UNIVERSITY OF MUMBAI
No.UG / 398 of 2008

CIRCULAR :-

A reference is invited to the Ordinances, Regulations and syllabi relating to the Bachelor of Engineering degree course **vide** this office Circular No. UG/347 of 2002 dated 17th August, 2002 and the Principals of the affiliated collages in Engineering are hereby informed that the recommendation made by the Faculty of Technology at its meeting held on 26th March, 2008 has been accepted by the Academic Council at its meeting held on 15th April, 2008 **vide** item No.4.34 and that, in accordance therewith, the scheme of Examination and syllabi for the Second Year (Biomedical Engineering) (Sem. III & IV) leading to the B.E. degree course is revised as per **Appendix** and that the same has been brought into force with effect from the academic year 2008 – 2009.

MUMBAI-400 032
26th August, 2008

PRIN.K.VENKATARAMANI
REGISTRAR

To,

The Principals of the affiliated colleges in Engineering.

A.C./4. 34/15.04. 2008

No.UG/ 398 - A of 2008, MUMBAI-400 032 26th August, 2008

Copy forwarded with compliments for information to :-

1) The Dean, Faculty of Technology
2) The Chairman, Board of Studies in Electrical Engineering .
3) The Controller of Examinations,
4) The Co-Ordinator, University Computerization Centre,

26/08

(D. H. KATE)
DEPUTY REGISTRAR
(U.G./P.G.Section.)

Copy to :-

The Director, Board of College and University Development, , the Deputy Registrar (Eligibility and Migratio Section), the Director of Students Welfare, the Executive Secretary to the Vice-Chancellor, the Pro-Vice-Chancellor, th Registrar and the Assistant Registrar, Administrative sub-center, Ratnagiri for information .

The Controller of Examinations (10 copies), the Finance and Accounts Officer (2 copies), Record Section (5 copi Publications Section (5 copies), the Deputy Registrar, Enrolment, Eligibility and Migration Section (3 copies), the Dep Registrar, Statistical Unit (2 copies), the Deputy Registrar (Accounts Section),Vidyanagari (2 copies), the Deputy Regis Affiliation Section (2 copies), the Director, Institute of Distance Education,(10 copies) the Director University Comp Center (IDE Building), Vidyanagari, (2 copies) the Deputy Registrar (Special Cell), the Deputy Registrar,(PRO) Assistant Registrar, Academic Authorities Unit (2 copies)and the Assistant Registrar, Executive Authorities Unit (2 c They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council refer in the above Circular and that, no separate Action Taken Report will be sent in this connection. the Assistant Reg Constituent Colleges Unit (2 copies), BUCT(1 copy), the Deputy Account, Unit V(1 copy), the In-charge Director, Ce Computing Facility (1 copy), the Receptionist (1 copy), the Telephone Operator (1 copy), the Secretary MUASA (1 c Superintendent, Post-Graduate Section (2 copies), the Superintendent, Thesis Section (2 copies)

sk/26/8/2008

Enclosure to Item No. 4·34
15.4.2008

UNIVERSITY OF MUMBAI

Revised Syllabus

and Scheme of Examinations

For

The Second Year

(Semester III and IV)

Of the

B.E. Degree Course

In

Biomedical Engineering

(With effect from the academic year 2008-2009)

Semester-IV

S. No.	Subject	Scheme of Instructions Periods per Week (Each 60 min.)		Scheme of Evaluation					
		Theory	Practical/ Tutorial	Paper		TW	Practical & Oral	Oral	Total Marks
				Hours	Marks				
1.	Electronic Circuit Analysis and Design-II	04	03	3	100	25	50	---	175
2.	Transducers in Biomedical Instrumentation	04	02	3	100	25	---	25	150
3.	Electronic Instruments	03	02	3	100	25	---	---	125
4.	*Engineering Mathematics-IV	05	---	3	100	---	---	---	100
5.	Biomechanics, Prosthetic & Orthotics	04	02	3	100	25	---	25	150
6.	Logic Circuits	03	02	3	100	25	25	---	150
	Total	23	11		600	125	75	50	850

* Subject common with Instrumentation and Electrical Engineering branches.

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering	**Semester:** III	
Subject: Electronic Circuit Analysis and Design-I			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	03	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	02	50
	Oral	---	---
	Term Work	---	25
	Total	05	175

M	Content	Time
1.	**Diode Circuits:** Design of Rectifier Circuits, Half Wave Rectification, Full Wave Rectification, Filter Ripple Voltage and Diode Current, Voltage Doubler Circuit, Zener Diode Circuits, Clipper and Clamper Circuits, Multiple-Diode Circuits, Photodiode and LED Circuits.	4hrs
2.	**The Bipolar Junction Transistor:** BJT Biasing, DC analysis, Configurations (CB, CC, CE), Stability, Multistage (Cascade and Cascode Amplifiers).	5hrs
3.	**The Bipolar Junction Transistor Amplifiers:** The Bipolar Linear Amplifier, Graphical Analysis and AC Equivalent Circuit, Small Signal Hybrid-Π Equivalent Circuit of the Bipolar Transistor, Hybrid-Π Equivalent Circuit Including the Early Effect, Expanded Hybrid-Π Equivalent Circuit, Small signal analysis of BJT using h parameter, r_e model, Basic Transistor Amplifier Configurations, Common Emitter Amplifiers, AC Load Line Analysis, Common Collector Emitter Follower Amplifier, Common Base Amplifier, The Three Basic Amplifier Configurations: Summary and Comparison, Multistage Amplifiers (Cascade and Darlington). Power Considerations, Environmental Thermal Considerations in Transistor Amplifiers, Manufacturer's Specifications.	10hrs
4.	**The Field Effect Transistor:** Junction Field-Effect Transistor, MOS Field-Effect Transistor, MOSFET DC Circuit Analysis and basic MOSFET Applications: Switch, Digital Logic Gate and Amplifier. Temperature effects on MOSFETs, Input Protection in MOSFET, The Power FET (VMOS), Power MOSFETs etc.	5hrs
5.	**Basic FET Amplifiers:**	8hrs

