehealth & Applications for delivering care at a distance–Technologies, Clinical Practice considerations for healthcare professionals, Operational & Organizational success factors & barriers, Telehealth challenges, Clinical Decision support system in Health care

Module 3:

Health information exchange & health care analytics - Health information exchange-Basic definitions, The Nationwide Health Information Network (NHIN) and, NHIN Exchange &NHIN Direct, Health Information Organizations (HIOs), Federal Gateway Overview, Web Services and Service Oriented Architecture, Healthcare Analytics-Introduction, Components of healthcare analytics, Tools: SQL (basics)-SQLite, Python

features-Lists and tuples, Dictionaries, Sets, Python libraries- pandas and scikit-learn-Linear regression model, Logistic Regression

Module 4:

Healthcare security & data integrity - Patient medical Information-Privacy, Confidentiality, Security-Definition, Legal & historical context, Principles, laws & Regulations, the importance of information security, Current security Vulnerabilities-External, Internal Vulnerabilities, Use of ICT in healthcare, Managing security risk with security controls-Administrative, Technical & Physical.

Module 5:

Bioinformatics & mobile computing in health care - Basics for Bioinformatics- Cells, DNA and Chromosome, the Central Dogma, Genes and the Genome, DNA Sequencing, Transcriptomics and DNA Microarrays, Proteomics and Mass Spectrometer, Chip-Chip and Chipset, Basic Principles of Genetics-Mendel and Morgan's Legacy, Disease Gene Mapping in the Genomic Era.m-health-Introduction, Basic building block of m-Health, Old Episodic model of health care delivery, Benefits of m-health, Opportunities & obstacles in adoption of m-health

mini-project in hospital standardization of data using m- health app

Text Books

1. Ramona Nelson, Nancy Staggers "Health Informatics: An Inter professional Approach " Elsevier , 2nd Edition,2013
2. Edward H. Shortliffe, James J. Cimino "Biomedical Informatics-Computer Applications In Health Care and Biomedicine" Springer, Fourth edition, 2013
3. David J. Lubliner "An Introduction to Information Systems and Software in Medicine and Health ", CRC Press, New Jersey Institute of Technology, Newark, USA,2015
4. C Willam Hanson III MD "Health care informatics", Medical Publishing Division McGraw-Hill Education / Medical; 1st edition, 2006
5. Rick Krohn, MA, MAS, David Metcalf, PhD" mHealth: From Smart phones to Smart Systems "Himss 2012
6. Vikas (Vik) Kumar "Healthcare Analytics Made Simple" PacktPublishing, Second edition ,2018

References

1. L.K. Schaper "Health Informatics: Digital Health Service Delivery - The Future is Now " IOS Press ,2013
2. Penny Duquenoy, Carlisle George, Kai Kimppa "Ethical, Legal, and Social Issues in MedicalInformatics"Medical Information Science Reference, New York,2008

3. Eta S. Berner "Clinical Decision Support Systems Theory and Practice" Springer, 2007
4. Rui Jiang • Xuegong Zhang • Michael Q. Zhan,"Basics of Bioinformatics"Springer, 2013

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Definition of health informatics, Theories & models underlying health informatics-Systems Theory, Chaos's Theory, Complexity Theory, Information Theory, Diffusion of innovation theory, Learning Theory, Change Theory	3
1.2	System Life cycle models, Staggers & Nelson system Life cycle model, Evidence based practice & Informatics-Evidence based practice models,	2
1.3	ACE star model of knowledge transformation, Knowledge, Data mining & Practice based medicine	2
2	**Module 2**	
2.1	Electronic health Records– Definition, Electronic medical Record versus Electronic Health Record,	3
2.2	EHR: components, Functions & Attributes, EHR applications used in clinical settings, benefits, Barriers to EHR adoption. Telehealth & Applications for delivering care at a distance–Technologies	2
2.3	Clinical Practice considerations for healthcare professionals, Operational & Organizational success factors & barriers, Telehealth challenges, Clinical Decision support system in Health care	2
3	**Module 3**	
3.1	Health information exchange-Basic definitions, The Nationwide Health Information Network (NHIN) and, NHIN Exchange &NHIN Direct, Health Information Organizations (HIOs), Federal Gateway Overview, Web Services and Service Oriented Architecture	2
3.2	Healthcare Analytics-Introduction, Components of healthcare analytics	2
3.3	Tools: SQL (basics)-SQLite, Python Features-Lists and tuples, Dictionaries, Sets, Python libraries- pandas and scikit-learn- Linear regression model, Logistic Regression	3

4	**Module 4**	
4.1	Patient medical Information-Privacy, Confidentiality, Security-Definition, Legal & historical context,	2
4.2	Principles, laws & Regulations, The importance of information security, Current security Vulnerabilities-External, Internal Vulnerabilities,	3
4.3	Use of ICT in healthcare, Managing security risk with security controls-Administrative, Technical & Physical	2
5	**Module 5**	
5.1	Basics for Bioinformatics- Cells, DNA and Chromosome, the Central Dogma, Genes and the Genome, DNA Sequencing, Transcriptomics and DNA Microarrays, Proteomics and Mass Spectrometer, ChIP-Chip and ChIP-Seq,	3
5.2	Basic Principles of Genetics-Mendel and Morgan's Legacy, Disease Gene Mapping in the Genomic Era	2
5.3	m-health-Introduction, Basic building block of m-Health, Old Episodic model of health care delivery, Benefits of m-health, Opportunities & obstacles in adoption of m-health	2

BMT332	ADVANCED MICROPROCESSORS & MICROCONTROLLERS	CATEGORY	L	T	P	CREDIT
		PEC	3	0	0	3

Preamble: This course gives a broad overview of the architecture of basic and advanced microprocessors along with an update of current technology in SOC design and high-performance computing. Students shall be encouraged to review technical manuals of relevant processors and one of the assignments shall be a case study of Medical Embedded application of the latest hardware technology.

Prerequisite: A thorough knowledge on basic digital circuits and systems is expected from the students learning this course. Students should also be familiar with the architecture of basic microcontrollers. Skill of programming would be helpful, but not necessary.

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

CO 1	Describe the architecture, registers and memory unit in a basic CISC processor-based computing device
CO 2	Discuss about advanced RISC platforms and illustrate its usage in a typical Medical Embedded application
CO 3	Outline the architecture of high-performance GPUs and their application areas
CO 4	Describe parallelism in supercomputing processors

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2								2		3
CO2	2	2	3							2		3
CO3	2	2								2		3
CO4	2	2								2		3

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 contains 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):

1. With the help of a neat block diagram, explain the architecture of 8086.
2. What are the advantages of memory segmentation in Intel architecture?
3. What is branch prediction logic as applied in Pentium Processors

Course Outcome 2 (CO2):

1. Give an overview of ARM 7 architecture
2. With the help of a block diagram and flow chart, explain the functional units required in a simple ventilator machine designed with an ARM Cortex M core.
3. Discuss the functional features of Raspberry Pi and compare with Pi Pico

Course Outcome 3(CO3):

1. What are the main components of a GPU?
2. List the primary differences between GPU and CPU architectures
3. Describe the typical application areas of a GPU

Course Outcome 4 (CO4):

1. Justify the statement - GPUs are Parallel Computers
2. Compare and contrast data parallelism with task parallelism

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____ _	

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__

Course Code: BMT332

Course Name: ADVANCED MICROPROCESSORS AND MICROCONTROLLERS

Max. Marks: 100		Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks

1		Discuss various data transfer instructions of 8086.	
2		Explain the structure of stack in 8086 with necessary diagrams.	
3		What is branch prediction?	
4		What are the modes of operation of 80386?	
5		What is the relevance of byte ordering in ARM Processor?	
6		List various categories of ARM cores	
7		Explain pipelining in Classic ARM processors	
8		Compare any 3 functional features of Raspberry Pi 4 with Pi Pico	
9		List the functional features of Apple A14	
10		What are the application areas of GPU based computing?	
		PART B	
11	a)	Explain the different addressing modes of 8086	14
		OR	
12	a)	What are the Signal descriptions of 8086 chips in minimum mode?	14
13	a)	Describe the general features of Pentium processors.	14
		OR	
14	a)	Describe the paging mechanism in 80386	14
15	a)	List any 10 instructions supported in ARM 7 and explain the usage with sample programs	14
		OR	
16	a)	Describe briefly the important architectural support for ARM based system development	14
17	a)	With the help of a simplified block diagram explain the system functionalities of Samsung Exynos 5410	14

		OR	
18	a)	Propose a system-on-chip (SoC) architecture for an ICU ventilator. Draw and explain the functional units	14
		OR	
19	a)	Compare the architecture of Raspberry Pi with NVIDIA Jetson NANO	14
		OR	
20	a)	Describe the fundamental difference in design philosophy of CPU and GPU architecture	14

Syllabus

Module 1

Historical milestones in cpu architecture: Architecture overview of 8086, Register organization of 8086, Signal descriptions of 8086, Physical memory - Organization, address generation, Introduction to Stack, Interrupts & Interrupt service. External memory interfacing- overview of memory technologies, partial and absolute decoding- Example, Timing diagram - Memory Read and write

Module2

High performance CISC architecture: 80386 - Salient features, Architecture and Signal Description, Register Organization. Real Address mode, Protected mode, Segmentation, Paging & Virtual modes. Pentium - General features, pipelining and super scalar architecture. **Introduction to multicore processors**: Advantages of multicore, Concept of Hyper-Threading, homogeneous and heterogeneous multicore processors, Internal architecture of Intel Core2 Duo (Simple block diagram level only), Comparison of Core i3, i5 and i7 processors

Module3

High performance RISC architecture: ARM Processor Fundamentals: ARM category overview- Classic ARM, ARM Cortex, ARM for Embedded Applications. The Classic ARM programmer's model, ARM Processor Families, ARM Organization - 3-stage and 5-stage pipeline ARM organization, ARM instruction execution, ARM Instruction Set, Thumb Instruction set. Architectural Support for System Development - The ARM memory interface, The Advanced Microcontroller Bus Architecture (AMBA)

Module4

ARM Classic/Cortex based SOC: Basic system-on-chip (SoC) architecture, Overview of SoC design flow. Raspberry Pi family - Overview and general architecture, accessories. Application and use in healthcare (Case study such as People's Ventilator Project), Feature comparison: Pi 4 vs Pi Pico

Module5

Introduction to high performance computing: CPU vs GPU, Application areas, GPUs as Parallel Computers, Evolution of Graphics Pipelines, GPU Computing, Parallelism with GPUs - Data parallelism and task parallelism, Feature comparison: Raspberry Pi vs NVIDIA Jetson NANO. **Literature Review:** Smartphone processors (Overview of system functionalities) - Samsung Exynos 5410 SoC and Apple A14

Text Books

1. A.K. Ray, K.M. Bhurchandi, "Advanced Microprocessors and Peripherals", 2nd Edition, Tata Mcgraw Hill, 2006
2. Andrew N. Sloss, Dominic Symes, Chris Wright "ARM System Developer's Guide", Morgan Kaufmann., 2005
3. Steve Furber, "ARM System-on-Chip Architecture," Second Edition, Addison Weley, 2000
4. Joseph Yiu, "The Definitive Guide to the ARM Cortex-M3," Newnes, 2009
5. David B. Kirk and Wen-mei W. Hwu, "Programming Massively Parallel Processors: A Hands-on Approach", ISBN: 978-0-12-381472-2, 2010

Reference Books/Materials

1. Barry B. Brey, The Intel Microprocessors 8086/8088,80286, 80386 80486, Pentium, Pentium Pro Processor, Pentium II, Pentium III, Pentium 4, Architecture, Programming and interfacing, Prentice Hall of India Private Limited, New Delhi, 2003.
2. D. V. Hall, "Microprocessor and Interfacing Programming & Hardware" TMH
3. Shane Cook, "CUDA Programming A Developer's Guide to Parallel Computing with GPUs", ISBN: 978-0-12-415933-4, 2013
4. AgusKurniawan, "IoT Projects with NVIDIA Jetson Nano AI-Enabled Internet of Things Projects for Beginners", https://doi.org/10.1007/978-1-4842-6452-2
5. Technical reference manuals of respective processing cores

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Architecture overview of 8086, Register organization of 8086, Signal descriptions of 8086	2
1.2	Physical memory - Organization, address generation	1
1.3	Introduction to Stack, Interrupts & Interrupt service.	1

1.4	Overview of memory technologies	1
1.5	Partial and absolute decoding- Example, Timing diagram - Memory Read and write	2
2	**Module 2**	
2.1	80386 - Salient features, Architecture and Signal Description, Register Organization.	1
2.2	Real Address mode, Protected mode, Segmentation, Paging & Virtual modes.	1
2.3	Pentium - General features, pipelining and super scalar architecture	2
2.4	Advantages of multicore, Concept of Hyper-Threading, homogeneous and heterogeneous multicore processors	1
2.5	Internal architecture of Intel Core2 Duo (Simple block diagram level only), Comparison of Core i3, i5 and i7 processors	2
3	**Module 3**	
3.1	ARM Processor Fundamentals: ARM category overview- Classic ARM, ARM Cortex, ARM for Embedded Applications.	2
3.2	The Classic ARM programmer's model, ARM Processor Families, ARM Organization - 3-stage and 5-stage pipeline ARM organization,	2
3.3	ARM instruction execution, ARM Instruction Set, Thumb Instruction set.	2
3.4	Architectural Support for System Development - The ARM memory interface	1
3.5	The Advanced Microcontroller Bus Architecture (AMBA)	1
4	**Module 4**	
4.1	Basic system-on-chip (SoC) architecture, Overview of SoC design flow.	1
4.2	Raspberry Pi family - overview and general architecture, accessories.	2
4.3	Application and use in healthcare (Case study such as People's Ventilator Project)	2

4.4	Feature comparison: Pi 4 vs Pi Pico	1
5	**Module 5**	
5.1	CPU vs GPU, Application areas	1
5.2	GPUs as Parallel Computers, Evolution of Graphics Pipelines, GPU Computing	1
5.3	Parallelism with GPUs - Data parallelism and task parallelism,	1
5.4	Feature comparison: Raspberry Pi vs NVIDIA Jetson NANO	1
5.5	Smartphone processors - Samsung Exynos 5410 SoC, Apple A14: Overview of system functionalities	2

BMT342	DESIGN OF BIOMEDICAL DEVICES	CATEGORY	L	T	P	CREDIT
		PEC	3	0	0	3

Preamble: This course gives an overview of design concepts for a medical device starting from generating ideas, classifying medical devices and understanding the design procedures. It aims to develop product specification, enhance quality in design are very much essential for a product design. The course looks into the manufacturing supply chain components and post market surveillance.

