YEAR III
SEMESTER - VI

Biomedical Digital Signal Processing
BEG 3B5 BM

Micro Syllabus

SN	Chapters	Descriptions	Time ,Hrs	Hours	Weight
1	Unit 1. Introduction to Signal and System	Signal • Unit Impulse • Unit Step Signal • Unit Ramp Signal • Exponential Signal • Sinc Signal • Harmonic signal • Rectangular Pulse • Triangular Pulse	0.5	5	8 Marks
		Types of Signal • Causal Signal, non causal anti Anti Causal • Analog, Discrete and Digital • Periodic and Non-Periodic • Energy type and Power Type	0.5		
		ECG Signal Characteristics	0.5		
		Basic sampling theorem • Analog to Digital Conversion • Digital to Analog Conversion • Sampling of Analog Signal ▪ Relation between Analog Frequency and Digital Frequency ▪ Range of Analog frequency ▪ Range of Discrete frequency	1		
		System • Introduction • Memory less system • Linear System • Time Invariant System • FIR and IIR System • Recursive and non-recursive system	1.5		
		Convolution summation of Biomedical discrete systems to discrete inputs • Derivation • Properties of Convolution • Properties of LTI	0.5		
		Stability of biomedical system with reference to convergence of Power series • Introduction • Necessary and sufficient condition	0.5		

		• Example of stable system			
2	Unit 2. Difference Equation and Frequency Response	Review of Z-transform • Introduction • Z-transform of ▪ Delta ▪ Unit step ▪ Ramp ▪ Sinc ▪ exponential Properties • Linear • Associative • Commutative • Distributive • Shifting • Multiplication • Convolution Z-Plane Plot and Region of convergence Inverse Z-transform • Power series • Standard form	3.5	5	14 Marks
		General form of the linear ;Shift invariant constant coefficient difference equation-signal flow graph representation	0.5		
		Steady state and transient response to sinusoidal, periodic and ECG Signal • Introduction • Derivative • Examples	1		
3	Unit 3. Basic of Digital Filter	Introduction	0.5	5	10 Marks
		Elements of Digital Filter • Delay • Multiplier • Adder	0.5		
		Types of Digital Filter • Finite Impulse Response • Infinite Impulse Response	0.5		
		Structure of Digital Filter • Cascaded and Parallel ▪ Direct form-I ▪ Direct form-II • Lattice and Lattice Ladder ▪ FIR ▪ IIR	3		
		Z-plane pole and zero plot • Condition of stability	0.5		
4	Unit 4:FIR Filter Design	Characteristics of FIR filters • Ideal filter • Practical Filter • Gibb's Phenomena	0.5	7	20 Marks
		Smoothing filter	0.5		

		• Introduction			
		Notch filter • Introduction			
		Window design: • Design with structure of Linear phase FIR filter using ▪ Rectangular ▪ Bartley ▪ hanning ▪ hamming ▪ and Kaiser	4		
		Frequency sampling • Derivation • Example • Equiripple filter	1		
		FIR filter design using the Remez exchange algorithm • Derivation • Algorithm	1		
5	Unit 5. IIR Filter Design	Classical filter design using polynomial approximations-Butterworth, Chebychev, elliptic • Butterworth filter ▪ Derivation for cutoff frequency, ▪ order of filter ▪ analog equation • Chabychev Filter ▪ Introduction ▪ order of filter • Elliptic Filter ▪ Introduction ▪ Order of Filter	1.5	6	12 Marks
		IIR filter design by transformation Matched Z- transform, impulse invariant transform and bilinear transform • Derivation • Formula to convert s domain to Z domain	1		
		Application of the bilinear transform to IIR low pass discrete filter Design	1.5		
		Spectral transformations, High pass, band pass and notch filters • Continuous Equation for converting ▪ Low Pass filter to High pass ▪ Low Pass filter to Band pass ▪ Low Pass filter to Band Reject pass • Discrete Equation for	1		