	The MOSFET Amplifier, Basic Transistor Amplifier Configurations, Common Source Amplifier, Source Follower Amplifier, Gate Configuration, Basic Amplifier Configurations: Summary and Configuration, Single- Stage Integrated Circuit MOSFET, Amplifiers, Multistage Amplifiers, Basic JFET Amplifiers.	
6.	**Frequency Response of Amplifiers:** Amplifier Frequency Response, System Transfer Functions, S-Domain Analysis, First Order Functions, Bode Plots, Short Circuit and Open Circuit Time Constants. Frequency Response; Transistor Amplifiers with Circuit Capacitors, Frequency Response: Bipolar Transistor, Frequency Response: The FET, High Frequency Response Of Transistor Circuits,	8hrs
7.	**Differential Amplifiers:** Basic BJT & JFET and differential amplifiers, constant current source and current mirror circuits, differential amplifiers with active loads.	6hrs

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Practical & Oral Examination:

Practical examination will be based on one experiment performed from the list of experiments given in the syllabus and the oral will be based on entire subject.

Term work:

Term work consists of minimum eight experiments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Experiments and Journal) :10 marks
Test (at least one) :10 marks
Attendance (Practical and Theory) :05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

List of experiments:

1. Electronic Measurements
2. Rectifiers and Filters
3. Clipper and Clampers
4. BJT characteristics in CE configurations
5. BJT as a switch
6. Biasing of BJT
7. BJT as a CE Amplifier

8. FET Characteristics
9. FET as a CS Amplifier
10. PSPICE Simulations of transistorized circuits (at least 4)

Text Books:

1. Neamen Donald A., *Electronics Ckt. Analyzer & Design*, 2nd ed., Tata McGraw Hill.
2. Boylestad Robert L., Nashelsky Louis, *Electronics Devices & Circuits*, Pearson Education.
3. *Semiconductor Data Manual*, BPB Publications.

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering	**Semester:** III	
Subject: Electrical Network Analysis & Synthesis			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	---
	Oral	---	---
	Term Work	---	25
	Total	03	125

Module	Content	Time
1.	**Review:** D.C. & A.C. circuits.	2 hrs
2.	**Mesh & Node Analysis:** Mesh & Node Analysis of circuits with independent & dependent sources.	4 hrs
3.	**Linearity, Superposition & Source Transformation:** Linearity, Superposition, Current & Voltage Source Transformation.	4 hrs
4.	**Network Theorems:** Thevenin's & Norton's Theorem (with independent and dependent sources), Maximum power transfer theorem.	4 hrs
5.	**Circuit Analysis:** Introduction to Graph Theory. Tree, link currents, branch voltages, cut set & tie set Mesh & Node Analysis, Gauss Elimination Technique, Duality.	6 hrs
6.	**Time and Frequency Response of Circuits:** First & second order Differential equations, initial conditions. Evaluation & Analysis of Transient Steady state responses using Classical Technique as well as by Laplace Transform (for simple circuits only). Transfer function, Concept of poles and zeros. Frequency response of a system (concepts only), stability criteria & bode plot (concepts only)	10 hrs
7.	**Two-Port Networks:** Concept of two-port network. Driving point and Transfer Functions, Open Circuit impedance (Z) parameters, Short Circuit admittance (Y) parameters, Transmission (ABCD) parameters. Inverse Transmission (A'B'C'D') parameters. Hybrid (h) parameters. Inter Relationship of different parameters. Interconnections of two-port networks. T & Pi representation. Terminated two-port networks.	8 hrs
8.	**Fundamentals of Network Synthesis:** Positive real functions, Driving Point functions, Brono's Positive real functions, Properties of positive real functions. Testing Positive real functions. Testing driving point functions, Maximum modulus theorem, Properties of Hurwitz polynomials, Residue computations, Even & odd functions, Sturm's theorem. Driving Point Synthesis with L-C, R-C, R-L and R-L-C networks.	8 hrs

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Term work:

Term work consists of minimum eight experiments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Experiments and Journal) :10 marks
Test (at least one) :10 marks
Attendance (Practical and Theory) :05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

List of experiments:

1. To study transfer functions
2. a) To study Y parameters of a two port network.
   b) To study Z parameters of a two port network.
3. To study Norton theorem
4. To study Thevenin's theorem
5. To study superposition theorem
6. To study and verify Maximum power theorem
7. To study the second order frequency response of an RLC circuit
8. To study Time Response of first order system
9. Perform above mentioned list of experiments on p-spice or similar software as well (At least 4)

Text Books:

- Sudhakar & Shyammohan, Circuits and Networks, Tata McGraw Hill, thirteenth reprint, 2000.
- William H. Hayt, Jack e. Kemmerly & Steven M. Durbin, Engineering Circuit Analysis, McGraw Hill International, sixth edition, 2002.
- M. E. Van Valkenburg, Introduction to Modern Network Synthesis, Wiley Eastern Ltd.