Prerequisite: Nil

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

CO 1	Prepare documentation based on needs identification and specification preparation.
CO 2	Evaluatethe design aspects of biomedical equipment and its safety.
CO 3	Identify steps in the verification and validation of the product design
CO 4	Assess thequality control and performance in manufacturing supply chain
CO 5	Familiarise with the standards and regulations for medical devices

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	3	2		3				3		2
CO 2	3	3	3	2		3		2		1		2
CO 3	3	3	3	2		3				2		2
CO 4	3	3	2	1	1	3				2		2
CO 5	3	3	3	2		3		1				2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	5	5	10
Understand	7.5	7.5	15
Apply	7.5	7.5	15
Analyse	20	20	40
Evaluate	10	10	20

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): Prepare documentation based on needs identification and specification preparation.

1. Document with an example a medical device life cycle.
2. What are the different types of brain storming and idea generation techniques?
3. With the help of an example describe process of developing specification for a medical device.

Course Outcome 2 (CO2): Evaluate the design aspects of biomedical equipment and its safety.

1. Why are human factors important in medical device design?
2. What are the common errors while designing a medical device?
3. What are the types of FMEA?

Course Outcome 3 (CO3):Identify steps in the verification and validation of the product design

1. What are the anticipated risks and roadblocks in the process of a medical device design and how will you mitigate them?
2. Why is verification important in medical device design
3. Identify the steps in design transfer process.

Course Outcome 4 (CO4): Assess the quality control and performance in manufacturing supply chain.

1. What are the 5 basic steps of supply chain management?
2. Explain the advances and challenges linked to biodesign tools and biomanufacturing technologies
3. With the help of a block diagram explain the risk management process.

Course Outcome 5 (CO5): Familiarise with the standards and regulations for medical devices

1. What are the regulatory guidelines for medical devices in India?
2. Explain the preparation of FDA submission (510k process),
3. What are the legal tests to validate an invention as a patent? Explain the patent process steps.

Model Question paper

Reg No.: _____		Name: _____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY _____SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT 342			
Course Name: DESIGN OF BIOMEDICAL DEVICES			
Max. Marks: 100			Duration: 3 Hours
PART A			
	Answer any all questions. Each carry 3 marks.		Marks
1	List the generalised steps a product life cycle may follow.		(3)
2	What is proof of concept?		(3)
3	State the different stages of quality function deployment process.		(3)
4	What are the components of product specification		(3)
5	What are human factors in medical device design		(3)
6	Define software design description		(3)
7	What do you verify in system testing?		(3)
8	What are the 5 basic steps of supply chain management?		(3)
9	What are quality system regulations?		(3)
10	What are design controls FDA?		(3)
PART B			
Answer any one full question from each module. Each carry 14 marks.			
MODULE 1			()
11	a)	Explain the steps in Idea feasibility/Generating concept : prototype development to prove the idea.	(7)
	b)	Determine the classification (EU and USA) for I) A single-use scalpel ii) An x-ray imaging machine	(7)
12	a)	Consider a simple medical equipment such as automatic BP monitor. Develop a list of customer needs and system-level requirements.	(10)

		a. Develop the system and subsystem architecture. b. Cascade system-level requirements to each subsystem. Review the system specification	
	b)	Differentiate between proof of concept and prototype	(4)
MODULE 2			
13	a)	How does a FMEA process work? Explain the steps to perform a FMEA	(6)
	b)	Product specification **is** the first step in the process of transforming product ideas into approved product development efforts. What are the different factors that affect product specification?	(8)
14	a)	Define software requirement specification. Explain the components of typical software requirement specification	(8)
	b)	What is bill of materials. How bill of materials for software is prepared.	(6)
MODULE 3			
15	a)	Explain the three verification elements required to carry out verification of design process	(7)
	b)	Describe a validation life cycle model explaining the procedures followed in different phases of product development.	(7)
16	a)	What is System Testing? Explain the various types and give definition with example.	(6)
	b)	What is the difference between design verification and design validation? What are the different methods of design verification?	(8)
MODULE 4			
17	a)	Explain the advances and challenges linked to bio design tools and bio manufacturing technologies	(7)
	b)	Differentiate between micro-manufacturing and nano-manufacturing Technologies	(7)
18	a)	Explain the importance of In-Silico testing	(7)
	b)	With the help of a block diagram explain the risk management process.	(7)
MODULE 5			
19	a)	What are the ISO standards for medical devices?	(7)
	b)	What are the regulatory guidelines for medical devices in India	(7)
20	a)	What are the legal tests to validate an invention as a patent? Explain the patent process steps.	(8)
	b)	What are the benefits of ISO 13485 Medical Devices?	(6)

Syllabus

Module 1

Determining and Documenting device requirements: Idea feasibility and Generating concept: Need identification, prototype development to prove the idea, proof of concept.
Device requirements: Product specification, specification review, design specification Software and / or Hardware requirement specification, Software/Hardware design description, Device Records (Case study- Automatic BP monitor, ECG machine etc.) Medical device classification

Module 2

Design Phase – Risk analysis- hazards review, risk trace matrix, Failure Mode and Effects Analysis(FMEA): Design and system FMEA, Hardware design, Software design, design reviews, Design of experiments, safety margin, environmental protection, product misuse, Biocompatibility, sterilization requirements, human factors engineering, Bill of materials preparation (mechanical/electrical/software/system). (Case study: Example drug infusion system)

Module 3

Design Verification, Product Validation and Design Transfer: Basic concepts, Design verification plan, protocols, design transfer process, software-hardware test plan for medical devices, system testing- subsystem and full device, Risk assessment of medical devices.
Computer-Aided Design (CAD), and Computer-Aided Manufacturing (CAM) in biomedical device design.

Module 4

Manufacturing supply chain: Product manufacturing, Installation Qualification, Operational Qualification and Performance Qualification (IQ/OQ/PQ) protocols, Labelling-Instructions for Use (IFU), design and manufacture process, Quality assurance, audits, post market surveillance, Manufacturing supply chain- process optimization inmanufacturing, Rapid prototyping-3D printing (Case study for manufacturing supply chain).

Module 5

Medical Device Standards and Regulations: Food and Drug Administration (FDA) regulations, Preparing FDA submission (510k process), European standards, International Organisation for Standardisation (ISO)- ISO-13485/14971, International Electrotechnical Commission (IEC)-IEC-60601(1-2), Indian Certification for Medical Devices (ICMED)-*ICMED* 13485, Safety and essential performance of medical electrical equipment, Intellectual Property (IP)- protection for medical devices. Steps for patent process.

Text Books

1. Fries, Richard C. Reliable design of medical devices. CRC Press, 2012.
2. PeterOgrodnik,"MedicalDeviceDesignInnovationfromConcepttoMarket",Elsevier, 2013.
3. Lam, Raymond HW, and Weiqiang Chen. Biomedical devices: materials, design, and manufacturing. Springer, 2019
4. Paul H. King,Richard C. Fries,Arthur T. Johnson,"Design of Biomedical Device andSystems",Third Edition 2015
5. Jamnia, Ali. Introduction to product design and development for engineers. CRC Press, 2018.

Reference Books

1. Teixeira, Marie B. Design controls for the medical device industry. CRC press, 2019.
2. Ramakrishna, Seeram, Lingling Tian, Charlene Wang, Susan Liao, and Wee Eong Teo. Medical devices: regulations, standards and practices. Woodhead Publishing, 2015.
3. Fries, Richard C., ed. Handbook of medical device design. CRC Press, 2019.
4. JackWong,,RaymondTong, "HandbookofMedicalDeviceRegulatoryAffairsinAsia"Second Edition, 2018
5. Yock, Paul G., Stefanos Zenios, Josh Makower, Todd J. Brinton, Uday N. Kumar, FT Jay Watkins, Lyn Denend, Thomas M. Krummel, and Christine Q. Kurihara. Biodesign: the process of innovating medical technologies. Cambridge University Press, 2015.
6. Vogel, David A. Medical device software verification, validation and compliance. Artech House, 2011.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Determining and Documenting device requirements**	
1.1	Idea feasibility/Generating concept : prototype development to prove the idea, proof of concept	2
1.2	Device Requirements: Product specification, Specification review, design specification,	1
1.3	Software/Hardware requirement specification, Software/Hardware design description,	1
1.4	Device History Record, Device Master Record, Design history files, Medical device classification	2
1.5	Case study for a biomedical device	1

2	**Design Phase**	
2.1	Risk analysis- hazards review, risk trace matrix, FMEA: Design and system FMEA, , ,	2
2.2	Hardware design, Software design, design reviews, Design of experiments, safety margin, environmental protection, product misuse,	2
2.3	Biocompatibility – sterilization requirements	1
2.4	Human factors engineering in design	2
2.5	Bill of materials preparation (mechanical/electrical/software/system).	1
3	**Design Verification, Product Validation and Design Transfer**	
3.1	Basic concepts, Design verification plan, protocols, design transfer process	2
3.2	Software-hardware test plan for medical devices, system testing-subsystem and full device	2
3.3	Risk assessment of medical devices	1
3.4	Computer-Aided Design (CAD), and Computer-Aided Manufacturing (CAM) in biomedical device design.	2
4	**Manufacturing supply chain**:	
4.1	Product manufacturing, Installation Qualification, Operational Qualification and Performance Qualification (IQ/OQ/PQ) protocols	2
4.2	Labelling-Instructions For Use (IFU), design and manufacture process,	2
4.3	Quality assurance, audits, post market surveillance,	1
4.4	Manufacturing supply chain, optimization in manufacturing	1
4.5	Rapid prototyping-3D printing	1
5	**Medical Device Standards and Regulations**	
5.1	Food and Drug Administration (FDA) regulations, Preparing FDA submission (510k process),	2
5.2	European standards, International Organisation for Standardisation (ISO)- ISO-13485/14971, International Electrotechnical Commission (IEC)- IEC-60601(1-2) Indian Certification for Medical Devices (ICMED)-ICMED 13485	2
5.3	Safety and essential performance of medical electrical equipment	1
5.4	Intellectual Property (IP)- protection for medical devices. Steps for patent process.	2

BMT352	BIOSTATISTICS	CATEGORY	L	T	P	CREDIT
		PEC	3	0	0	3

Preamble: Biostatistics is the application of statistical science to research in health-related fields including medicine, biology, nursing, public health and pharmacy. The study of biostatistics helps to disentangle the data received and to make valid inferences that can be used to solve problems in public health. The course is structured so that the students may be made capable to collect, analyse, and form statistical conclusions from case studies using any of the modern statistical tools.

Prerequisite: Require basic mathematical skills to apply statistics along with algebra.

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

CO 1	Explain the basic concepts of statistical analysis.
CO 2	Analyse the concepts of probability and distributions.
CO 3	Examine the data and to identify distribution forms relating to the variables.
CO 4	Analyse applications of correlation and regression in biostatistics.
CO 5	Apply hypothesis testing via some statistical distributions in biological problems.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										2
CO2	3	3										2
CO3	3	3										2
CO4	3	3	3	2	2					1		2
CO5	3	3	3	2	2					1		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	2.5	2.5	5
Understand	5	5	10
Apply	15	15	30
Analyse	15	15	30
Evaluate	12.5	12.5	25

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 a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand the basic concepts of statistical analysis.

1. What are the measures to describe the variability of a sample?
2. Differentiate between geometric mean and harmonic mean.
3. For a study of kidney disease, the following measurements were made on a sample of women working in several factories in Switzerland. They represent concentrations of bacteria in a standard-size urine specimen. High concentrations of these bacteria may indicate possible kidney pathology. The data are presented in following Table;

Concentration	Frequency
10^0	521
10^1	230
10^2	115
10^3	74
10^4	69
10^5	62
10^6	43
10^7	30
10^8	21
10^9	10
10^{10}	2

a) Compute the arithmetic mean of this sample.
b) Compute the geometric mean of this sample.

c) Which do you think is the most appropriate measure of location? Justify your answer.

Course Outcome 2 (CO2): Analyse the concepts of probability and distributions.

1. Define expected value and variance of a discrete random variable.
2. State the Bayes' theorem and mention its applications.
3. Studies show that about one woman in seven (approximately 14.3%) who live to be 90 will develop breast cancer. Suppose that of those women who develop breast cancer, a test is negative 2% of the time. Also suppose that in the general population of women, the test for breast cancer is negative about 85% of the time. Let B= woman develops breast cancer and let N= tests negative. Suppose one woman is selected at random.
    a) Given that the woman has breast cancer, what is the probability that she tests negative?
    b) Given that a woman develops breast cancer, what is the probability that she tests positive?
    c) What is the probability that the woman has breast cancer or tests negative?
    d) Are having breast cancer and testing negative mutually exclusive?