		▪ Low Pass filter to High pass ▪ Low Pass filter to Band pass ▪ Low Pass filter to Band Reject pass			
6	Unit 6. Discrete Fourier Transform	Derivation	1	6	13 Marks
		DFT as linear transform • Computation of DFT • Computation of IDFT	1		
		Properties • Periodicity • Linearity • Multiplication • Circular Convolution	0.5		
		Correlation • Definition • Example	0.5		
		Fast Fourier transform • Radix 2 Dissemination in Time(DIT) up to 8 sample data • Radix 2 Dissemination in Frequency (DIF) up to 8 sampling data	2.5		
		Power spectrum estimation • Introduction • Example	0.5		
7	Unit 7. Signal Averaging	Basic of signal averaging • Background • need	0.5	2	3
		Typical of Signal averaging • Derivation for reduction of noise	1		
		Software for signal averaging	0.5		
		Limitation of signal averaging			
8	Unit 8. Data Reduction Techniques	Turning point algorithm • Algorithm • Example	1	5	5
		Fan Algorithm • Algorithm • Example	1		
		AZTEC algorithm • Algorithm • Example	1		
		Huffman Coding • Algorithm • Example	2		
9	Unit 9. . Real Time Biomedical System	Introduction and need	1	5	5
		Real time ECG processing • Power spectrum ECG Signal • A QRS detection algorithm ▪ Subtraction	4		

		▪ Matched ▪ Differentiation Technique			
			Total	45	80

Laboratory:

- Introduction of signal-plot and analysis of different biomedical signals
- Response of recursive (IIR) digital filter- for ECG Analysis
- Scaling, dynamic range and noise behavior of a recursive digital filter, observation of nonlinear precision effects.
- Response of a non recursive (FIR) for Domain Analysis of ECG
- Use of DFT and FFT transforms of ECG frequency
- Signal averaging: ECG Signal Averaging
- Data Reduction Technique: ECG Data reduction Algorithm

Text Book:

1. Willis J Tompkins, Editor, " Biomedical Digital Signal Processing", Prentice Hall of India, 1995
2. John G. Proakis and Dimitris G. Manolakis, "Digital Signal Processing"

Reference:

A.V. Oppenheim, "Discrete- Time Signal Processing", Prentice Hall, 1990

Prepared by:

Achyuta Nand Mishra

BIOMEDICAL INSTRUMENTATION I

Semester VI **BEG 3B4 BM** **Year III**

COURSE OBJECTIVE: To provide specific engineering and instrumentation methods and principles to the task of obtaining basic knowledge of design, application and maintenance of different biomedical instruments.

1.0 Fundamental of Medical Instrumentation: (4 hours)

- **1.1** Anatomy and Physiology
- **1.2** Physiological System of the Body
- **1.3** Sources of Biomedical Signals
  - **1.3.1** Resting Potential
  - **1.3.2** Action Potential
  - **1.3.3** Waveforms of Resting and Action Potential
- **1.4** Basic Medical Instrumentation System
- **1.5** Biometrics and Design Consideration Factors of Medical Instruments
- **1.5** Man Instrument System and their Objectives
- **1.6** Components of Man Instrument System
- **1.7** Biomedical Engineering and Areas of Engineering Contributions

2.0 Bioelectric Signals and Electrodes: (4 hours)

- **2.1** Origin of Bioelectric Signals
- **2.2** Electrodes
  - **2.2.1** Electrode Theory
- **2.3** Types of Recording Electrodes
  - **2.3.1** Electrodes for ECG Recording
  - **2.3.2** Electrodes for EEG Recording
  - **2.3.3** Electrodes for EMG Recording
- **2.4** Electrical Conductivity of Electrodes and Electrode Jellies
- **2.5** Micro Electrodes
- **2.6** Bio Chemical Electrodes