Reference Books:

- Artice M. Davis, Linear Circuit Analysis, Thomson Asia Pte. Ltd, Singapore, first edition, 2001.
- M.E. Van Valkenburg, Network Analysis, Prentice Hall of India, third edition.
- Raymond A. DeCarlo & Pen-Min Lin, Linear Circuit Analysis, Oxford University Press, second edition, 2001.

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering		**Semester:** III
Subject: Engineering Mathematics-III			
Periods per Week (60 min. each)	Lecture	05	
	Practical	---	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	05	100
	Practical & Oral	---	---
	Oral	---	---
	Term Work	---	---
	Total	05	100

Module	Contents	Hours
1	**Laplace Transform** Functions of bounded variations. Laplace Transforms of 1, t^n, e^{at}, sin at, cos at, sinh at, cosh at, erf(t) Linear property of L.T .First shifting theorem Second shifting theorem $L\{t^n f(t)\}$, $L\{f(t)/t\}$, $L\{\int f(u)du\}$, $L\{d^n/dt^n f(t)\}$.Change of scale property of L.T. Unit step function , Heavyside, Dirac delta functions, Periodic functions and their Laplace Transforms. **a) Inverse Laplace Transforms** Evaluation of inverse L.T., partial fractions method, convolution theorem. **b) Applications** to solve initial and boundary value problems involving ordinary diff. Equation with one dependant variable.	15
2	**Complex Variables** Functions of complex variables, continuity and derivability of a function, analytic functions, necessary condition for f(z) to be analytic, sufficient condition (without proof), Cauchy – Riemann conditions in polar forms. Analytical and Milne – Thomson method to find analytic functions f(z) = u + iv where (i) u is given (ii) v is given (iii) u+v (iv) u-v is given. Harmonic functions and orthogonal trajectories. **a) Mapping** Conformal mapping, Bilinear mapping, fixed points and standard transformation, inversion, reflection, rotation and magnification. **b)Line Integral** of function of complex variable, Cauchy's theorem for analytical function (with proof), Cauchy's Goursat theorem (without proof), properties of line integral, Cauchy's Integral formula and deduction.	25

	c) Singularities and poles: Taylor's and Laurent's development (without proof), residue at isolated singularity and it's evaluation. **d) Residue theorem** application to evaluate real integrals of type $\int_0^{2\pi} f(\cos\theta, \sin\theta)d\theta$ *and* $\int_{-\infty}^{\infty} f(x)dx$	
3	**Fourier series** Orthogonality & orthogonal functions, Expression for the function in a series of orthogonal functions, Dirichlet's conditions, Fourier series of periodic functions with period 2pi or 2*l*. (Derivation of Fourier coefficients a0, an, bn is not expected) Dirichlet's theorem Even & Odd functions. Half range sine & cosine expressions Parsaval's identities (without proof) **a) Complex form of Fourier Series:** Fourier transform & Fourier integral in detail	20

Theory Examination:

1. Question paper will consist of total 7 questions carrying 20 marks each.
2. Only 5 questions need to be attempted.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. Wartikar P.N. / Wartikar J. N., *Textbook of Applied Mathematics*, Pune Vidyarthi Griha Prakashan, 1981.
2. Kreyszig Erwin, Advanced Engineering Mathematics, 8th ed., Wiley Student Edition, New Delhi, 2006.

Reference Books:

1. Churchil, *Coplex variables*, Mc Graw Hill.
2. Shantinarayan, *Theory of function Complex Variable*, S. Chand & co.
3. Shastri S.S., *Engineering Mathematics*, Prentice Hall.
4. Glyn James, Advanced Modern Engineering Mathematics, 3rd ed., Pearson Education Ltd., 2004.
5. Potter Merle C., Goldberg J. L., Aboufadel Edward F., 3rd ed., Oxford University Press, New Delhi, 2005.

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering	**Semester:** III	
Subject: Human Anatomy and Physiology			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	02	25
	Oral (Based on H.V.)	---	50*
	Term Work	---	25
	Total	03	200