Course Outcome 3 (CO3): Examine the data and to identify distribution forms relating to the variables.

1. Suppose a continuous random variable can only take on values between −1 and +1. What is the area under the pdf from −2 to 2?
2. What is a standard normal distribution?
3. Case: Hospital records of patients suffering from a certain disease shows that 75% of patients die due to the disease.
    a) Which distribution can be used for this case? Justify your answer.
    b) What is the probability that of 6 randomly selected patients, 4 will recover?

Course Outcome 4 (CO4): Analyse applications of correlation and regression in biostatistics.

1. Explain interval estimation for linear regression.
2. "In general, children whose parents have high blood pressure tend to have higher blood pressure than their peers". Analyse the statement and express this relationship in terms of correlation?

3. Obtain line of regression of Y on X on the given data

Age in Years(X)	66	38	56	42	72	36	63	47	55	45
Blood	145	124	147	125	160	118	149	128	150	124

Pressure (Y)										

Estimate blood pressure of a man whose age is 50 years.

Course Outcome 5 (CO5): Apply hypothesis testing via some statistical distributions in biological problems.

1. Describe the relationship between hypothesis testing and confidence intervals?
2. What non parametric tests could be used to compare the median grey levels of normal and cataract eyes? Justify your answer.
3. The following are the reaction times (in milliseconds) for randomly selected subjects who took either Drug A or Drug B.

Drug A	Drug B
1.96	2.11
2.24	2.43
1.71	2.07
2.41	2.71
1.62	2.50
1.93	4.84
	2.88

a) How could you analyse the data with a non-parametric method?
b) If we conduct the Wilcoxon Rank test on this data, what will be the sum of ranks for drug B?
c) Interpret the mean reaction time for drug A and B from the results.

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____ _	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT352			
Course Name: BIOSTATISTICS			
Max. Marks: 100			Duration: 3 Hours
PART A			
Answer all questions. Each question carries 3 marks			
1		Calculate mode for the given data: 100,97,110,200,75,120,150.	
2		What is the difference between box plot and bar graph?	
3		State the Bayes' theorem and mention its applications.	
4		What are mutually exclusive events? Give an example.	
5		Define confidence interval.	

6		What is the difference between a standard normal distribution and a general normal distribution?	
7		What is the relationship between hypothesis testing and confidence intervals?	
8		What is Sign Test?	
9		How can we apply regression in biostatistical analysis?	
10		What is ANOVA?	
		PART B	
11	a)	Table shows the distribution of dietary vitamin-A intake as reported by 14 students who filled out a dietary questionnaire in class. The total intake is a combination of intake from individual food items and from vitamin pills. The units are in IU/100 (International Units/100).	14

Student number	Intake (IU/100)	Student number	Intake (IU/100)
1	31.1	8	48.1
2	21.5	9	24.4
3	74.7	10	13.4
4	95.5	11	37.1
5	19.4	12	21.3
6	64.8	13	78.5
7	108.7	14	17.7

a) Construct a stem and leaf plot of the given data on some convenient scale?
b) Do you think the mean or median is a more appropriate measure of location for this data set?
c) Compute mean and median from these data
d) Compute standard deviation and coefficient of variation from this data

		OR	
12	a)	For a study of kidney disease, the following measurements were made on a sample of women working in several factories in Switzerland. They represent concentrations of bacteria in a standard-size urine specimen. High concentrations of these bacteria may indicate possible kidney pathology. The data are presented in following Table;	14

		<table><tr><th>Concentration</th><th>Frequency</th></tr><tr><td>10^0</td><td>521</td></tr><tr><td>10^1</td><td>230</td></tr><tr><td>10^2</td><td>115</td></tr><tr><td>10^3</td><td>74</td></tr><tr><td>10^4</td><td>69</td></tr><tr><td>10^5</td><td>62</td></tr><tr><td>10^6</td><td>43</td></tr><tr><td>10^7</td><td>30</td></tr><tr><td>10^8</td><td>21</td></tr><tr><td>10^9</td><td>10</td></tr><tr><td>10^{10}</td><td>2</td></tr></table> d) Compute arithmetic mean of this sample e) Compute geometric mean of this sample f) Which do you think is the most appropriate measure of location?	
13	a)	Define Poisson distribution. Find its mean, expected value and variance.	14
		OR	
14	a)	Suppose a rare infectious disease occurs at the rate of 2 per 10^6 people per year. (a) What is the probability that in New York City (population about 8 million) exactly 25 cases occur in a given year? (b) What is the probability that at least 25 cases occur in a given year? (Use the Poisson approximation to the binomial distribution.)	14
15	a)	What is a standard normal distribution?	4
	b)	a) Suppose a continuous random variable can only take on values between −1 and +1. What is the area under the pdf from −2 to 2? b) What is the area to the left of −0.2 under a standard normal distribution? What symbol is used to represent this area?	10
		OR	
16	a)	How can we estimate the mean and variance of a distribution?	14
17	a)	Explain the following hypothesis test for categorical data a) Fisher's Exact Test b) Chi-Square Goodness-of-Fit Test	14
		OR	
18	a)	Explain One sample test for the mean of a normal distribution.	14
19	a)	Explain on multiple regressions.	7

	b)	How is it useful in statistical analysis of medical data?	7
		OR	
20	a)	Explain the method of least squares to estimate the parameters of a regression line.	10
	b)	What is the difference between a regression coefficient and a correlation coefficient?	4

Syllabus

Module 1

Descriptive statistics: Measures of location, Arithmetic Mean, Median, Mode, Geometric mean and harmonic mean, measures of spread, Variance and standard deviation, coefficient of variation, properties of Arithmetic Mean and Variance, Grouped data, Graphic Methods.

Module 2

Probability: Notations, Laws of probability, Bayes' rule and screening tests, Bayesian Inference, ROC Curves. Random variables. **Discrete Probability distributions:** Probability mass function, expected value, variance and cumulative distribution. Binomial distribution, Poisson distribution.

Module 3

Continuous Probability distribution: Normal distribution, properties of standard normal distribution.**Estimation:** Relationship between Population and Sample, Random number trials, clinical trials, Estimation of Mean, Variance, Binomial distribution and Poisson distribution. One sided confidence Intervals.

Module 4

Hypothesis testing: One sample inference: One sample test for the mean of a normal distribution,one- and two-sided alternatives. Categorical data: Fisher's Exact Test,Chi-Square Goodness-of-Fit Test. **Nonparametric methods:** The Sign Test, The Wilcoxon Signed-Rank Test

Module 5

Regression and Correlation Methods: Fitting regression lines- Method of least squares, Inference about parameters from regression lines, interval estimation for linear regression,

Correlation coefficient, multiple regressions. Multisample Inference: Introduction to ANOVA.

Text Books

1. Bernard Rosner, "Fundamentals of Biostatistics", Fifth edition, Duxbury Press, 2010.
2. PSS Sunder Rao and J Richard, "Introduction to Biostatistics and Research Methods", Fifth Edition, PHI Learning, 2012.

Reference Books

1. Khan, Irfan A., and Atiya Khanum. *Fundamentals of biostatistics*. Ukaaz, 2004.
2. Moore and McCabe, "Introduction to the Practice of Statistics", W.H. Freeman and Company, 2009.
3. N.G. Das, "Probability and Statistics" AtlanticPublishers, 2016.
4. Marcello Pagano "Principles of Biostatistics", 2nd ed., Chapman and Hall/CRC, 2018

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Measures of location, Arithmetic Mean, Variance, Median, Mode, Geometric mean and harmonic mean	4
1.2	Measures of spread, Variance and standard deviation, coefficient of variation, properties of Arithmetic Mean and Variance	2
1.3	Grouped data, Graphic Methods.	1
2	**Module 2**	
2.1	Notations, Laws of probability, Random variables Notations, Laws of probability	2
2.2	Bayes' rule screening tests Bayesian Inference, ROC Curves. Random variables, Discrete Probability distributions, Probability mass function	3
2.3	Expected value, variance and cumulative distribution. Binomial distribution, Poisson distribution	2
3	**Module 3**	
3.1	Continuous probability distribution: Normal distribution, properties of standard normal distribution	2
3.2	Estimation; Relationship between Population and Sample, Random	2

	number trials, clinical trials, Estimation of Mean, Variance	
3.3	Binomial distribution and Poisson distribution. One sided confidence Intervals	3
4	**Module 4**	
4.1	Hypothesis testing. One sample inference: One sample test for the mean of a normal distribution, one- and two-sided alternatives.	2
4.2	Categorical data: Fisher's Exact Test,Chi-Square Goodness-of-Fit Test	2
4.3	Nonparametric methods: The Sign Test, The Wilcoxon Signed-Rank Test	3
5	**Module 5**	
5.1	Fitting regression lines- Method of least squares, Inference about parameters from regression lines, interval estimation for linear regression,	3
5.2	Correlation coefficient, multiple regressions.	2
5.3	Multisample Inference: Introduction to ANOVA.	2

BMT362	NETWORK ANALYSIS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The objective of this course is to understand the various Network circuits and apply them in biomedical circuits.

Prerequisite: Nil

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

CO 1	Classify the various Network theorem and apply them in circuits
CO 2	Analyse current voltage relations and also loop connections in circuits
CO 3	Extend the basic concepts of electric circuits and their analysis in time and frequency domain
CO 4	Analyse the concept of filter circuits and design of passive filters
CO 5	Familiarise the techniques of network synthesis

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3								2		
CO2	3	3	2							2		
CO3	2	3	2							2		
CO4	3	3	2							2		
CO5	3	3	2							2		

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	15	15	60
Analyse	5	5	10
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.

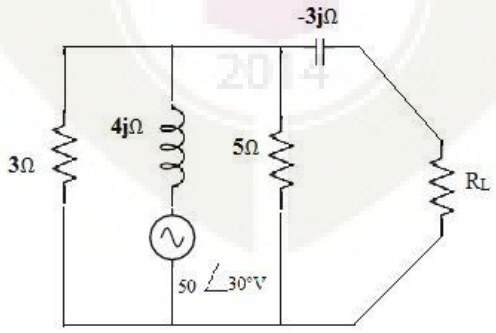
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. State reciprocity theorem.
2. Obtain impulse response of series RC network?

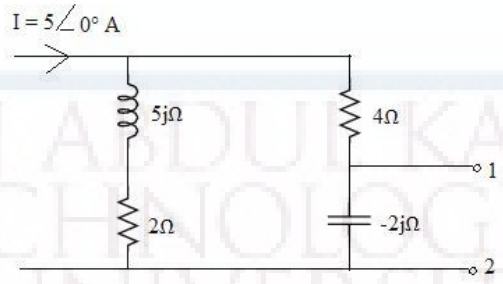
Course Outcome 2 (CO2):

1. Give the s domain representation of Step, Ramp & exponential signals
2. State the maximum power transfer theorem. What should be the value of RL so that maximum power can be transferred from source to RL. Also find Pmax.



Course Outcome 3(CO3):

1.a) State Norton's theorem.



Find Norton's equivalent circuit for the network at the left of terminals 1&2

Course Outcome 4 (CO4):

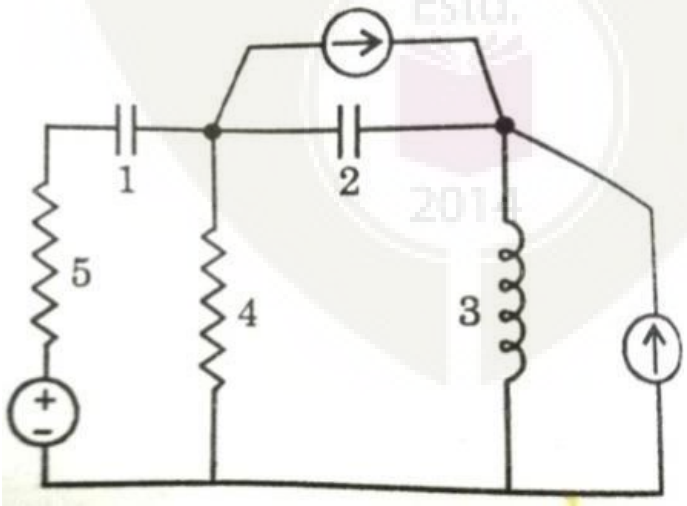
1. If a T-section of a constant K LPF has series inductance 85 mH and shuntcapacitance 0.025 μF, calculate its cut-off frequency and the nominal designimpedance Ro. Design an equivalent π-section too.?
2. Compare constant K LPF and constant K HPF
3. Explain the classification of filters

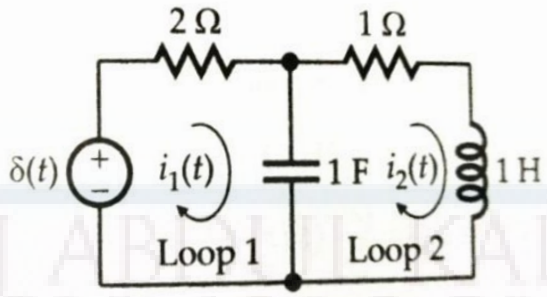
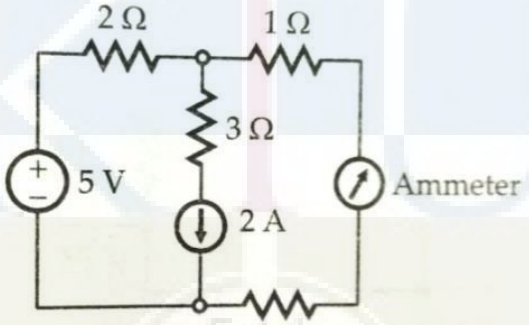
Course Outcome 5 (CO5):

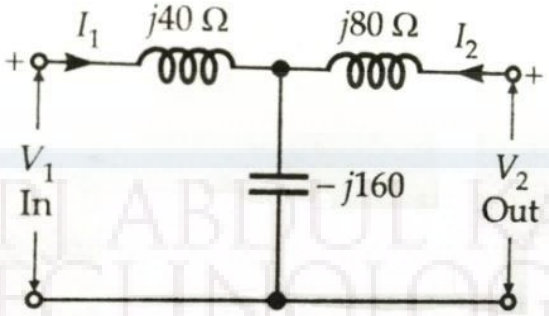
1. Test whether the polynomial $s^5 + s^3 + s$ is Hurwitz or not.
2. Explain the properties of P.R function.