3.0 Physiological Transducers: (4 hours)

- **3.1** Classification of Transducers
- **3.2** Performance Characteristics of Transducers
- **3.3** Active Transducers and their Application in Medical Instruments
  - **3.3.1** Piezoelectric Transducer
  - **3.3.2** Equivalent Circuit of Piezoelectric Transducer
- **3.4** Passive Transducers and their Application in Medical Instruments
  - **3.4.1** Pressure Transducers
  - **3.4.2** Transducers for the Body Temperature Measurement
- **3.5** Biosensors

4.0 Biomedical Recorders and Recording System: (9 hours)

- **4.1** Aspects of Bioelectric Signals
- **4.2** Electrocardiography (ECG)
  - **4.2.1** Normal Characteristics of Electrocardiogram
  - **4.2.2** ECG Lead Configuration and Recording Techniques
  - **4.2.3** Computer –Aided Electrocardiograph Analysis
  - **4.2.4** Digital Recorders
- **4.3** Electroencephalography (EEG)
  - **4.3.1** Electroencephalogram and Evoked Potential
  - **4.3.2** EEG Pre amplifier Design
  - **4.3.3** EEG Electrode Configuration and Recording Techniques
  - **4.3.4** Practical Details of EEG
- **4.4** Electromyography (EMG)
  - **4.4.1** Electromyography Recording Technique
  - **4.4.2** Applications of EMG
- **4.5** Sources of Noise in Low Level Measurement
- **4.6** Direct Writing Recorders
- **4.7** The Inkjet Recorders

5.0 Patient Monitoring Systems: (4 hours)

- **5.1** System Concept
- **5.2** Cardiac Monitor
  - **5.2.1** Measurement of Heart Rate
  - **5.2.2** Measurement of Pulse Rate
  - **5.2.3** Measurement of Respiration Rate
    - **5.2.3.1** Thermistor Method
    - **5.2.3.2** Impedance Pneumography
    - **5.2.3.3** Apnoea Detectors
  - **5.2.4** Measurement of Blood Pressure
  - **5.2.5** Measurement of Temperature
- **5.3** Bedside Patient Monitoring Systems
- **5.4** Central Monitors
  - **5.4.1** Central Monitoring Station for ICU Beds
- **5.5** Catheterization Laboratory Instrumentation

6.0 Arrhythmia and Ambulatory Monitoring Instruments: (3 hours)

- **6.1** Cardiac Arrhythmia
  - **6.1.1** Basic Arrhythmia Monitoring System
  - **6.1.2** Detection of Ventricular Fibrillation
- **6.2** Ambulatory Monitoring Instruments

7.0 Foetal Monitoring Instruments: (4 hours)

- **7.1** Cardiotocograph
- **7.2** FHR Measurement from Ultrasound Doppler Foetal Signal
- **7.3** Labour Activity Monitoring

8.0 Biomedical Telemedicine and Telemetry: (3 hours)

- **8.1** Wireless Telemetry
- **8.2** Single Channel Telemetry Systems
  - **8.2.1** The Components of Biotelemetry System
- **8.3** Multi channel Wireless Telemetry Systems
  - **8.3.1** Telemetry of ECG and Respiration
- **8.4** Implantable Telemetry System
  - **8.4.1** Implantable Blood Flow meter
- **8.5** Digital Landline Telemetry System
- **8.6** Telemedicine
  - **8.6.1** Application of Telemedicine Technology
  - **8.6.2** Telemedicine Using Mobile Communication
  - **8.6.3** Digital Imaging and Communication in Medicine

9.0 Oximeters: (2 hours)

- **9.1** Oximetry
- **9.2** Pulse Oximeter
  - **9.2.1** Analog to Digital Signal Processing by Pulse Oximetry
- **9.3** Photo electric Pulse Transducer
  - **9.3.1** Transmittance Method
  - **9.3.2** Reflectance Method

10.0 Blood Flowmeters: (3 hours)

- **10.1** Blood Flow Measurement Principle
- **10.2** Types of Blood Flowmeters
  - **10.2.1** Electro magnetic Blood Flowmeter
  - **10.2.2** Ultrasonic Blood Flowmeter
  - **10.2.3** NMR Blood Flowmeter
  - **10.2.4** Blood Flow Determination by Radiographic Methods