Anatomy:		
1.	**Cell:** Structure and functions of cell. Polarization and depolarization of cell	**2hrs**
2.	**Body Structure:** Basic tissues and their functions in brief. Outline of structures of the following system. Cardiovascular System, Respiratory System, Alimentary System, Central Nervous System. Reproductive System, Urinary System, Skeletal System, Muscular System, Endocrine System, Special Organs – Eye and Ear, Integumentary system (Skin Study)	**4hrs**
Physiology:		
1.	**Cardiovascular System:** Heart, Conductive tissues of heart, Cardiac cycle, Heart Valves, System and Pulmonary Circulation, Transmission of Cardiac Impulse, Blood Pressure, ECG (Einthoven's Triangle, Various leads and Waveforms).	**8hrs**
2.	**Respiratory System:** Respiration external (Ventilation) Exchange in gases in the alveoli, Artificial respiration. Spiro meter (Forced expiratory volumes) peak flow meter.	**4hrs**
3.	**Alimentary System:** All organs of the digestive system, other secretions and main Functions. Deglutition and defecation.	**4hrs**
4.	**Blood:** Composition of Blood – Blood cells and their functions. Cell counting, Hemoglobin, Blood groups, Coagulation, Blood transfusion.	**4hrs**
5.	**Excretory System:** Structure of Nephron, formation of urine and function of Kidney, Urinary Bladder, urethra, internal / external sphincters.	**3hrs**
6.	**Nervous System:** Different parts, their functions. Reflex actions and reflex arc, Function of Sympathetic and Parasympathetic nervous system. Nerve conduction and action potentials.	**4hrs**
7.	**Reproductive System:** (Male and Female) Different organs and their functions. Main actions of Androgens, Oestrogens and Progesterone.	**3hrs**
8.	**Endocrine System:** All glands, their secretions and functions. Control of secretions.	**3hrs**
9.	**Eyes and Ears:** Eyes-Structure, Refractive Medias of the eye, formation of image on the Retina, Ophthalmoscope. Ear – Structure of Cochlea, Hearing mechanism, type of Deafness. Hearing aid.	**4hrs**
10.	Muscle physiology and aspects of skin resistance	**3hrs**

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Practical & Oral Examination:

Oral exam will be based on entire subject.

*Oral Examination Based on Hospital Visit

Visit to Hospitals to study the human anatomy and physiology to acquire the knowledge about human body. During the visit the students are required to study

i) The human anatomy, skeletal system and body organs and the equipments used for measurement of physiological parameters.

ii) How to identify the different body parts and their activities.

The student should submit the detailed report depending on the observations made. The concerned teachers of subject HAP will co-ordinate the visit. Oral examination will be based on the visit report.

Term work:

Term work consists of minimum eight assignments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Assignments and Journal)	:10 marks
Test (at least one)	:10 marks
Attendance (Practical and Theory)	:05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

List of Experiments:

1. To measure Blood Pressure using sphygmomanometer using occlusive cuff method.
2. To determine hemoglobin count in the blood by Shali's method.
3. Invitro recognition of A, B, O blood groups by slide test.
4. To find the total Red Blood Cell count using Neubauer's haemocytometer.
5. To find the total White Blood Cell count using Neubauer's haemocytometer.
6. To study the Defibrillator
7. To study external Pacemaker
8. To study ECG Machine

Text Books:

1. Anatomy and Physiology in Health and Illness: Ross and Wilson. (ELBS Pub)
2. Essentials of Anatomy and Physiology: Elaine N Marieb. (Pearson Education)

References:

1. Physiology of Human Body. : Guyton. (Prism Book)
2. Review of Medical Physiology: William Ganong. (Prentice Hall Int.)
3. Principles of Anatomy and Physiology: Tortora and Grabowski. (Harper Collin Pub.)

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering	**Semester:** III	
Subject: Biomaterials			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	---	
	Tutorial	01	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	02	25
	Oral (Based on I.V.)	---	50*
	Term Work	---	25
	Total	03	200

Module	Contents	Time
1.	**Introduction:** Introduction of Biomaterials, Classification of Biomaterials	2 hrs
2.	**Properties and Applications of Metallic Biomaterials:** Stainless steel, Titanium, Titanium based alloys, Cobalt – Chromium alloys in fabrication of biodevices and implants	5 hrs
3.	**Properties and Applications of Polymeric Biomaterials:** Classification, polyurethanes, PTFE, Polyethylene, Polypropylene, Polyacrylates, PMMA, PHEMA, Hydrogel, Silicone rubber, Biopolymer in fabrication of biodevices and implants.	7 hrs
4.	**Properties and Applications of Ceramic Biomaterials:** Bioceramics – classifications, Alumina, Zirconia and types, Bioglass, Hydroxyapatite, Tricalcium phosphate in fabrication of biodevices and implants	7 hrs
5.	**Composite Biomaterials:** Properties and Applications of Composite Biomaterials in fabrication of biodevices and implants	5 hrs
6.	**Properties and Applications of Degradable Biomaterials:** Polymers & Ceramics in fabrication of biodevices and implants	4 hrs
7.	**Biomaterials for Soft Tissue Replacements:** Properties and Applications of biomaterials for Soft Tissue Replacements	5 hrs
8.	**Properties and Applications of Materials used in Prosthetics:** The Indigenous metals and their alloys, Different types of leather, Types of rubber, Thermoplastic and thermosetting resins, Wood and binding materials	4 hrs
9.	**Surface properties of Biomaterials:** Surface properties of Biomaterials and their testing with reference to biological safety	4 hrs
10.	**Testing of Biomaterials:** Biological Testing of Biomaterials, Biocompatibility of Materials, Biomaterials corrosion and wear	4 hrs

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Practical & Oral Examination:

Oral exam will be based on entire subject and the practical's conducted.

***Oral Examination Based on Industrial Visit**

Visit to Biomaterial manufacturing industry to study the manufacturing of the Biomaterial from raw material to finished product. During the visit the students are required to study

iii) The manufacturing steps of different Biomaterials.
iv) How to identify of the different Biomaterials?
v) Subject teacher can arrange seminar on Biomaterials.

The student should submit the detailed report depending on the observations made. The concerned teachers of subject Biomaterial will co-ordinate the visit. Oral examination will be based on the visit report.