Model Question paper

			Total Pages: 2
Reg No.:_____			**Name:_____**
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY **SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__**			
Course Code: BMT362			
Course Name: Network Analysis			
Max. Marks: 100			**Duration: 3 Hours**
PART A			

Answer all questions. Each question carries 3 marks			
1		State Norton's theorem	3
2		Obtain the step response of RL series circuit.	3
3		Give the s-domain representation of step and ramp signals	3
4		Obtain h-parameter in terms of Y-parameter	3
5		Explain Z-parameter with equivalent diagram.	3
6		Explain the classification of filters.	3
7		Explain necessary conditions of stability of a network function	3
8		Obtain the second foster form of the admittance function of an LC network $Y(s) = \frac{s(s^2+9)}{10\,(s^2+4)(s^2+25)}$	3
9		Explain the properties of driving point immittance function of LC networks	3
10		Explain the properties of RL driving point impedance function.	3
PART B			
11		Obtain the Laplace transform of the following: a) e^{-bt} cosbt, where b being a constant b)1-e^{-at}, a being a constant.	14
OR			
12		For a network shown in figure i) Draw the graph ii) determine all the trees and co trees iii) Form the incident matrix iv) reduced matrix 	14

13		 In a circuit of the figure find i1 (t) and i2 (t). Assume zero initial condition	14
		OR	
14	a)	A function in the Laplace domain is given by $F(s)$ =2(S + 4)/ (s + 3) (s + 8) Find the initial and final value using initial and final value theorem?	7
	b)	 Find the ammeter reading using Thevenin's theorem	7
15	a)	Discuss the cascaded connection in the two-port network	7

	b)	Find the open circuited parameters of the two port networks shown in figure and also find the Y parameters from open circuited parameters 	7
		OR	
16	a)	Design a m and k derived high pass filter section (T and π) having design impedance of 600 Ω., cut off frequency 5 KHz and m 0.35. Also find the frequency of infinite attenuation	14
17	a)	Design a prototype band pass filter section (T and π) having cut off frequenciesof 3000Hz and 6000Hz nominal characteristic impedance of 600 Ω . Also findthe resonant frequencies of shunt and series arm	14
		OR	
18	a)	18. Check whether the given polynomial is a Hurwitz or not i) S4+7S3+4S2+18S+6 ii) S5 +3S4+3S3+4S2+S+1	14
		OR	
19	a)	19. Explain i) the concept of positive real function ii) Properties of positive real function iii) Requirements of positive real functions	14
		OR	
20	a)	Check whether the function $z(s)$ =2S2 + 2S + 1/S3 + 2S2 + S + 2 is a PR function	14

Syllabus

Module 1

Thevenin's and Norton's theorems – Superposition theorem – Source transformations – Maximum Power Transfer theorem – Reciprocity theorem

Definition of basic terms – Incidence matrix – Tie-sets and Cut-sets – Analysis and formulation of network equations using tie-set and cut-set, Response of RC, RL and LC networks to impulse and step inputs – Step response of RLC network

Module 2

Review of Laplace transform – Transforms of basic signals – Transformation of a circuit into S-domain – Transformed equivalent of inductance, capacitance and mutual inductance – Impedance and admittance in the transformed domain Nodal analysis and Mesh analysis of the transformed circuit, Impulse response and Transfer function – Poles and Zeros – Restriction of pole and zero locations of network functions - Steady state response and Frequency response from Laplace transform.

Module 3

Characterization in terms of Impedance, Admittance, Transmission and Hybrid parameters – Inter-relationships among parameter sets. Analysis of interconnected two-port networks – Series, Parallel and Cascade connections of two-port networks, T and π equivalent of a two-port network Image impedance – Characteristic impedance and propagation constant of a symmetrical two-port network

Module 4

Filter fundamentals – Pass and stop bands – Types of filtering – Characteristic impedance – Design of Constant K – Low Pass, High Pass, Band Pass and Band Reject Filters, T and π sections – Design of m-derived Low Pass and High Pass filters. Types of attenuators, T and Bridged T attenuators - compensated attenuators

Module 5

Causality and Stability analysis of network functions – Hurwitz polynomials – Properties of Hurwitz polynomials. Positive Real functions – Properties of positive real functions – Testing driving point functions. Foster and Cauer forms of realization of network functions – Properties of driving point immittance functions of LC networks. Synthesis of LC driving point functions – Properties of RC driving point immittance functions, Synthesis of RC network functions. Properties of RL driving point immittance functions, Synthesis of RL network functions

Text Books

1. Chakrabarti, Abhijit. *Circuit Theory: Analysis and Synthesis*. Dhanpat Rai & Company, 2007.
2. Core, AEEB09. "Network analysis." (1987).
3. Choudhury, D. Roy. *Networks and systems*. New Age International, 1988.

Reference Books

1. Nahvi, Mahmood, and Joseph A. Edminister. *Schaum's outline of Electric Circuits*. McGraw-Hill Education, 2018.
2. Johnsen, Erik. "Franklin F. Kuo: Network Analysis and Synthesis. John Wiley & Sons, New York and London, 1962. 413 s., 64 sh." *LedelseogErhvervsøkonomi*.
3. William, H. A. R. T., and Jack E. Kemmerly. *Engineering circuit analysis*. McGraw-Hill Book Company, 1986.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Thevenin's and Norton's theorems-Superposition theorem – Source transformations	3
1.2	Maximum Power Transfer theorem – Reciprocity theorem	2
1.3	Definition of basic terms – Incidence matrix – Tie-sets and Cut-sets – Analysis and formulation of network equations using tie-set and cut-set	3
1.4	Response of RC, RL and LC networks to impulse and step inputs – Step response of RLC network	2
2	**Module 2**	
2.1	Laplace transform- Transforms of basic signals – Transformation of a circuit into S-domain	3
2.2	Transformed equivalent of inductance, capacitance and mutual inductance – Impedance and admittance in the transformed domain	2
2.3	Nodal analysis and Mesh analysis of the transformed circuit	1
2.4	Impulse response and Transfer function – Poles and Zeros – Restriction of pole and zero locations of network functions	2
2.5	Steady state response and Frequency response from Laplace transform.	2
3	**Module 3**	
3.1	Characterization in terms of Impedance, Admittance, Transmission and Hybrid parameters -Inter-relationships among parameter sets. Analysis of interconnected two-port networks – Series, Parallel and Cascade connections of two-port networks	2
3.2	T and π equivalent of a two-port network Image impedance	1
3.3	Characteristic impedance and propagation constant of a symmetrical two-port network	1
4	**Module 4**	
4.1	Filter fundamentals -Pass and stop bands – Types of filtering – Characteristic impedance – Design of Constant K	2
4.2	Low Pass, High Pass, Band Pass and Band Reject Filters, T and π sections – Design of m-derived Low Pass and High Pass filters	2
4.3	Types of attenuators, T and Bridged T attenuators - compensated attenuators	1
5	**Module 5**	
5.1	Causality and Stability analysis of network functions-Hurwitz polynomials – Properties of Hurwitz polynomials. Positive Real functions – Properties of positive real function	2
5.2	Testing driving point functions. Foster and Cauer forms of realization of network functions – Properties of driving point immittance functions	2

	of LC networks	
5.3	Synthesis of LC driving point functions – Properties of RC driving point immittance functions, Synthesis of RC network functions	1

BMT372	COMMUNICATION TECHNIQUES	CATEGORY	L	T	P	CREDIT
		PEC	3	0	0	3

Preamble: This course helps create a firm grounding in electronic communication fundamentals and understanding real-world components, circuits, equipment, and systems in everyday use. This course attempts to balance the principles with an overview of the latest techniques.

Prerequisite: Nil

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

CO 1	Explain different types of electronic communication systems and the role of modulation and multiplexing in facilitating signal transmission.
CO 2	Discuss different digital communication techniques.
CO 3	Describe transmitter and receiver configurations and the circuits in radio transmission systems
CO 4	Classify widely used wireless communication technologies and apply it for biomedical scenarios

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3							2		
CO2	3	3	3							2		
CO3	3	3	3			2				2		
CO4	3	3	3			2				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 contains 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 in which students should answer anyone. Each question can have a maximum 2 sub-divisions and carry 14 marks.

Course level Assessment Questions

Course Outcome 1 (CO1)

1. An amplifier has an input of 3 mV and an output of 5 V. What is the gain in decibels?
2. Explain why modulation is necessary or desirable
3. What is the primary advantage of FM over AM?
4. Mention any three benefits of spread spectrum

Course Outcome 2 (CO2)

1. With the help of a block diagram, explain frequency division multiplexing and its applications
2. With block diagrams and waveforms, explain frequency hopping spread spectrum and direct sequence spread spectrum.
3. Mention any three benefits of Digital Communication.
4. How can shift registers be used for serial to parallel data conversion?

Course Outcome 3 (CO3)

1. Define the selectivity and sensitivity of communication receivers.
2. State any three basic requirements of a communication transmitter.
3. With the help of a block diagram, explain the working of the super heterodyne receiver

4. Discuss the concept of Mixing and explain any mixer circuits.

Course Outcome 4 (CO4)

1. Explain the applications and benefits of small cells in future communications
2. Briefly explain Wireless LAN, Wi-Fi, PANs and Bluetooth and ZigBee
3. Illustrate an IOT based framework for healthcare applications.
4. What primary characteristic determines the cell site range of coverage?

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT372			
Course Name: COMMUNICATION TECHNIQUES			
Max. Marks: 100		Duration: 3 Hours	
PART A			
Answer all questions. Each question carries 3 marks			
1		An amplifier has an input of 3 mV and an output of 5 V. What is the gain in decibels?	
2		Explain why modulation is necessary or desirable	
3		What is the primary advantage of FM over AM?	
4		Mention any three benefits of the spread spectrum.	
5		How can shift registers be used for serial to parallel data conversion?	
6		Mention any three benefits of Digital Communication.	
7		Define the selectivity and sensitivity of communication receivers.	
8		State any three basic requirements of a communication transmitter.	
9		Define Wi-Fi Direct.	
10		What primary characteristic determines the cell site range of coverage?	
PART B			
11	a)	With the help of a block diagram explain multiplexing and demultiplexing in communication systems	8
	b)	Derive the expression for total power in an AM signal.	6
		OR	
12	a)	Explain the basic multiplexing schemes in communication systems.	6
	b)	With the help of circuit and waveforms, explain Low-level AM modulation.	8

13	a)	With the help of a circuit diagram, explain Varactor modulators.	14
		OR	
14	a)	Explain the basic principle of phase modulators.	14
15	a)	With the help of a block diagram, explain frequency division multiplexing and its applications	14
		OR	
16	a)	With the help of block diagram and waveforms, explain frequency hopping spread spectrum and direct sequence spread spectrum	14
17	a)	With the help of a block diagram, explain the working of the superheterodyne receiver	14
		OR	
18	a)	Discuss the concept of Mixing and explain any mixer circuits.	14
		OR	
19	a)	Illustrate an IoT based framework for healthcare applications.	14
		OR	
20	a)	Briefly explain Wireless LAN, Wi-Fi, PANs and Bluetooth and ZigBee	14

Syllabus

Module I

Introduction to Electronic Communication, Communication Systems, Types of Electronic Communication, Modulation and Multiplexing-Bandwidth, Gain, Attenuation, and Decibels. Amplitude Modulation-AM Concepts, Modulation Index, Sideband Modulation, AM Power, Amplitude Modulators-Low-Level AM, Amplitude Demodulators-Diode Detectors

Module II

Frequency Modulation-Basic Principles of Frequency and Phase Modulation, Modulation Index and Sidebands, FM Signal Bandwidth, Frequency Modulators, Frequency Demodulators-Slope Detectors, PLL, Phase Modulators

Module III

Digital communication techniques-Digital transmission of data, parallel and serial transmission, data conversion, pulse modulation.Digital Data Transmission-Digital Codes,Transmission Efficiency, Wideband Modulation. Multiplexing and Demultiplexing-FDM, TDM, PCM, duplexing. Serial Communications Interface (SCI), Controller Area Network (CAN) module

Module IV

Radio transmitters-Transmitter fundamentals, Communication Receivers-Signal reproduction, superheterodyne receivers, frequency conversion (study of mixer circuits not required), intermediate frequency and images-frequency relationship and images, Noise-Signal to Noise Ratio, external noise, internal noise

Module V

Cell Phone Technologies-Cellular Concepts-Multiple Access, Duplexing, Base Stations and Small Cells (Overview Only)Wireless Technologies-Wireless LAN, Wi-Fi, PANs and Bluetooth, ZigBee, WiMAX, Radio-Frequency Identification, Infrared Wireless, Machine-to-Machine (M2M) and Internet of Things Healthcare Applications (Overview Only)

Textbooks:

1. Louis E. Frenzel Jr. Principles of Electronic Communication Systems, Fourth Edition, McGraw-Hill Education, 2015.

References:

1. Simon Haykin: Communication Systems, Fifth Edition,Wiley India, 2009,
2. Wayne Tomasi, Advanced Electronic Communications Systems, Pearson New International Edition,2013
3. John G Proakis& Masoud Salehi: Communication System Engineering, Second edition, Prentice Hall India,2002
4. Samuel O. Agbo, Matthew N. O. Sadiku Principles of Modern Communication Systems, Cambridge University Press, 2019

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction to Electronic Communication Systems	1
1.2	Types of Electronic Communication	1
1.3	Modulation and Multiplexing	1
1.4	Bandwidth, Gain, Attenuation, and Decibels	1
1.5	AM Concepts, Modulation Index	1
1.6	Sideband Modulation, AM Power	1
1.7	Amplitude Modulators-Low-Level AM	1
1.8	Amplitude Demodulators-Diode Detectors	1
2	**Module 2**	
2.1	Basic Principles of Frequency and Phase Modulation	1
2.2	Modulation Index and Sidebands	1

2.3	FM Signal Bandwidth	1
2.4	Frequency Modulators,	1
2.5	Frequency Demodulators-Slope Detectors	1
2.6	PLL, Phase Modulators	1
3	**Module 3**	
3.1	Digital transmission of data	1
3.2	Parallel and serial transmission	1
3.3	Data conversion, pulse modulation	1
3.4	Digital Codes, Transmission Efficiency	1
3.5	Wideband Modulation	1
3.6	Multiplexing and Demultiplexing-FDM, TDM, PCM, duplexing	1
3.7	Serial Communications Interface (SCI), Controller Area Network (CAN) module	1
4	**Module 4**	
4.1	Transmitter fundamentals	1
4.2	Communication receivers	1
4.3	Signal reproduction	1
4.4	Superheterodyne receivers	1
4.5	frequency conversion	1
4.6	Intermediate frequency and images, Noise	1
5	**Module 5**	
5.1	Cellular Concepts	1
5.2	Multiple Access, Duplexing	1
5.3	Base Stations and Small Cells	1
5.4	Wireless LAN, Wi-Fi, PANs and Bluetooth	1
5.5	ZigBee, WiMAX	1
5.6	Radio-Frequency Identification, Infrared Wireless,	1
5.7	Machine-to-Machine (M2M) and Internet of Things (IoT) Applications	2

SEMESTER VI

MINOR

BMT382	MEDICAL IMAGE PROCESSING	CATEGORY	L	T	P	CREDIT
		VAC	4	0	0	4

Preamble: The objective of this course is to provide an overview of the different image processing techniques used in medical images and how to use these classical image processing techniques to different types of medical images.

Prerequisite: Students should have a basic knowledge on the concept of image formation and different modalities of imaging.

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

CO 1	Identify the need for applying image processing techniques to medical images.
CO 2	Apply image processing techniques to medical images.
CO 3	Recognize different methods of feature extraction and interpolation
CO 4	Analyse hybrid image processing & deep learning techniques in medical images.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2								2
CO2	3	3	3	2	2					1		2
CO3	3	3	3	3	2	1				1		2
CO4	3	3	3	3	2	1				1		3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	10	10	30
Apply	30	30	45
Analyse	10	10	25

Evaluate			
Create			

Assignment: Image processing algorithm (PO5 and PO10)

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 contains 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):

1. Compare and contrast histogram stretching and histogram equalization?
2. Briefly explain the qualities of a digital image.
3. Detail the characteristics of images obtained from different imaging modalities.

Course Outcome 2 (CO2)

1. Analyse the different types of segmentation techniques used in medical images.
2. Why are smoothing and sharpening of images important operations in medical image processing and analysis? Give some specific examples to illustrate your answer.
3. How can an analog image be recovered from its sampled (digitized) version? Describe the operations required in (i) the spatial domain and (ii) the frequency domain. Comment on the conditions to be met for accurate recovery of the analog image.

Course Outcome 3(CO3):

1. Give an application of the k- Nearest neighbour classifier for the classification of features extracted from medical images
2. Analyse hybrid feature selection-based feature fusion for liver disease classification of ultrasound images.
3. Comment on the significance of image interpolation.

Course Outcome 4 (CO4):

1. Detail the different types of transfer learning concepts.
2. Implement Convolution Network for medical image assessment.
3. Detail the application of deep learning in medical image examination of brain abnormality

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT382			
Course Name: MEDICAL IMAGE PROCESSING			
Max. Marks: 100		Duration: 3 Hours	
PART A			
Answer all questions. Each question carries 3 marks			
1		Interpret image segmentation technique utilised in boundary representation?	
2		Explain in detail the method for smoothing the image in frequency domain.	
3		Explain the process of edge linking through Hough transform.	
4		Discuss Edge Detection-Gradient Operators used in image analysis.	

5		Describe gradient operators-based edge detection method with necessary masks and equations.	
6		With necessary equations, explain about Homomorphic filtering.	
7		Explain the representation of an image in arrays and matrix.	
8		Detail image sampling and quantization.	
9		Compare Region-based Approach and Template Matching method of image segmentation.	
10		Examine the limitations and drawbacks of Nearest-Neighbor method of image interpolation.	
PART B			
11	a)	Show that the Fourier transform and its inverse are linear processes.	14
		OR	
12	a)	How can an analog image be recovered from its sampled (digitized) version? Describe the operations required in (i) the spatial domain and (ii) the frequency domain.	10
	b)	Comment on the conditions to be met for accurate recovery of the analog image.	4
13		Brief the different processes in enhancing the quality of an image.	14
		OR	
14		Describe the Fourier transform and spectral content of an image.	14
15		Briefly explain different types of low pass, bandpass and band stop filters.	14
		OR	
16	a)	Suppose that you had a scene of three objects of different distinct intensities against an extremely bright background. What would the histogram of the corresponding image look like?	8
	b)	Briefly explain the difficulties encountered during image acquisition?	6
17	a)	Explain Nearest-Neighbour or Linear method of image interpolation.	14

		OR	
18		Explain region splitting and region merging method of image segmentation.	14
		OR	
19	a)	Suppose an image is rotated and then the result rotated back by the same amount (using either (i) nearest-neighbour or (ii) bilinear interpolation).	9
	b)	Is the resulting image exactly the same as the original? If not, why not?	5
		OR	
20		Detail Hough Transform in boundary representation.	14

Syllabus

Module 1

Image quality and Information content: Characteristics of medical images from different modalities, artefacts in medical images, Fundamentals of digital image processing- digitization of image- sampling and quantization, array and matrix representation of images. Characterization of image quality- Optical Density, Dynamic range, Contrast, Histogram stretch and equalization, Entropy, Signal to Noise ratio, Blur & Spread functions, resolution.

Module 2

Image enhancement and restoration: Image enhancement in the spatial domain- Gray level transformations, histogram processing, averaging, image subtraction, smoothing and sharpening, spatial filters.**Image enhancement in the frequency domain**- Fourier transform & spectral content, MTF, application of Fourier Transform in the reconstruction of tomographic images. Filters- low pass, high pass, band pass and band stop filters, homomorphic filter.**Image restoration:** Noise reduction filters- Adaptive filters, Wiener filters, Inverse filters, geometric degradations.

Module 3

Boundary detection and Image segmentation: Boundary Representation- Chain Codes. Boundary Extraction-Connectivity, Contour Following, Edge Linking and Heuristic Graph Searching, Dynamic Programming, Hough Transform.**Edge Detection**-Gradient Operators, Compass Operators, Laplace Operators and Zero Crossings.**Image Segmentation** - Amplitude Thresholding or Window Slicing, Component Labelling, Boundary-based Approaches, Region-based Approaches and Clustering, Template Matching, Texture Segmentation. Application of CNN based segmentation techniques for medical images.

Module 4

Feature extraction and interpolation: Feature recognition and classification- Connected component labelling, Statistical classification- Parametric, non- parametric techniques- k-Nearest-neighbour (k-NN) classifier, unsupervised methods- k- means clustering &Hierarchical clustering. Hybrid feature selection-based feature fusion for liver disease classification on ultrasound images. **Image Interpolation:** Classical and generalized Interpolation, Nearest-Neighbour and linear interpolation, Bilinear, cubic B-spline, since based interpolation.

Module 5

Hybrid image examination technique and deep learning models: Need for thresholding techniques, bilevel and multi-level threshold, thresholding for grey scale and RGB images, heuristic algorithm- optimization techniques, firefly algorithm, bat algorithm, cuckoo search.

Deep learning models in medical image analysis- Implementation of Convolution Network for medical image assessment, transfer learning concepts, Application of deep learning in medical image examination of brain and lung abnormality.

Text Books

1. Jain Anil K: Fundamentals of Digital Image Processing-, Prentice Hall of India. 1989

2. Gonzalez Rafel C, Wintz Paul: Digital Image Processing, Addison Wesley.1993

Reference Books

1. Thomas M. Deserno Biomedical Image Processing, Springer-Verlag Berlin Heidelberg, 2011

2. Bankman, Isaac, ed. *Handbook of medical image processing and analysis*. Elsevier, 2008.

3. Dougherty, Geoff. *Digital image processing for medical applications*. Cambridge University Press, 2009..

4. Rajinikanth, Venkatesan, E. Priya, Hong Lin, and Fuhua Lin. *Hybrid Image Processing Methods for Medical Image Examination*. CRC Press, 2021.

5 Koundal, Deepika, Virender Kadyan, Parul Dutta, Vatsala Anand, Shankar Aggarwal, and Sharut Gupta. "Computational techniques in biomedical image analysis: overview." *Advances in Computational Techniques for Biomedical Image Analysis* (2020): 3-31.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Difficulties in Image Acquisition and Analysis, Characterization of Image Quality, Digitization of image-sampling, quantization.	3
1.2	Array and matrix representation of images. Optical Density, Dynamic range, Contrast	3
1.3	Histogram, Entropy, Blur & Spread functions, Resolution	3
2	**Module 2**	
2.1	Image enhancement in the spatial domain- Gray level transformations, histogram processing, averaging, image subtraction, smoothing and sharpening, spatial filters.	2
2.2	Image enhancement in the frequency domain- Fourier Transform & spectral content, MTF, application of Fourier Transform in the reconstruction of tomographic images. Filters- low pass, high pass, band pass and band stop filters, homomorphic filter	4
2.3	Image restoration: Noise reduction filters- Adaptive filters, Wiener filters, Inverse filters, geometric degradations.	3
3	**Module 3**	
3.1	Boundary Representation- Chain Codes. Boundary Extraction- Connectivity, Contour Following, Edge Linking and Heuristic Graph Searching, Dynamic Programming, Hough Transform.	3
3.2	Edge Detection-Gradient Operators, Compass Operators, Laplace Operators and Zero Crossings.	2
3.3	Image Segmentation -Amplitude Thresholding or Window Slicing, Component Labelling, Boundary-based Approaches, Region-based Approaches and Clustering, Template Matching, Texture Segmentation. Application of CNN based segmentation techniques for medical images.	4
4	**Module 4**	
4.1	Feature recognition and classification- Connected component labelling, Statistical classification- Parametric, non- parametric techniques- k-Nearest-neighbour (k-NN) classifier.	3

4.2	Unsupervised methods- k- means clustering &Hierarchical clustering, Hybrid feature selection-based feature fusion for liver disease classification on ultrasound images.	3
4.3	Image Interpolation: Classical and generalized Interpolation, Nearest-Neighbour and linear interpolation, Bilinear, cubic B-spline, sinc based interpolation.	3
5	**Module 5**	
5.1	Need for thresholding techniques, bilevel and multi-level threshold, thresholding for grey scale and RGB images, heuristic algorithm-optimization techniques, firefly algorithm, bat algorithm, cuckoo search.	3
5.2	Deep learning models in medical image analysis- Implementation of Convolution Network for medical image assessment, transfer learning concepts.	3
5.3	Application of deep learning in medical image examination of brain and lung abnormality.	3

BMT384	IMPLANTS & PROSTHETICS ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	4	0	0	4

Preamble: The first part of this course gives an overview of various types of prostheses with specific emphasis on visual and auditory implants and neural prostheses. Concepts are also addressed. The second part of this course is intended to illustrate the technical design characteristics of the main components that go into forming a smart prosthetic arm for adults. The course handling faculty may encourage the students to perform literature surveys on engineering implementation of leading upper arm prosthetic companies and update with the state-of-the-art rehabilitation solutions.

Prerequisite: The student must have a thorough knowledge of Artificial organs and Implants, and an overview of types of limb and neural prosthetic devices. Basic knowledge in Physiology of Musculo-skeletal systems, and Automatic engineering control are also preferred.

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

CO 1	Describes state-of-the-art advances in techniques associated with implantable neural prosthetic devices and their applications
CO 2	Describe the challenges in the design and implementation of upper limb prostheses
CO 3	Apply the concepts of human motor system and control strategies for upper limb prosthetic development
CO 4	Design the engineering control of smart prosthetic hand prostheses

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3								2		2
CO2	3	3								2		2
CO3	3	3	3							2		2
CO4	3	3	3			2	2	2		2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	10	10	20
Apply	25	25	50
Analyse	10	10	20
Evaluate	5	5	10
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 contains 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):

1. Conduct a literature survey and detail the biomedical engineering approaches for restoring vision to the blind. Describe the advantages and challenges in each method.
2. Depending on the location of stimulating electrodes, how visual prostheses can be divided into?
3. Compare and contrast ABI with AMI technique for Cochlear implantation

Course Outcome 2 (CO2)

1. Justify the statement - biomaterials can be converted to 'living tissues' after implantation
2. What are the biomechanical considerations of designing an upper arm prosthesis
3. What are the challenges and problems in the development of implantable miniature peripheral nerve interface for a prosthetic arm

Course Outcome 3(CO3):

1. List some terminal devices that may be controlled by a myoelectric system.
2. Draw a block diagram to illustrate the digital requirements for the signal processing in an artificial hand. Use appropriate considerations in the design, assuming the customer is an adult of normal BMI.
3. A designer considers using the EMG signals from four muscles to control a powered prosthesis. Describe why this proposal is not a practical solution and discuss suitable methods.
4. Under what circumstances would you select a single-site control system for a client?