11.0 Cardiac Output Measurement: (4 hours)

- **11.1** Cardiac Output
  - **11.1** Stroke Volume
  - **11.2** Minute Volume
- **11.2** Methods to Measure Cardiac Output
- **11.3** Measurement of Continuous Cardiac Output
  - **11.3.1** Impedance Technique
  - **11.3.2** Ultrasound Technique

11.3.3 Thermal Dilution Technique

12.0 Pulmonary Function Analyzers: (4 hours)

12.1 Pulmonary Function Measurement
- **12.1.1** Respiratory Volumes
- **12.1.2** Respiratory Capacities

12.2 Spirometry
12.3 Pneumotachometers
12.4 Pulmonary Function Analyzers
12.5 Respiratory Gas Analyzers

Laboratory:
1. Introduction to Sensors and Types
2. Blood groups and its Cross- Matched
3. Pulse Oximetry
4. Electrocardiography
5. Electrencephalography
6. Electromyography

Textbook: Handbook of Biomedical Instrumentation, R S Khandpur, Tata Mc-Graw Hill
Reference Book: Biomedical Instrumentation and Measurements, Leslie Cromwell, et AI, Prentice Hall India

Marks Distribution:

Chapter	Lecture Hours	No of Questions	Marks
Fundamental of Medical Instrumentation	4	1	8
Bioelectric Signals and Electrodes	4	1	8
Physiological Transducers	4	1	8
Biomedical Recorders and Recording System	9	1	8
Patient Monitoring Systems	4	1	8
Arrhythmia and Ambulatory Monitoring Instruments	3	1	8
Foetal Monitoring Instruments	4	1	8
Biomedical Telemedicine and Telemetry	3	0.5	4
Oximeters	2	0.5	4
Blood Flowmeters	3	1	8
Cardiac Output Measurement	4	0.5	4
Pulmonary Function Analyzers	4	0.5	4
Total	**48**	**10**	**80**

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Engineering Economics
BEG 2C1 BM

Semester VI **Year III**

Teaching Schedule Hours/Week			Examination Schedule						Total Marks	Remarks
			Final				Internal Assessment			
			Theory		Practical		Theory Marks	Practical Marks		
L	T	P	Duration	Marks	Duration	Marks				
3	1	-	3	80	-	-	20	25	125	

COURSE OBJECTIVE:

- To provide the students a knowledge of the basic tools and methodology of economic studies for evaluating engineering project in private industry, in the public sector and in the utilities areas.

1. Introduction (3 hr)
   - 1.1 Businesses and accounting terminology
     - 1.1.1 Definition of Economics
     - 1.1.2 Why Engineering Economics
     - 1.1.3 Essential Economic Terminology
   - 1.2 Cash flow
     - 1.2.1 Definition & diagram
   - 1.3 Economic systems
     - 1.3.1 Capitalistic Economic System
     - 1.3.2 Pure Socialistic System
     - 1.3.3 Mixed Economic System

2. Cost Classification and analysis (5 hr)
   - 2.1 The elements of cost: Material, Labor & Expenses
   - 2.2 Classification of cost: Overhead, prime cost
   - 2.3 Cost variance analysis
   - 2.4 Job and process costing

3. Interest and the time value of money (6 hr)
   - 3.1 Simple interest, compound, interest tables, interest charts
   - 3.2 Present worth
   - 3.3 Nominal and effective interest rates
   - 3.4 Continuous compounding and continuous compounding formula
   - 3.5 Interest calculation for uniform gradient

4. Basic Methodologies of Engineering Economic Studies (7 hr)
   - 4.1 Present worth and annual worth methods
   - 4.2 Future worth method
   - 4.3 Internal rate of return method
   - 4.4 Drawbacks of the internal rate of return method
   - 4.5 External rate of return method
   - 4.6 Minimum attractive rate of return method
   - 4.7 The payback (payout) period method