Term work:

Term work consists of minimum eight assignments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Assignments and Journal)	:10 marks
Test (at least one)	:10 marks
Attendance (Practical and Theory)	:05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Text Books:

- Biomaterial Science and Engineering: J.V. Park (Plenum Press- New York)
- Fundaments of Biomedical Engineering: G S. Sawhney (New Age International Publication)
- Biomaterial Science: An Introduction to Materials in Medicine, Rotner & Hoffmann

Reference Books:

- Encyclopedia of Medical Devises and Instrumentation: John G. Webster. Vol. I, II, III, IV (Marcel Dekkar Pub).
- Encyclopedia – Handbook of Biomaterials and Bioengineering: Part-A: Materials Vol I, II (Marcel Dekkar Pub) Part – B: Applications Vol. I, II.
- Design Engineering on Biomaterials for medical devices: David Hill, John Willey Publication
- Biological Performance of Materials, 2nd Edition – Jonathan Black, Marcel Dekker Inc. New York. Basel. Hong Kong.

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering	**Semester:** III	
Subject: Presentation and Communication Techniques			
Periods per Week (each 60 min)	Lecture	02	
	Practical	02	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory	---	---
	Practical and Oral	--	--
	Oral	---	--
	Term Work	---	50
	Total	--	50

	Contents	Hours
1.	**Communication in a business organization:** Internal and external communication, Types of meetings, strategies for conducting successful business meetings, documentation (notice, agenda, minutes, resolution) of meetings. Introduction to modern communication techniques. (e-mail, internet, video-conferencing, etc.) Legal and ethical issues in communication (Intellectual property rights: patents, TRIPS, Geographical indications).	05
2	**Advanced technical writing:** Report writing: Definition and importance of reports, qualities of reports, language and style in reports, types of reports, formats (letter, memo, project-repots). Methods of compiling data for preparing report. A computer-aided presentation of a technical project report based on survey-based or reference based topic. The topics are to be assigned to a group of 8-10 students. The written report should not exceed 20 printed pages. Technical paper-writing, Writing business proposals.	07
3	**Interpersonal skills:** Introduction to emotional intelligence, motivation, Negotiation and conflict resolution, Assertiveness, team-building, decision-making, time-management, persuasion	03

4	**Presentation skills:** Elements of an effective presentation, Structure of a presentation, Presentation tools, Audience analysis, Language: Articulation, Good pronunciation, Voice quality, Modulation, Accent and Intonation.	03
5	**Career skills:** Preparing resumes and cover letters. Types of Resumes, Interview techniques: Preparing for job interviews, facing an interview, verbal and non-verbal communication during interviews, observation sessions and role-play techniques to be used to demonstrate interview strategies (mock interviews).	03
6	**Group discussion:** Group discussions as part of selection process. Structure of a group discussion, Dynamics of group behavior, techniques for effective participation, Team work and use of body language.	03

Term work:

Part-I (25 Marks): Assignments;

Two assignments on communication topics
Three assignments on report-writing
Three assignments on interpersonal skills
Two assignments on career skills
At least one class test (written)
Distribution of term work marks will be as follows:

Assignments : 10 marks
Written test : 10 marks
Attendance (Theory and Practical) : 05 marks

Part-II (25 Marks): Presentation;

Distribution of term work marks will be as follows:

Project report presentation : 15 marks
Group discussion : 10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Text books:

1. Lesikar and Petit, *Report writing for business*, Tata McGraw Hill.
2. Raman and Sangeeta Sharma, *Technical communication*, Oxford University Press, New Delhi.

Reference Books:

1. Wallace & Masters, *Personal development for Life & work*, Thomson Lerning.
2. Heta Murphy, *Effective Business Communicatioh*, McGraw Hill.
3. Huckin & Olsen, *Technical writing and professional communication*, McGraw Hill.
4. Fred Luthans, Organizational behavior, McGraw Hill

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering	**Semester:** IV	
Subject: Electronic Circuit Analysis and Design-II			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	03	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	02	50
	Oral	---	---
	Term Work	---	25
	Total	05	175

Module	Content	Time
1.	**Feedback and Stability:** Introduction to Feedback, Basic Feedback Concepts, Ideal Close-Loop Gain, Gain Sensitivity Bandwidth Extension, Nose Sensitivity, Reduction of Non-Linear Distortion, Ideal Feedback Topologies, Series-Shunt, Shunt-Series, Series-Series, Shunt-Shunt Configurations, Voltage (Series-Shunt) Amplifiers, Current (Shunt-Series) Amplifiers, Trans-Conductance (Series-Series) Amplifiers, Trans-Resistance (Shunt-Shunt) Amplifiers, Loop Gain, Stability of Feedback Circuit, The Stability Problem, Bode Plots, One –Pole, Two-Pole and Three-Pole Amplifiers, Nyquist Stability Criterion, Phase and Gain Margins, Frequency Compensation Basic Theory, Closed Loop Frequency Response, Miller Compensation.	**8hrs**
2.	**Output Stage and Power Amplifiers:** Power Amplifier, Power Transistors-Power B.J.T'S Power MOSFETs, Heat Sinks, Design of Heat Sinks, Classes of Amplifiers, Class-A Operation, Class-B operation, Class AB Operation, Class C Operation, Class-A Power Amplifiers, Class-AB Push Pull Complementary Output Stages., Power amplifier designing	**6hrs**
3.	**Operational amplifiers:** Basics of operational amplifiers, open loop and closed loop response, Application of op-amps (Non-linear and linear applications): viz inverting and non inverting amplifiers, voltage follower, adder, substractor, differentiator and integrator, Comparators, clippers and clampers, Schmitt triggers, precision rectifiers, peak detectors, Log and Antilog amplifiers, gyrator, Current to voltage and voltage to current converters, Instrumentation and isolation amplifiers, transducer Bridge amplifiers.	**15hrs**
4.	**Sinusoidal oscillators using Op-amps:** Phase shift oscillators, Wein bridge oscillators, Tuned circuit oscillators, Colpitts oscillators and Hartley oscillators.	**6hrs**
5.	**Operational Amplifier Circuit Design:** General op-amp circuit design, detailed circuit description and working of 741 Op-amp.	**5hrs**