Course Outcome 4 (CO4):

1. What are the components of a myoelectric controlled hand? Describe the ethical principles that gets applied to the selection of components for a teenager.
2. Conduct a literature survey of the Current components available to the prosthetist and therapist to implement a myoelectric control system. Describe the impact of recommending them to an amputee who lost the arm from shoulder joint.
3. Discuss the Southampton and Edinburgh control philosophies, compare them with more conventional styles.
4. Compare and contrast suitable actuators for use in prosthetic devices
5. Discuss the design constraints of smart hand prosthetics.

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT384			
Course Name: IMPLANTS AND PROSTHETICS ENGINEERING			
Max. Marks: 100			Duration: 3 Hours
PART A			
Answer all questions. Each question carries 3 marks			
1		What are the considerations for implantable microelectrodes	
2		Draw schematic architecture of the optical nerve stimulator and list the	

		components	
3		Draw the architecture and functional block diagram of a modern cochlear implant	
4		Stimulation of the cochlea requires exposure to right amounts of electrical energy. How is this consideration achieved in the design of modern cochlear implants?	
5		What is the mean value of the MES?	
6		Explain the electro - physiology associated with the contraction process and the resultant generation of the MES	
7		Give three reasons for using a non-powered upper-extremity prosthesis?	
8		Name the three types of upper-extremity prosthetic components that can be activated electrically?	
9		Suggest a list of Slip and texture sensors for implementing a robotic hand prosthesis	
10		How can the function of a prosthetic hand design be assessed?	
PART B			
11	a)	With help of a neat block diagram explain the concept of optic nerve stimulation using penetrating microelectrode array	14
		OR	
12	a)	Explain the working of a DSP-based image processing system for visual prostheses	14
13	a)	Justify the selection of IC as a target structure for the Auditory Midbrain Implant	14
		OR	
14	a)	What are the safety consideration in the design of an auditory neural prosthetic device	7
	b)	Write a note on electrode technologies for auditory neural prostheses	7
15	a)	Explains the origin and nature of the myoelectric signal (MES) as used in the control of powered prostheses	14
		OR	
16	a)	Describe the process of EMG signalacquisition and the problems associated with it. Illustrate the way in which myoelectric signal is used to control powered upper limb prostheses.	14
17	a)	Why might you select a digital control system over a proportional control system for an upper arm prosthesis?	14
		OR	
18	a)	Propose a control strategy for controlling the speed of the terminal device and explain the working with neat sketches	14
19	a)	Describe the various sensors and instrumentation required for the design and fabrication of a Myoelectrically controlled hand	14

		OR	
20	a)	Draw the block diagram and design a suitable control system for an EMG controlled smart arm prosthesis.	10
	b)	Write notes on neural chips.	4

Syllabus

Module 1

Microelectronic Visual Prostheses: Microelectronic visual implant technologies: Retinal stimulation and retinal implant - Epiretinal, Subretinal and Extraocular implants, Visual stimulation in the brain, Optic Nerve Stimulation, Engineering challenges in the development of visual prostheses, Stimulation microelectrode arrays - types and electrode materials, optic nerve stimulation using penetrating microelectrode arrays, Neural electrical stimulator, DSP-based image processing system for visual prostheses

Module 2

Modern Cochlear Implant: System Review - Architecture and functional block diagram of a modern cochlear implants, External unit, RF link, Internal unit, Electrodes, Safety Considerations, Auditory Prosthesis Using Deep Brain Stimulation: Development and Implementation - Design considerations, approaches for implementation, Electrode technologies, Stimulation strategies.

Module 3

Signals and Signal Processing for Myoelectric Control: Brief history of artificial hands - Origin and nature of the myoelectric signal, Anatomy, Contraction Process, Connections to the CNS, Fibre membrane and the action potential, Measurement of the potentials associated with depolarization, Spatial variation in the arrangement of motor units, Muscle force mediation, Myoelectric Signal - Acquisition, Processing, Control of prosthetic function, Terminal device electronics

Module 4

Upper Limb Prosthetics: Pre-prosthetic Assessment, Prosthetic Options, Components for the Upper Limb Prosthesis - Hands and Work Hands (Terminal Devices), Pinch Force, Weight, Work Hands, Cosmetic/Protective Covers, Electric wrist rotation, Wrist Flexion, Electronic Controllers, proportional Versus Digital control, Elbow components, All electric alternatives control Systems, Interface designs, Indications and contraindications, Training and outcome measurement

Module 5

Mechatronic hands- prosthetic and robotic design: Myoelectrically controlled hand Signal acquisition, principles, Materials, actuators, Sensors. Instrumentation, Control -

finger position, object slip, EMG reference control, Artificial prehension, Brain control and sensing of artificial limbs, Brain implantable chips, signal transmission mechanism.

Text Books

1. David D. Zhou Elias Greenbaum, "Implantable Neural Prostheses 1 Devices and Applications", Springer, 2009, e-ISBN 978-0-387-77261-5
2. L. McLean, R. N. Scott (auth.), Ashok Muzumdar , "Powered Upper Limb Prostheses: Control, Implementation and Clinical Application", Springer-Verlag Berlin Heidelberg, 2004, ISBN: 978-3-642-62302-8,978-3-642-18812-1
3. Paul H. Chappell, "Mechatronic Hands Prosthetic and Robotic Design", The Institution of Engineering and Technology 2016, ISBN 978-1-78561-155-1 (PDF)

Reference Books

1. Kevin Chui, Milagros Jorge, Sheng-Che Yen, Michel M. Lusardi, "ORTHOTICS AND PROSTHETICS IN REHABILITATION", FOURTH EDITION, Elsevier, ISBN: 978-0-323-60913-5
2. ZlataJelacic, RemzoDedic, HarisDindo, "Active Above-Knee Prosthesis - A Guide to a Smart Prosthetic Leg", 2020, Elsevier Inc, ISBN: 978-0-12-818683-1
3. Lisa A. Pruitt and Ayyana M. Chakravartula "Mechanics of Biomaterials Fundamental Principles for Implant Design", Cambridge University Press, 2011
4. Frank E. Johnson, MD Katherine S. Virgo, "The Bionic Human Health Promotion for People With Implanted Prosthetic Device", 2006 Humana Press Inc.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Microelectronic visual implant technologies: Retinal stimulation and retinal implant - Epiretinal, Subretinal and Extraocular implants	1
1.2	Visual stimulation in the brain, Optic Nerve Stimulation, Engineering challenges in the development of visual prostheses	2
1.3	Stimulation microelectrode arrays - types and electrode materials	1
1.4	Optic nerve stimulation using penetrating microelectrode arrays, Neural electrical stimulator,	2
1.5	DSP-based image processing system for visual prostheses	2
2	**Module 2**	
2.1	System Review - Architecture and functional block diagram of a modern cochlear implants, External unit, RF link, Internal unit	**2**

2.2	Electrodes, Safety Considerations	**2**
2.3	Auditory Prosthesis using Deep Brain Stimulation: Development and Implementation - Design considerations, Approaches for implementation	**2**
2.4	Electrode technologies, Stimulation strategies.	**2**
3	**Module 3**	
3.1	Brief history of artificial hands - Origin and nature of the myoelectric signal	1
3.2	Anatomy, Contraction Process, Connections to the CNS, Fibre membrane and the action potential	2
3.3	Measurement of the potentials associated with depolarization, Spatial variation in the arrangement of motor units	2
3.4	Muscle force mediation and the Myoelectric Signal	1
3.5	Acquiring the Myoelectric signal, Processing MES	2
3.6	Control of prosthetic function, Terminal device electronics	2
4	**Module 4**	
4.1	Pre-prosthetic Assessment, Prosthetic Options	2
4.2	Components for the Upper Limb Prosthesis - Hands and work hands (Terminal Devices), Pinch Force, Weight, Work hands, Cosmetic/Protective covers, Electric wrist rotation, Wrist flexion	2
4.3	Electronic Controllers, proportional Versus Digital control, Elbow components, All electric alternatives control Systems	2
4.4	Interface designs, Indications and contraindications, Training and outcome measurement	3
5	**Module 5**	
5.1	Myoelectrically controlled hands, Mechanisms - materials, actuators	3
5.2	Sensors - instrumentation, Control - finger position, object slip, EMG reference control, Artificial prehension	4
5.3	Brain control and sensing of artificial limbs	3

BMT386	PHYSIOLOGICAL SYSTEM MODELING	CATEGORY	L	T	P	CREDIT
		VAC	4	0	0	4

Preamble: The objective of this course is to provide a basic idea related to modeling and different modeling techniques of physiological systems.

Prerequisite: Students should have a basic knowledge on the concept of modeling and process of modeling dynamically varying physiological systems.

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

CO 1	Explain the concepts of mathematical modeling in physiological systems
CO 2	Explore different models of neuronal activity
CO 3	Identify modeling for respiratory and muscle models
CO 4	Analyze modeling for cardiovascular system
CO 5	Evaluate various models of renal system

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2					3		2
CO2	3	3	3	3	2					3		2
CO3	3	3	3	3	2					3		2
CO4	3	3	3	3	2					3		2
CO5	3	3	3	3	2					3		2

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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):

1. Explain the classification of model.
2. What is the limitation of mathematical model?
3. Describe the significance of mathematical modelling in the study of physiological systems.

Course Outcome 2 (CO2)

1. What are integrate and fire neuron models?
2. What is the significance of concept of voltage dependent conductance?
3. Define compartmental models.

Course Outcome 3(CO3):

1. Mathematically derive oxygen uptake by pulmonary capillaries andRBC
2. Describe about muscle mechanics.

Course Outcome 4 (CO4):

1. Derive analytical model of blood flow in heart.
2. Mathematically modelling the cardiac electrical activity

Course Outcome 5 (CO5):

1. Explain the methods of waste removal.
2. Mathematically explain counter current mechanism in nephron.

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY			
SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT386			
PHYSIOLOGICAL SYSTEM MODELING			
Max. Marks: 100			Duration: 3 Hours
PART A			
Answer all questions. Each question carries 3 marks			
1		What are the applications of pharmokinectic modelling?	
2		Write a short note on compartmental models.	
3		Explain the classification of model.	
4		What are integrate and fire neuron models?	
5		What is the significance of concept of voltage dependent conductance?	
6		Describe about muscle mechanics	
7		Briefly explain about the electrical analogue model of blood flow	
8		Explain transport through cells and tubules.	
9		Describe briefly about the model of cardiac cell model	
10		Write steps for developing model of urine concentration	
PART B			
11		Define complexity .Elaborate the need for complexity in physiological modelling	14
		OR	
12		Explain HodginHuxley model.	14
13		Describe FitzhughNagumo model	14
		OR	
14		With the help of block diagram explain how an integrate and fire neuron model produce action potential	14
15		With the help of a suitable model explain Huxley model of isotonic muscle contraction	14
		OR	

16		Mathematically model oxygen uptake by pulmonary capillaries.	14
17		Mathematically derive model of Circulation	14
		OR	
18		Draw the ultra-structure of human respiratory membrane and discuss relation between alveolar partial pressure of oxygen and carbon dioxide and alveolar ventilation.	14
19		Derive analytical model of Henle's loop	14
		OR	
20		Explain the counter current model of urine formation in kidney	14

Syllabus

Module 1

Modeling concepts: The techniques of mathematical modeling. Classification of model's characteristics of models. Formulation of mathematical model. Physiological complexity and the need for models: Complexity, Different approaches of modeling physiological systems: Linear Modeling - Distributed Modeling - Nonlinear Modeling - Time varying Modeling. Pharmacokinetic modeling - compartmental models, blood-tissue models

Module 2

Neuron Models: Electrical properties of Neurons, Single compartment models, voltage dependent conductance, Hodgkin Huxley model, integrate fire neuron model, conductance-based models, Cable equation, and multi compartment models. Fitzhugh Nagumo models.

Module 3

Respiratory and muscle model: Anatomy and physiology of respiratory systems, capillary -alveoli exchange, capillary alveoli transport-carbon dioxide removal- Modeling of oxygen uptake by RBC and pulmonary capillaries-Muscle physiology- Cross bridge theory, Force-velocity relationship: The Hills model, cross bridge model: Huxley model
|

Module 4

Cardio-vascular system modelling:cardiac conduction system-cardiac electrical activity-The bidomain model-cardiac cell models-models of blood flow and pressure-mathematical model of circulation-modeling of blood flow in heart-

Module 5

Modeling of Renal system – Renal Anatomy and physiology-Transport through cells and tubules-methods of waste removal-The glomerulus–urinary concentration; loop of Henle-counter current mechanism-counter current mechanism in nephrons .