5. Cash/Benefit Analysis (4 hr)
   - 5.1 Conventional Cost/Benefit ratio

5.2 Modified Cost/Benefit ratio
5.3 Break even analysis

6. Investment Decisions (8 hr)
   6.1 Comparison of alternatives having some useful life
   6.2 Comparison of alternatives having different useful life
   6.3 Comparison of alternatives including & excluding time value of money
   6.4 Comparison of alternatives using the capitalized worth method
   6.5 Definition of mutually exclusive investment alternatives in terms of combination of projects
   6.6 Comparison of mutually exclusive alternatives

7. Risk Analysis (4 hr)
   7.1 Projects operating under conditions of certainty
   7.2 Projects operating under conditions of uncertainty
   7.3 Decision tree
   7.4 Sensitivity analysis

8. Taxation System in Nepal (3 hr)
   8.1 Taxation law in Nepal
   8.2 Depreciation rates for building, equipment, furniture
   8.3 Recaptured depreciation
   8.5 Taxes on capital gains
   8.6 VAT

9. Demand Analysis and sales forecasting (5 hr)
   9.1 Demand analysis
   9.2 Correlation of price and consumption rate
   9.3 Market research
   9.4 Sales forecasting
   9.5 Criteria for desirable sales forecasting procedures
   9.6 Factors affecting accuracy of forecasting

Marks Distribution:

Chapter	Lecture Hours	No. of Questions	Marks
Introduction	3	1	5
Cost Classification and Analysis	5	1	8
Interest and Time Value of money	6	2	12
Basic Methodologies of Engineering Economic Studies	7	2	12
Cash/Benefit analysis	4	1	5
Investment Decisions	8	2	16
Risk Analysis	4	1	8
Taxation System in Nepal	3	1	6
Demand Analysis and sales forecasting	5	1	8
Total	**45**	**10** ***(one choice)***	**80**

MEDICAL IMAGING- I
(BEG 3B3 BM)

Semester VI **Year III**

Teaching Schedule Hours/Week			Examination Schedule						Total Marks	Remarks
			Final				Internal Assessment			
			Theory		Practical		Theory Marks	Practical Marks		
L	T	P	Duration	Marks	Duration	Marks				
3	1	2	3	80			20	25	125	

Course Objective:

The main objective of this course is to provide the students with the fundamental knowledge on Medical Imaging Physics and knowledge on the working principle of different medical imaging equipment.

1. **Basic Principle of Medical Imaging** **2Hrs**
   - 1.1 Introduction to Medical Imaging Science
   - 1.2 Different types of Medical Imaging Modalities

2. **Radiation Physics** **7Hrs**
   - 2.1 Review of electricity
   - 2.2 Transformers
   - 2.3 Thermionic emission and rectifiers
   - 2.4 Review of Atomic structure
   - 2.5 Radioactivity
   - 2.6 Electromagnetic radiation

3. **X-rays** **15Hrs**
   - 3.1 Historical background
   - 3.2 Production of x-rays
     - 3.2.1 Phenomena of x-ray production
     - 3.2.2 Bremsstrahlung x-rays
     - 3.2.3 Characteristic x-rays
     - 3.2.4 Factors affecting production of x-rays
   - 3.3 Interaction of radiation with matter
     - 3.3.1 Compton scattering
     - 3.3.2 Photoelectric absorption
     - 3.3.3 Differential absorption
   - 3.4 Measurement of electromagnetic radiation and other particles
   - 3.5 Radiation Protection
     - 3.5.1 Basic radiation units
     - 3.5.2 Introduction to Radiobiology
     - 3.5.3 Biological effects of radiation
     - 3.5.4 Principles of radiation protection
     - 3.5.5 ICRP recommendations
     - 3.5.6 Introduction to personnel monitoring
   - 3.6 Control of scattered radiation
     - 3.6.1 Scatter radiation and its significance
     - 3.6.2 Methods of scatter radiation control
     - 3.6.3 Control of scatter radiation produced
     - 3.6.4 Control of scatter radiation reaching to the film
     - 3.6.5 X-ray grid
     - 3.6.6 Grid characteristics