6.	**Voltage references and voltage regulators:** Basics and types of voltage regulators. Performance specifications, voltage references voltage reference applications, linear regulators and their applications, IC 78XX, LM317, IC 723, switching regulators and monolithic switching regulators. Switching mode power supply, DC to DC convertors.	**6hrs**

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Practical & Oral Examination:

Practical examination will be based on one experiment performed from the list of experiments given in the syllabus and the oral will be based on entire subject.

Term work:

Term work consists of minimum eight experiments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Experiments and Journal) :10 marks
Test (at least one) :10 marks
Attendance (Practical and Theory) :05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

List of Experiments:

1. Fequency response of CE Amplifiers
2. Frequency Response of CS Amplifiers
3. Differential Amplifier
4. Negative Feedback.
5. Op-Amp as integrator.
6. Op-Amp as differentiator
7. RC Phase shift oscillator using opamps
8. Wein Bridge Oscillator using opamps
9. Opamp as adder and substractor
10. PSPICE (or similar software) simulations of various circuits

Text Books:

1. Electronic Circuit Analysis and Design- Donald A Neamen,
2. Electronic Devices and circuits – R Bolystead.
3. Op-Amps and linear integrated circuits – R. Gayakwad

Reference Books:

4. Integrated Electronics –Millman & Halkias
5. Opamps and linear integrated circuits, Theory and Applications- James Fiore

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering	**Semester:** IV	
Subject: Transducers in Biomedical Instrumentation			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	---
	Oral	---	25
	Term Work	---	25
	Total	03	150

Module	Contents	Time
1.	**Generalized Instrumentation System, General Properties of Input Transducer:**	6 hrs
	Static Characteristics: Accuracy, Precision, Resolution, Reproducibility, Sensitivity, Drift, Hysteresis, Linearity, Input Impedance and Output Impedance.	
	Dynamic Characteristics: First Order and Second Order Characteristics, Time Delay, Error Free Instrument, Transfer Functions. Design Criteria, Generalized Instrument Specifications.	
2.	**Displacement and Pressure Measurement: (with applications)** Resistive: Potentiometers, Strain Gauges and Bridge Circuits. Inductive: Variable Inductance and LVDT. Capacitive type, Piezoelectric Transducers. Types of Diaphragms, Bellows, Bourdon Tubes.	6 hrs
3.	**Temperature Measurement:** Thermistor, Thermocouple, Resistive Temperature Detector, IC based Temperature Measurement	6 hrs

4.	**Electro chemistry and Biopotential Electrodes:** Electrodes Electrolyte Interface, Half-Cell Potential, Polarization, Polarizable and Non Polarizable, Electrodes, Calomel Electrode, Electrode Circuit Model, Electrode Skin-Interface and Motion Artifact. Body Surface Electrodes. Internal Electrodes: Needle and Wire Electrodes (Different Types). Microelectrodes: Metal, Supported Metal Micropipette (Metal Filled Glass And Glass Micropipette Electrodes)	**8 hrs**
5.	**Chemical Sensors:** Blood gas and Acid- Base Physiology Potentiometric Sensors, Ion Selective Electrodes, ISFETS. Amperometric Sensors, Clark Electrode with examples- pH, pO2, pCO2 Electrodes, Transcutaneous Arterial Oxygen Tension, Carbon Dioxide measurements: capnostat, electrolyte sensors, O2 cell.	**6 hrs**
6.	**Biosensor:** Classifications: Biological phenomenon, transduction phenomenon i.e. Enzyme sensor and Electrode based: affinity sensors (Catalytic Biosensors), Two examples of each biosensors and Immunosensors.	**8 hrs**
7.	**Fiber optic sensor:** Design Principles in fabrication of fiber optic sensors - Temperature, Chemical, Pressure.	**4 hrs**
8.	**Radiation Sensors and Applications.**	**2 hrs**

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Practical & Oral Examination:

Oral exam will be based on entire subject.