Text Books

1. James Keener & James Sneyd (2009) *Mathematical Physiology*. Second edition, vol. 1-2. ISBN: 978-0-387-09419-9
2. Claudio Cobelli& Ewart Carson (2008) *Introduction to Modeling in Physiology and Medicine*. ISBN: 978-0-12-160240-6
3. John D. Enderle& Joseph D. Bronzino (2012) Introduction to Biomedical Engineering. ISBN: 978-012-374-979-6
4. Modelling and Simulation in Medicine and the Life Sciences (2nd Edition), by F.C.Hoppenstead andC.S.Peskin, Springer (2002) ISBN: 0-387-95072-9.
5. Suresh R. Devasahayam (2019)Signals and Systems in Biomedical Engineering: Physiological Systems Modeling and Signal Processing. ISBN: 978-981-13-3530-3
6. Peter Dayan, L. F. Abbott · (2001)Theoretical Neuroscience:Computational and Mathematical modelling of Neural SystemsMIT Press

Reference Books

1. V.Z. Marmarelis, Advanced methods of physiological modeling , Springer, 1989

2.Arthur C Guyton, Text Book of Medical physiology, PRISM Books India, 2000

3. Modelling and Simulation in Medicine and the Life Sciences (2nd Edition), by F.C. Hoppensteadand C.S.Peskin, Springer (2002) ISBN: 0-387-95072-9.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Techniques of mathematical modelling. Classification of models, characteristics of models. Formulation of mathematical model	2
1.2	Physiological complexity and the need for models: Complexity	1
1.3	Different approaches of modelling physiological systems: Linear ModellingDistributed Modelling - Nonlinear Modelling - Time varying Modelling	3
1.4	Pharmacokinetic modelling - compartmental models, blood-tissue models	3
2	**Module 2**	

2.1	Electrical properties of Neurons, Single compartment models, voltage dependent conductances, Hodgkin Huxley model	3
2.2	Integrate fire neuron model, conductance based models	3
2.3	Cable equation, multi compartment models. Fitzhugh Nagumo models	3
3	**Module 3**	
3.1	Anatomy and physiology of respiratory system	2
3.2	capillary -alveoli exchange	2
3.3	capillary -alveoli transport	2
3.4	Carbon dioxide removal	1
3.5	Modeling of oxygen uptake by RBC and pulmonary capillaries	2
3.6	Muscle physiology, Cross bridge theory	2
3.7	Force –velocity relationship- Hills model	2
3.8	Cross bridge model: Huxley model	2
4	**Module 4**	
4.1	Cardiac conduction system	1
4.2	Cardiac electrical activity, The bidomain model	2
4.3	Cardiac cell models	1
4.4	Models of blood flow and pressure	2
4.5	Mathematical model of circulation	2
5	**Module 5**	
5.1	Renal anatomy and physiology	1
5.2	Transport through cell and tubules	1
5.3	Methods of waste removal	1
5.4	The glomerulus	2
5.5	Urinary concentration, loop of Henle	2
5.6	Counter current mechanism, Counter current mechanism in nephrons	2

SEMESTER VI

HONOURS

BMT394	SPEECH & AUDIO SIGNAL PROCESSING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble : The students will be able to analyse speech signals to extract the characteristics and implement algorithms for processing speech and audio signals considering the properties of acoustic signals and human hearing.

Prerequisite: Thorough knowledge of biomedical signal processing concepts

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

CO 1	Familiarize the basic speech production and audio perception mechanism
CO 2	Implement different methods of processing speech and audio signals using time & transform domain techniques
CO 3	Analyse the methods of parametric representation of speech signals
CO 4	Apply the concepts of speech coding
CO 5	Apply various speech and audio signal processing techniques in biomedical applications

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	3	2	1							1
CO 2	3	3	2	2	3	1	1	1	2	2		1
CO 3	3	3	2	2	1							1
CO 4	3	3	3	1	1							1
CO 5	3	2	3	3	1							1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10%	10%	10%
Understand	30%	30%	30%
Apply	30%	30%	30%
Analyse	30%	30%	30%

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 anyone. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Outcome 1 (CO1): Familiarize the basic speech production and audio perception mechanism

1. What are the characteristics of vowels? Explain the vowel sound production mechanism.
2. How a lossless tube model is related to digital filters.
3. Describe the mechanisms of Vowel Perception.

Course Outcome 2 (CO2): Implement different methods of processing speech and audio signals using time & transform domain techniques

1. How the formant frequencies are estimated in speech signal
2. With related equations explain STFT
3. Explain the procedure of calculation of MFCC.

Course Outcome 3 (CO3): Analyse the methods of parametric representation of speech signals

1. State the advantage of using LPC parameters for format analysis.
2. Derive the covariance matrix of LPC analysis.
3. Describe Sinusoidal Model of speech

Course Outcome 4 (CO4): Apply the concepts of speech coding

1. Describe any one vocoder based on the CELP algorithm.
2. Draw and explain the structure of a perceptual sub band speech coder.
3. Explain harmonic coders.

Course Outcome 5 (CO5): Apply various speech and audio signal processing techniques in biomedical applications

1. Explain the speech processing steps in emotion recognition.
2. What are neurodegenerative disorders?
3. Explain how the speech signal processing techniques are used for detection of Alzheimer's disease.

Model Question Paper

			Total Pages:
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SEMESTER VI B. TECH DEGREE EXAMINATION			
Course Code: EBT394			
Course Name: SPEECH & AUDIO SIGNAL PROCESSING			
Max. Marks: 100			Duration: 3 Hours
PART A			
		Answer full questions, each carries 3 marks.	
1		What is articulatory phonetics?	(3)
2		What is the formant structure of speech?	(3)
3		What are critical band phenomena in hearing?	(3)
4		What is the relation between sound pressure level and loudness?	(3)
5		Why is short time analysis carried out in processing speech signals?	(3)
6		With related equations explain the terms, short time average magnitude and short time zero crossing rate	(3)
7		Differentiate between AR, MA & ARMA models	(3)
8		What is HMM? Draw the state diagram of HMM.	(3)
9		Distinguish between adaptive transform coders and harmonic coders	(3)
10		What are the components of analysis by synthesis speech coders	(3)
PART B			
Answer any one question, each carries 14 marks.			
11	a)	What is the significance of the speech production model? Analyse the acoustic modelling of the vocal tract in speech processing	(9)
	b)	Explain voice and unvoiced speech signals?	(5)
		OR	
12	a)	What is Pitch of aspeech signal? What are formant frequencies in speech signal	(6)
	b)	Explain the anatomy & physiology of speech production	(8)

13	a)	Distinguish between simultaneous masking & temporal masking in audio signals	(6)
	b)	What are auditory filter banks? Explain how human cochlea act as a frequency encoder.	(8)
		OR	
14	a)	What are the stages of speech perception & Explain the speech perception model	(9)
	b)	What reason can you give to explain why a low-frequency tone is better able to mask a tone of higher frequency than vice versa?	(5)
15	a)	Explain how cepstral analysis is used in speech signal processing, with relevant block diagram	(8)
	b)	Differentiate between narrow band and wideband spectrogram	(6)
		OR	
16	a)	Describe the use of autocorrelation function & short-term energy in time domain analysis of speech signals	(7)
	b)	Explain the frequency domain analysis of speech signals using filter banks.	(7)
17	a)	Explain the steps of Levinson Durbin algorithm with suitable example	(8)
	b)	Derive the expression for autocorrelation matrix in linear prediction analysis of speech signals	(6)
		OR	
18	a)	Derive the solutions for LPC using covariance method	(9)
	b)	Explain the application of LPC parameters for pitch detection	(5)
19	a)	Explain how Adaptive Transform Coding is performed in speech coding	(7)
	b)	Explain in detail speaker verification system	(7)
		OR	
20	a)	Illustrate the significance of Code-Excited LPC (CELP) in speech coding	(7)
	b)	Explain how the speech signal processing techniques are used for detection of Parkinson's disease	(7)

Syllabus

Module 1

Speech Production: - Anatomy & physiology of speech production. Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds; Articulation, Voicing, Articulatory model. Acoustic Phonetics – acoustics of speech production; Acoustic theory of speech production-Excitation,Vocal tract model, Formant structure, Pitch.

Module 2

Audio Perception: Basic anatomy of hearing System. Psycho-acoustic analysis: Sound pressure level & loudness, Auditory Filter Banks, Critical Band Structure, Absolute Threshold of Hearing, Simultaneous Masking, Temporal Masking. Speech perception: Vowel Perception

Module 3

Time and frequency domain methods for speech and audio processing Speech Analysis: - Short-Time Speech Analysis, Time domain analysis- Short time energy, short time average magnitude, short time zero crossing rate, short time ACF. Frequency domain analysis- Filter Banks, STFT, Spectrogram, Formant Estimation & Analysis, Cepstral Analysis-MFCC

Module 4

Parametric representation of speech: - AR Model, ARMA model. LPC Analysis- LPC model, Auto correlation method, Covariance method. Levinson-Durbin Algorithm, Sinusoidal Model, HMM. Applications of LPC parameters as pitch detection and formant analysis.

Module 5

Speech coding: - Phase Vocoder, LPC, Sub-band coding, Adaptive Transform Coding, Harmonic Coding, Vector Quantization based Coders, CELP. **Biomedical applications of speech signal processing**: - Detection of neurodegenerative diseases, emotion recognition, Speaker Verification.

Textbooks

1. Thomas F. Quatieri, Discrete-Time Speech Signal Processing: Principles and Practice, Prentice Hall; ISBN: 013242942X; 1st Edition, 2001
2. Rabiner and Schafer, Digital Processing of Speech Signals, Prentice Hall,2 nd Edition
3. Deller J. R. Proakis J. G. and Hanson J. H, Discrete Time Processing of Speech Signals, Wiley Inter science, 2010
4. Nelson Morgan and Ben Gold, Speech and Audio Signal Processing: Processing and Perception of Speech and Music, John Wiley & Sons, ISBN: 0471351547, 2nd Edition, 2011

Reference

1. Douglas O'Shaughnessy, Speech Communications: Human & Machine, IEEE Press, 2nd Edition, 1999; ISBN: 0780334493.
2. Donald G. Childers, Speech Processing and Synthesis Toolboxes, John Wiley & Sons, September 1999; ISBN: 0471349593
3. Rabiner and Juang, Fundamentals of Speech Recognition, Prentice Hall,1st Edition, 1994 ISBN-10 -0130151572

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Speech Production: - Anatomy & physiology of speech production	1
1.2	Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds	2
1.3	Articulation, Voicing, Articulatory model	1
1.4	Acoustic Phonetics – acoustics of speech production; Acoustic theory of speech production-Excitation	2
1.5	Vocal tract model, Formant structure, Pitch	2
2	**Module 2**	
2.1	Audio Perception: Basic anatomy of hearing System	1
2.2	Psycho-acoustic analysis: Sound pressure level & loudness	1
2.3	Auditory Filter Banks, Critical Band Structure, Absolute Threshold of Hearing	2
2.4	Simultaneous Masking, Temporal Masking	2
2.5	Speech perception: Vowel Perception	2
3	**Module 3**	
3.1	Speech Analysis: - Short-Time Speech Analysis: Time domain analysis- Short time energy, short time average magnitude	1
3.2	Short time zero crossing rate, short time AC	2
3.3	Frequency domain analysis- Filter Banks	2
3.4	STFT, Spectrogram	2
3.5	Formant Estimation & Analysis, Cepstral Analysis-MFCC	3
4	**Module 4**	
4.1	Parametric representation of speech: - AR Model, ARMA model	2
4.2	LPC Analysis- LPC model, Auto correlation method, Covariance method	2
4.3	Levinson-Durbin Algorithm	2
4.4	Sinusoidal Model, HMM	2
4.5	Applications of LPC parameters as pitch detection and formant analysis	2
5	**Module 5**	
5.1	Speech coding: - Phase Vocoder, LPC, Sub-band coding	2
5.2	Adaptive Transform Coding, Harmonic Coding	2
5.3	Vector Quantization based Coders, CELP	2
5.4	Biomedical applications of speech signal processing: - Detection of neurodegenerative diseases	1
5.5	Emotion recognition, Speaker Verification	2

BMT396	ELECTRO ANALYTICAL TECHNIQUES	CATEGORY	L	T	P	CREDIT
		VAC	4	0	0	4

Preamble: This subject provides the introduction to fundamentals electro analytical techniques that are used in clinical chemistry and other biomedical sensor technology. Electro analytical techniques are an area of electrochemistry and analytical chemistry. The analysis of chemicals in all kinds of industry and research purposes. This analysis is carried out by measuring the potential (volts) and current (amperes) in an electrochemical cell containing the analyte. To be able to get fundamental knowledge and mechanism of electro analysis which could apply in various fields.

Prerequisite: Fundamental knowledge in electrochemistry and physics

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

CO 1	Compare, evaluate and explain the concepts of electroanalysis methods
CO 2	Describe the principles and constructions of the analytical equipment's
CO 3	Analyse the principles, constructions and working of electrodes.
CO 4	Correlate the different biomedical applications of electroanalysis techniques.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3								2		3
CO2	3	3	3	3						2		3
CO3	3	3								2		3
CO4	3	3	3	3						2		3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	10	10	10
Apply	20	20	20
Analyse	15	15	60
Evaluate	5	5	10

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):

1. State the fundamental concepts of electroanalysis
2. Explain the thermodynamics of electrochemical reactions.
3. List the types and applications of electrodes in electrochemistry.

Course Outcome 2 (CO2)

1. Discuss the working of Voltammetry and pulse voltammetry,
2. Explain the working and applications of potentiometry.
3. What are the components of polarography and coulometry.

Course Outcome 3(CO3):

1. Discuss the carbon electrodes, screen printed electrodes.
2. Evaluate the process of modified electrodes.
3. Discuss the working principles of reference electrodes.