3.6.7 Types of grid
3.6.8 Grid faults
3.6.9 Air gap technique

4. **X-ray Equipment** **10Hrs**

4.1 X-ray tubes
4.1.1 Historical development
4.1.2 Types of x-ray tubes
4.1.3 Construction of rotating anode x-ray tube
4.1.4 Line focus principle
4.1.5 Anode heel effect
4.1.6 Off focus radiation
4.1.7 X-ray tube housing
4.1.8 Filtration
4.1.9 X-ray tube rating charts
4.1.10 X-ray tube faults

4.2 X-ray control and indicating equipment
4.2.1 Line voltage compensation
4.2.2 Control of kVp
4.2.3 Control of mA
4.2.4 Control of exposure time
4.2.5 Exposure timers

4.3 Introduction to different types of x-ray equipment
4.3.1 Portable and mobile x-ray units
4.3.2 Fluoroscopic equipment
4.3.3 Mammography units

5. Radiographic Imaging **12Hrs**

5.1 Photographic principle

5.2 Film materials
5.2.1 Historical background of x-ray film and its construction
5.2.2 Duplitized x-ray film construction
5.2.3 Spectral sensitivity
5.2.4 Films for digital imaging

5.3 Intensifying screen
5.3.1 Fluorescence and phosphorescence
5.3.2 Phosphors used for Intensifying screens
5.3.3 Types of Intensifying screen and their application
5.3.4 X-ray cassettes

5.4 Radiographic processing
5.4.1 Manual film processing
5.4.2 Different steps in film processing
5.4.3 Automatic film processing
5.4.4 Introduction to dry film processing

5.5 Radiographic Image
5.5.1 Photographic density
5.5.2 Radiographic Contrast and factors affecting contrast
5.5.3 Image sharpness and factors affecting sharpness
5.5.4 Image Resolution

5.6 Exposure factors

5.7 Image quality control

6. Basics of Radioisotope Imaging **5Hrs**

6.1 Types of radioactivity
6.2 Radionuclide/radiopharmaceuticals
6.3 Mo-99/Tc-99m Generator
6.4 Principle of Gamma camera
6.5 SPECT and PET

Textbook:

1. **Physics for Medical Imaging, FR Farr and PJ Allisy-Roberts**

Marks Distribution

Chapter	Lecture Hours	No. of Questions	Marks
Basic principle of Medical Imaging	2	1	5
Radiation Physics	7	2	10
X-Rays	15	2-4	20
X-Ray equipment	10	2-3	15
Radiographic Imaging	12	2-4	20
Basics of radio-isotope imaging	5	1-2	10
Total	**51**	**10**	**80**

TISSUE DEVICE INTERACTIONS
BEG 3B2 BM

Semester VI **Year III**

Teaching Schedule Hours/Week			Examination Schedule						Total Marks	Remarks
			Final				Internal Assessment			
			Theory		Practical		Theory Marks	Practical Marks		
L	T	P	Duration	Marks	Duration	Marks				
3	1		3	80			20		100	

COURSE OBJECTIVE: To provide knowledge of interactions between biomaterials and surrounding tissues after implantation in human body.

1. Introduction to Tissue-Device Interactions and Their Importance: (1 hour)

1.1. Body Environment
1.2. Interactions
1.3. Implantations
1.4. Degree of host reaction

2. Inflammation, Wound Healing and Foreign Body Response: (10 hours)

2.1. Inflammation
- 2.1.1. General Introduction
- 2.1.2. Sequence of Host Reaction
- 2.1.3. Diagrammatic representation of inflammation in response to tissue injury
- 2.1.4. Events following implantation
- 2.1.5. Mediators

2.2. Acute Inflammation
- 2.2.1. General
- 2.2.2. Sequence of leukocyte events
  - 2.2.2.1. Margination
  - 2.2.2.2. Pavementing
  - 2.2.2.3. Emigration
  - 2.2.2.4. Chemotaxis
  - 2.2.2.5. Phagocytosis
  - 2.2.2.6. Intracellular killing and degradation (Oxygen-dependent & independent)