Term work:

Term work consists of minimum eight assignments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Assignments and Journal) :10 marks
Test (at least one) :10 marks
Attendance (Practical and Theory) :05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

List of Experiments

1. To study characteristics of thermistor.
2. To study thermistor linearization.
3. To study dynamic behavior of thermometer system.
4. To study characteristics of light dependent resister.
5. To study working & principle of LVDT.
6. To study working & principle of thermocouple.
7. To study working & principle of Capacitive Transducer
8. To study working & principle of Inductive Transducer
9. To study Polarizable characteristics of electrodes.
10. To study Non polarizable characteristics of electrodes.
11. To study electrode skin interface. (Contact Impedance)

Text Books:

- Medical Instrumentation-Application and Design by John G. Webster.
- Transducers for Biomedical Measurements: Principles and Applications, Richard S.C. Cobbold, John Wiley & Sons, 1974
- Instrument Transducer – An Intro to their performance and design, Hermann K P. Neubert
- Biomedical sensors – fundamentals and application by Harry N, Norton

References:

- Principles of applied Biomedical Instrumentation by La Geddes and L.E. Baker
- Biomedical instrumentation and measurement by Leslie Cromwell, Fred. J. Weibell and Pfeiffer.
- Principles of Biomedical Instrumentation and Measurement, Richard Aston, Merril Publishing Co., Columbus, 1990.
- Measurement Systems, Application and Design, Ernest O. Doeblin, McGraw-Hill, 1985
- Handbook of Modern Sensors – Physics, Design and Application, Jacob Fraden, AIP press.

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering	**Semester:** IV	
Subject: Electronic Instruments			
Periods per Week (Each 60 min.)	Lecture	03	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	---
	Oral	---	---
	Term Work	---	25
	Total	03	125

Module	Content	Time
1.	**Fundamental Concepts of Measurement & Performance Characteristics of an Instrumentation System:** System Configuration-Block Diagram of a generalized measurement system, Zero Order System, First Order System- Response of a system to Step, Ramp, Impulse Inputs & Frequency Response. Second Order System- Response of a system to Step, Ramp & Frequency Response. Dead Time Element, Dynamic Response of a Measurement system.	**4 hrs**
2.	**Electronic meter:** Principle of Operation, ammeter, ohmmeter, voltmeter, Advantages over Conventional type Analog Voltmeter, Factors involved in selection of Voltmeter, FET Voltmeter, Peak Responding, Average Responding, and True RMS responding voltmeter, Multimeter	**6 hrs**
3.	**Digital Voltmeter:** Methods of Analog to Digital and Digital to Analog Conversion. Principle of working of Ramp Type, Dual Slope Type, Successive Approximation Type Digital Voltmeter. Resolution & Sensitivity of digital voltmeter	**4 hrs**
4.	**Frequency Meter And Phase meter:** Analog and Digital frequency meter. Analog and Digital Phase meter	**3 hrs**
5.	**Oscilloscopes:** Block Diagram study of C.R.O. Description of Panel Layout & Implementation of controls, Requirements of Time base, Delayed Time Base, Lissajous Patterns, Intensity modulation, Velocity modulation, use of these in phase & frequency measurements, Dual trace. Double beam, Sampling, Storage, Digital readout oscilloscope, Use of CRO in tracing Diode & transistor characteristics.	**6 hrs**
6.	**Signal Generator:** Requirement of a good laboratory type Signal Generator, A.F. Signal Generator, Function Generator.	**4 hrs**

7.	**Data Acquisition:** Data Acquisition System- Generalized DAS, Multi channel DAS, PC based DAS.	**3 hrs**
8.	**Writing System:** Ink jet, Potentiometric, UV, Thermal, Light gate, Magnetic, Laser optics and Instrumentation tape recorders.	**3 hrs**
9.	**Medical Display System:** Oscilloscope for biomedical measurements, Single & multichannel Display, Non-fade Display System, LCD Display System & Touch Screen Display System	**3 hrs**

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Term work:

Term work consists of minimum eight assignments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Assignments and Journal) :10 marks
Test (at least one) :10 marks
Attendance (Practical and Theory) :05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Suggested List Of Experiments:

1. Study of Peak Responding Voltmeter
2. Study of Average Responding Voltmeter.
3. Study of FET voltmeter.
4. Study of Analog ammeter.
5. Study of Frequency Meter: Analog or Digital
6. Study of Phase meter
7. Study of Diode & Transistor characteristics using CRO
8. Study of Lissajous Patterns using CRO
9. Study of Function Generator.
10. Data Acquisition System

Text Books:

1. Cooper W. D. & Helfrick A.D.- Electronic Instrumentation & Measurement Techniques
2. Kalasi H.S.- Electronic Instrumentation
3. Electronic Instrumentation- Carr and Brown, Pearson Publication

Reference Books:

4. A.K. Sawhney- Electrical & Electronic Measurement & Instrumentation.
5. Rangan, Sharma and Mani- Insrtumentation devices and system

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering	**Semester:** IV	
Subject: Engineering Mathematics-IV			
Periods per Week (60 min. each)	Lecture	05	
	Practical	---	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	05	100
	Practical and Oral	---	---
	Oral	---	---
	Term Work	---	---
	Total	05	100