Course Outcome 4 (CO4):

1. What are applications of electrochemical Immunoassay?

2. Evaluate the microfabrication of biosensors.

3. How biosensors used in electrocatalytic determination of biochemical compounds?

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__			
Course Code: BMT396			
Course Name: ELECTROANALYTICAL TECHNIQUES			
Max. Marks: 100		Duration: 3 Hours	
PART A			
Answer all questions. Each question carries 3 marks			
1		What are half-wave potentials?	
2		Define electrodes.	
3		Define salt bridge.	
1		List the anode and cathode properties.	
5		Define electrode potentials.	
6		Define pH.	
7		Define the principle of carbon electrode.	
8		What is the mechanism of voltammetry?	
9		Define biosensor.	
10		Write notes on immunoassay.	
PART B			
11	a)	Discuss the electrical double layer and role in electroanalysis.	14
		OR	
12	a)	Analyse the thermodynamics of electrochemical reactions.	14
13	a)	Explain the electrode reaction mechanism with suitable examples.	14
		OR	
14	a)	Evaluate the relationship between the current density and potential in electrochemical reactions.	14
15	a)	1. Discuss the construction and mechanism of reference electrodes.	14
		OR	
16	a)	Analyse the efficiency of hydrogen electrodes with examples.	14
17	a)	Explain the working and applications of ampherometry and polarography.	14

		OR	
18	a)	Discuss the types and applications of electroanalytical instruments.	14
		OR	
19	a)	Evaluate the microfabrication process of biosensors with applications.	14
		OR	
20	a)	How are biosensors used in electrocatalytic determination of biochemical compounds?	14

Syllabus

Module 1

Electrochemistry – Introduction, fundamental concepts of electroanalysis, electrodes, electrolytes, Electrical Double Layer, The Half-Wave Potentials and Limiting Currents. Thermodynamics of electrochemical reactions, Standard Potentials, Characteristic Potentials of Electroanalytical Techniques.

Module 2

Transfer of Ions, electrolytic cells, galvanic cells, salt bridge, anode and cathode properties. Electrolytes - basics, Ionic Transport, Ionic Solutions, Electrodes and Reaction mechanisms, Kinetics of Electrochemical Reactions –basic principles, Relationship Between the Current Density and Potential, Under Steady-State Conditions, Current–Potential Transients.

Module 3

Working Electrodes –basics principles and applications, Electrode Materials, Electrode Geometry, Hydrodynamic Conditions, Chemically Modified Electrode. Reference Electrodes, basic principles, The Standard Hydrogen Electrodes, Electrodes of the Second Kind as Reference Electrodes, pH-Based Reference Electrodes, Inner Potential Standards, Solid-State Reference Electrodes, Pseudo Reference Electrodes. Mercury electrodes.

Module 4

Solid Electrodes – solid electrodes, carbon electrodes, screen printed electrodes, modified electrodes, Electroanalytical instruments – Types, principles, working and applications of Voltammetry, pulse voltammetry, square wave voltammetry, ampherometry, polarography, coulometry, and potentiometry.

Module 5

Electrochemical Biosensors – enzyme-basedbiosensors, PotentiometricBiosensors Impedimetric Biosensors. Bio electroanalysis– immune sensors, Electrochemical

Immunoassay, Electrochemical Detection of Peptides Microfabrication of Electrode Surfaces for Biosensors Electrocatalytic Determination of Biochemical Compounds Biomedical Applications of electroanalysis.

Text Books

1. Fritz Scholz., "Electroanalytical Methods" Guide to Experiments and Applications., 2nd, revised and extended edition., Springer 2010.
2. Joseph wang., "Analytical Electrochemistry" second edition., Viley-VCH 2000.

Reference Books

1. Allen J Bard., Israel Rubinstein, "Electroanalytical Chemistry" A series of advances., Marc el Dekker Inc 1996.
2. Anna Brajter-Toth., James Q. Chambers., "Electroanalytical Methods for Biological Materials"., Marcel Dekker, Inc.2002.
3. Graham M. Smithe., "Electroanalytical Chemistry: New Research" ., Nova Science Publishers, Inc. 2008.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Electrochemistry – Introduction, fundamental concepts of electroanalysis, electrodes, electrolytes, Electrical Double Layer	4
1.2	The Half-Wave Potentials and Limiting Currents. Thermodynamics of electrochemical reactions,	3
1.3	Standard Potentials, Characteristic Potentials of Electroanalytical Techniques.	2
2	**Module 2**	
2.1	Transfer of Ions, electrolytic cells, galvanic cells, salt brige, anode and cathode properties.	3
2.2	Electrolytes - basics, Ionic Transport, Ionic Solutions, Electrodes and Reaction mechanisms, Kinetics of Electrochemical Reactions – basic principles	3
2.3	Relationship Between the Current Density and Potential, Under Steady-State Conditions, Current–Potential Transients.	3
3	**Module 3**	
3.1	Working Electrodes –basics principles and applications, Electrode Materials, Electrode Geometry, Hydrodynamic Conditions,	3
3.2	Chemically Modified Electrode. Reference Electrodes, basic	2

	principles, The Standard Hydrogen Electrodes	
3.3	Electrodes of the Second Kind as Reference Electrodes, pH-Based Reference Electrodes, Inner Potential Standards, Solid-State Reference Electrodes, Pseudo Reference Electrodes. Mercury electrodes.	4
4	**Module 4**	
4.1	Solid Electrodes – solid electrodes, carbon electrodes, screen printed electrodes, modified electrodes,	3
4.2	Electroanalytical instruments – Types, principles, working and applications of Voltammetry, pulse voltammetry, square wave voltammetry, ampherometry, polarography, coulometry, and potentiometry.	6
5	**Module 5**	
5.1	Electrochemical Biosensors – enzyme-basedbiosensors, PotentiometricBiosensors Impedimetric Biosensors.	3
5.2	Bio electroanalysis– immune sensors, Electrochemical Immunoassay, Electrochemical Detection of Peptides	3
5.3	Microfabrication of Electrode Surfaces for Biosensors Electrocatalytic Determination of Biochemical Compounds Biomedical Applications of electroanalysis.	3

BMT398	DATA SCIENCE	CATEGORY	L	T	P	CREDIT
		VAC	4	0	0	4

Preamble: Data science is the area where applications of various tools and techniques from the disciplines of applied statistics, mathematics and computer science are used to get greater insight and to make better and informed decisions for various purposes by analysing a large amount of data. The course focuses on exposing to the students the essentials of applied statistics, applied mathematics, and computer science required in the context of data science and its applications with strong emphasis on having hands-on experience using Python with the help of practicum, labs and experience of dealing with real-world problems.

Prerequisite: The students are required to have a thorough knowledge in computational methods using basic Statistics

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

CO 1	Illustrate the basic data pre-processing concepts
CO 2	Apply different data types in Python
CO 3	Explain Mat plotlib tool for visualization in Python
CO 4	Recognize and implement various ways of selecting suitable model parameters for different machine learning techniques

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3				2	2		3
CO2	3	3	3	3	3				2	2		3
CO3	3	3	3	3	3				2	2		3
CO4	3	3	3	3	3				2	2		3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	10	10	20
Apply	10	10	50
Analyse	20	20	20

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 in which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the need for data cleaning
2. Differentiate scatter plots from line plots
3. Explain the various data pre-processing techniques

Course Outcome 2 (CO2)

1. Can arrays be reshaped? Justify your answer
2. Summarize the element wise operations on data in Pandas.
3. How can you compute the summary statistics for large data?

Course Outcome 3(CO3):

1. Can Matplotlib be customized? Justify your answers with examples.
2. Why is Indexing and Slicing a MultiFinder designed.
3. How can a 3D function be visualized.

Course Outcome 4 (CO4):

1. Summarize feature Engineering
2. Explain Naive Bayes Classification
3. Summarize Gaussian Mixture Models.

Model Question paper

			Total Pages: 2
Reg No.:_____		Name:_____ ____	

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, _____ 20__

Course Code: BMT398

Course Name: DATA SCIENCE

Max. Marks: 100		Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks

1		Explain the need for data cleaning	
2		Differentiate scatter plots from line plots	
3		Can arrays be reshaped? Justify your answer	
4		Summarize Broadcasting	
5		Distinguish between panda series and index object	
6		Why is Indexing and Slicing a MultiIndex designed?	
7		Explain simple scatter plots.	
8		How can a 3D function be visualized?	
9		Summarize feature Engineering	
10		Explain Naive Bayes Classification	
		PART B	
11	a)	Explain the various data pre-processing techniques	14
		OR	
12	a)	Summarize the visualization and graphic techniques used in the data analysis	14
13	a)	Explain the vectorized operations implemented through ufuncs.	14
		OR	
14	a)	How can you compute the summary statistics for large data?	14
15	a)	What are the general considerations for missing data? How pandas choose to represent it.	14
		OR	
16	a)	Summarize the element wise operations on data in Pandas.	14
17	a)	Explain how you can display three-dimensional data into two dimensions.	14
		OR	
18	a)	Can Matplotlib be customized? Justify your answers with examples	14

		OR	
19	a)	Illustrate manifold learning algorithms.	14
		OR	
20	a)	Summarize Gaussian Mixture Models.	14

Syllabus

Module 1

Introduction, Causality and Experiments, Data Pre-processing: Data cleaning, Data reduction, Data transformation, Data discretization. Visualization and Graphing: Visualizing Categorical Distributions, Visualizing Numerical Distributions, Overlaid Graphs, plots, and summary statistics of exploratory data analysis, Randomness, Probability, Sampling, Sample Means and Sample Sizes.

Module 2

Introduction to NumPy: Understanding Data Types in Python, The Basics of NumPy Arrays, Computation on NumPy Arrays: Universal Functions; Aggregations: Min, Max, and Everything in Between; Computation on Arrays: Broadcasting; Comparisons, Masks, and Boolean Logic; Fancy Indexing; Sorting Arrays; Structured Data: NumPy's Structured Arrays

Module 3

Data Manipulation with Pandas: Panda objects; Data Indexing and Selection; Operating on Data in Pandas; Handling Missing Data; Hierarchical Indexing; Combining Datasets: Concat and Append, merge and join; Aggregation and Grouping; Pivot Tables; Vectorized String Operations; Working with Time Series; High-Performance Pandas: eval() and query()

Module 4

Visualization with Matplotlib: Simple Line Plots; Simple Scatter Plots; Visualizing Errors, Density and Contour Plots; Histograms, Binning's, and Density, Customizing Plot Legends, Customizing Colorbars, Multiple Subplots, Text and Annotation, Customizing Ticks, Three-Dimensional Plotting in Matplotlib, Geographic Data with Basemap

Module 5

Machine Learning: Introducing Scikit-Learn; Hyperparameters and Model Validation, Feature Engineering, In Depth: Naive Bayes Classification, Linear Regression, Support Vector Machines, Principal Component Analysis, Manifold Learning, K-means clustering, Gaussian Mixture Models, Kernel Density Estimation

Text Books

1. Adhikari, Ani, and John DeNero. "Computational and Inferential Thinking: The Foundations of Data Science." (2017).
2. VanderPlas, Jake. *Python data science handbook: Essential tools for working with data*. " O'Reilly Media, Inc.", 2016.

Reference Books

1. Alit Shmueli, Peter C. Bruce, InbalYahav, Nitin R. Patel, Kenneth C. Lichtendahl Jr., Data Mining for Business Analytics: Concepts, Techniques and Applications in R, GWiley India, 2018.
2. Mohammed J. Zaki and Wagner Miera Jr, "Data Mining and Analysis: Fundamental Concepts and Algorithms", Cambridge University Press, 2014.
3. Matt Harrison, "Learning the Pandas Library: Python Tools for Data Munging, Analysis, and Visualization, O'Reilly, 2016.
4. Joel Grus, "Data Science from Scratch: First Principles with Python", O'Reilly Media, 2015.
5. Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", O'Reilly Media, 2012.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction to Data cleaning, Data reduction, Data transformation, Data discretization. Causality and Experiments	2
1.2	Visualization and Graphing: Visualizing Categorical Distributions, Visualizing Numerical Distributions,	2
1.3	Overlaid Graphs, plots, and summary statistics of exploratory data analysis, Randomness, Probability,	3
1.4	Introduction to Statistics, Sampling, Sample Means and Sample Sizes.	2
2	**Module 2**	
2.1	Understanding Data Types in Python, The Basics of NumPy Arrays, Computation on NumPy Arrays: Universal Functions	3
2.2	Aggregations: Min, Max, and Everything in Between; Computation on Arrays: Broadcasting;	3
2.3	Comparisons, Masks, and Boolean Logic; Fancy Indexing; Sorting Arrays; Structured Data: NumPy's Structured Arrays	3
3	**Module 3**	
3.1	Panda objects; Data Indexing and Selection; Operating on Data in Pandas; Handling Missing Data	3

3.2	Hierarchical Indexing; Combining Datasets: Concat and Append, merge and join; Aggregation and Grouping; Pivot Tables	3
3.3	Vectorized String Operations; Working with Time Series; High-Performance Pandas: eval() and query()	3
4	**Module 4**	
4.1	Simple Line Plots; Simple Scatter Plots; Visualizing Errors, Density and Contour Plots; Histograms, Binnings, and Density	4
4.2	Customizing Plot Legends, Customizing Colorbars, Multiple Subplots, Text and Annotation, Customizing Ticks, Three-Dimensional Plotting in Matplotlib, Geographic Data with Basemap	5
5	**Module 5**	
5.1	Introducing Scikit-Learn; Hyperparameters and Model Validation, Feature Engineering	4
5.2	In Depth: Naive Bayes Classification, Linear Regression, Support Vector Machines, Principal Component Analysis	3
5.3	Manifold Learning, K-means clustering, Gaussian Mixture Models, Kernel Density Estimation	2

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