2.3. Chronic Inflammation
- 2.3.1. General
- 2.3.2. Lymphocytes and chronic inflammation
- 2.3.3. Macrophages in chronic inflammation
- 2.3.4. Role of biomaterials
- 2.3.5. Macrophages and cytokines
- 2.3.6. Foreign body giant cells

2.4. Granulation Tissue
- 2.4.1. Neovascularization
- 2.4.2. Different factors in the development of granulation tissue, wound healing of first and secondary intention

2.5. Foreign body reaction
- 2.5.1. Different factors/cells involved

2.6. Fibrosis and fibrous encapsulation

2.7. Inflammation and wound healing
- 2.7.1. Repair of implant sites
- 2.7.2. Different cell types and wound healing
- 2.7.3. Other factors in wound healing
- 2.7.4. Role of implants in healing

3. Effect of Biomaterials on Host + Blood-Biomaterials Interaction: (5+5 hours)

- 3.1. Biochemical response to biomaterials
  - 3.1.1. Protein adsorption
    - 3.1.1.1. Introduction
    - 3.1.1.2. Major plasma proteins
    - 3.1.1.3. Vroman effect for protein adsorption
  - 3.1.2. Coagulation cascade
    - 3.1.2.1. Coagulation
    - 3.1.2.2. Platelet activation
    - 3.1.2.3. Coagualtion pathways- Intrinsic and Extrinsic
  - 3.1.3. Complement cascade
    - 3.1.3.1. Introduction to immune system
    - 3.1.3.2. Complement cascade- Classical and Alternate pathway
    - 3.1.3.3. MAC formation
    - 3.1.3.4. Control mechanisms
    - 3.1.3.5. Functions and actions of complements
- 3.2. Cellular response to biomaterials
  - 3.2.1. Cytokines
    - 3.2.1.1. Introduction
    - 3.2.1.2. Action
    - 3.2.1.3. Various important cytokines
    - 3.2.1.4. Functions and effects of cytokines
  - 3.2.2. Cellular response
    - 3.2.2.1. Fibrinolysis
    - 3.2.2.2. Platelets (Platelet structure Vs. function, Platelet deposition, Protein Vs. platelet)
    - 3.2.2.3. Leukocyte adhesion
    - 3.2.2.4. Cellular ingrowth (Endothelial cells and Smooth muscle cells)
- 3.3. Systemic response to biomaterials
  - 3.3.1. Thrombosis
  - 3.3.2. Anastomotic intinal hyperplasia
  - 3.3.3. Infection

4. Endothelial Cells and Biomaterials: (4 hours)

- 4.1. Introduction
- 4.2. Endothelial cell physiology
  - 4.2.1. Endothelium
  - 4.2.2. Endothelium functions
    - 4.2.2.1. Anticoagulant activity of ECs
    - 4.2.2.2. Procoagulant action of ECs
  - 4.2.3. Endothelial cell adhesive interactions
    - 4.2.3.1. Adhesion to ECM
    - 4.2.3.2. EC adhesion to leukocytes
    - 4.2.3.3. EC adhesion to ECs
- 4.3. Techniques for endothelial cell Harvest and culture
  - 4.3.1. Endothelial cell harvesting
  - 4.3.2. Endothelial cell seeding
    - 4.3.2.1. Seeding just before operation
    - 4.3.2.2. 2 step seeding
  - 4.3.3. Surface modification before EC seeding
    - 4.3.3.1. Through adsorbed molecules (Fibronectin, Collagen, Others)
    - 4.3.3.2. Through functional and reactive groups
    - 4.3.3.3. Combined modifications
- 4.4. Endothelial cell reading studies

5. The Extracellular Matrix and Biomaterials: (5 hours)

5.1. Introduction
- 5.1.1. ECM
- 5.1.2. Functions of ECM
- 5.1.3. ECM in injury

5.2. ECM components
- 5.2.1. Basement membrane components
- 5.2.2. Intersitial connective tissues
- 5.2.3. Laminin
- 5.2.4. Collagen
- 5.2.5. Hyaluronic acid
- 5.2.6. Proteoglycans and glycoproteins
  - 5.2.6.1. Heparan sulfate
  - 5.2.6.2. Chondroitin sulfate proteoglycans
  - 5.2.6.3. Keratan sulfate proteoglycans
  - 5.2.6.4. Fibronectin
- 5.2.7. Elastic fibers

5.3. Acute responses in injury or implantation
- 5.3.1. The provisional matrix
  - 5.3.1.1. Components of provisional matrix
  - 5.3.1.2. Role of fibrin
- 5.3.2. Resolution and reorganization
  - 5.3.2.1. Fibronectin
  - 5.3.2.2. Heparin

5.4. Chronic response

5.5. Future challenges

6. Bacteria and Biomaterials: (7 hours)

6.1. Introduction

6.2. Bacterial virulence factors

6.3. Specialties of infections due to biomaterials
- 6.3.1. Introduction
- 6.3.2. Infection associated with biomaterial
- 6.3.3. Implant associated infections
- 6.3.4. Microorganisms involved in infection
- 6.3.5. Common infections to particular implants

6.4. Nature of microbial adhesion
- 6.4.1. Molecular mechanisms of microbial adhesion
- 6.4.2. Microbial adhesion and biofilm formation
- 6.4.3. Nature of microbial adhesion

6.5. Tissue-centered and biomaterial-centered infections

6.6. Failure of integration due to infection

6.7. Surface modification of biomaterials for control of infection

7. Integrins, Adhesion Molecules and Biomaterials: (6 hours)

7.1. Introduction

7.2. Types of cell surface receptors

7.3. Integrins
- 7.3.1. Introduction
- 7.3.2. Beta subfamily
  - 7.3.2.1. ECM integrins (B1 subfamily)
  - 7.3.2.2. Leukocyte integrins (B2 subfamily)
  - 7.3.2.3. Beta-3 (B3 subfamily)

7.4. Cell adhesion molecules (CAMs)
- 7.4.1. Introduction to Adhesion Molecules
- 7.4.2. Types of Adhesion Molecules
- 7.4.3. Immunoglobulin (IgG) superfamily
  - 7.4.3.1. ICAM-1 (also ICAM-2,3,4,5)
  - 7.4.3.2. VCAM-1
  - 7.4.3.3. PECAM-1
- 7.4.4. Selectins
  - 7.4.4.1. E-Selectin
  - 7.4.4.2. P-Selectin
  - 7.4.4.3. L-Selectin
- 7.4.5. Cadherins

7.5. Integrins, adhesion molecules and biomaterials
- 7.5.1. Introduction
- 7.5.2. Integrins as mediators for cellular interactions with biomaterial surface
- 7.5.3. Integrin as targets for biomaterial manipulations

8. Controlling, manipulating the material/host interactions by changing material, chemistry i.e. surface charge, physical properties eg. shape, topography, porosity and others **(3 hours)**

Marks Distribution:

Chapter	Lecture Hours	No. of Questions	Marks
Introduction to Tissue-Device Interactions and Their Importance	1	1 short question	0-5
Inflammation, Wound Healing and Foreign Body Response	10	2-3 (1long, 1-2short)	15-20
Effect of Biomaterials on Host + Blood-Biomaterials Interaction	5+5	2-3 (1long, 1-2short)	15-20
Endothelial Cells and Biomaterials	4	1	5-10
The Extracellular Matrix and Biomaterials	5	2 (1long and/or 1short)	5-10
Bacteria and Biomaterials	7	1-2	10-15
Integrins, Adhesion Molecules and Biomaterials	6	1-2	10
Controlling, manipulating the material/host interactions by changing material, Chemistry i.e. surface charge, physical properties e.g. Shape, topography, porosity and others	3	Individual question or may be embedded in other questions	2-5
Total	**46**	**8**	**80**