Module	Contents	Hours
1	**Vector Analysis:** Scalar and vector point functions, curl, gradient and divergence, conservative, irrotational and Solenoidal fields. **a) Line Integral**, Greens thoerem for plane regions and properties of line integral, Stoke's theorem, Gauss's Divergence theorem (without proof) related identities and deductions.	18
2	**Matrices** **a) Types of matrices**, adjoint of a matrix inverse of a matrix, rank of a matrix, linear dependence and independence of rows and columns of a matrix over a real field, reduction to normal form and partitioning of a matrix. **b) Systems of homogeneous** and non-homogeneous equations, their consistency and solutions. **c) Brief revision** of vectors over real fields, inner product, norm, linear independence and orthogonality of vectors. **d) Characteristic Polynomial**, characteristic equation, characteristic roots, and characteristic vectors of square matrix, properties of characteristic roots and vectors of different types of matrices such as orthogonal matrix, Hermitian matrix, Skew-Hermitian matrix, Diagonal matrix, Cayley-Hamilton theorem (without proof), functions of square matrix, minimal polynomial and derogatory matrix.	25

	c) Quadratic forms, Congruent and orthogonal reduction of quadratic form, rank, index, signature and class value of quadratic form.	
3.	**Probability and Statistics :** Concept of probability, conditional probability. Baye's theorem (without proof). **a) Random variable** Probability distribution for discrete and continuous random variables. Density function and distribution function. Expected value, variance, moments, moment generating function, binomial, Poission, normal distributions for detailed study with proof, **b) Curve fitting** Correlation, Karl Pearson coefficient & Spearman's rank correlation coefficient (without proof), regression, lines of regression.	17

Theory Examination:

1. Question paper will consist of total 7 questions carrying 20 marks each.
2. Only 5 questions need to be attempted.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. Wartikar P.N. / Wartikar J. N., *Textbook of Applied Mathematics*, Pune Vidyarthi Griha Prakashan, 1981.
2. Kreyszig Erwin, Advanced Engineering Mathematics, 8th ed., Wiley Student Edition, New Delhi, 2006.

Reference Books:

1. Shastri S.S., *Engineering Mathematics*, Prentice Hall.
2. Shantinarayan, *Matrices*, S. Chand & co.
3. Gupta Kapoor, *Mathematical Statistics*.
4. Glyn James, Advanced Modern Engineering Mathematics, 3rd ed., Pearson Education Ltd., 2004.
5. Potter Merle C., Goldberg J. L., Aboufadel Edward F., 3rd ed., Oxford University Press, New Delhi, 2005.

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering	**Semester:** IV	
Subject: Biomechanics, Prosthetic & Orthotics			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	---
	Oral	---	25
	Term Work	---	25
	Total	03	150

BIOMECHANICS:		Time
1.	**Force system:** Classification of force system. Equilibrium of force system.	**2 hrs**
2.	**General principles of Biomechanics:** Analysis of biological sub system from the biomechanical view and rise modeling. Instrumentation.	**3 hrs**
3.	**Tissue Biomechanics:** Direct shear, bending and torque actions and the corresponding stresses and strains in biological tissues. Stress relaxation and creep, stability and instability. Biomechanical characterization of bone and the soft connective (skin, tendon, ligaments, etc.) covering structure function, and physiological factors.	**7 hrs**
4.	**Movement Biomechanics:** Force analyses in the joints, Gait Analysis, body and limb mass and motion characteristic actions. Forces transmitted by joints. Joint forces results in the normal and disabled human body. Normal and fast gait on the level. Strain and ramp ascent and descent. Joint replacements.	**8 hrs**
5.	**Joint analysis:** Instrumentation for gait analysis: Measurement devices-footswitches, instrumented walkway, Motion analysis- interrupted light photography, film/video, VICON, Selspot, Goniometers.	**6 hrs**
PROSTHETICS AND ORTHOTICS:		
6.	**Principles in designing orthoses and prostheses:** Principles of three points pressure, total contact, partial weight relieving.	**4hrs**
7.	**Positions of anatomical axis:** Positioning and corresponding movements of the body part international conventions with respect to above.	**3hrs**
8.	Purpose for providing prostheses and orthoses variation aspects regarding diagnosis, prognosis, stature and socio-economic conditions etc.	**3hrs**
9.	**Classification in Prosthetics and Orthotics:** Lower and Upper Extremity orthoses and prostheses, Spinal orthoses. Recent development in prosthesis and orthotics. Transducers in Prosthetics & Orthotics.	**10hrs**

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Practical & Oral Examination:

Oral exam will be based on entire subject.

Term work:

Term work consists of minimum eight assignments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Assignments and Journal) :10 marks
Test (at least one) :10 marks
Attendance (Practical and Theory) :05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

List of Experiments:

1. To study the coplanar force system.
2. To study different types of joints in human body and joint movements
3. To simulate elbow joint using bell crank lever.
4. To study the human gait cycle and instruments used for gait analysis.
5. To study the Stress – Strain relation of Mild steel.
6. Fabrication of PTB/socket.
7. Fabrication of PSI.
8. Fabrication of Cervical collar.
9. Study of different types of alignment techniques
10. Study of below elbow prosthetic device.
11. Study of Splints.

Text Books:

- Basic Biomechanics- Susan J. Hall, MC Graw Hill.
- Human Limbs and their substitutes – Atlas, C. V. Mosby
- American Atlas of Orthopedics: Prosthetics, C. V. Mosby.
- American Atlas of Orthopedics: Orthotics, C. V. Mosby

Reference Books:

- Biomechanics - Prof Ghista (Private Publication UAE)
- Biomechanics – Ey White and Puyator (Private Publication UAE)

University of Mumbai			
Class: S.E.	**Branch:** Biomedical Engineering	**Semester:** IV	
Subject: Logic Circuits			
Periods per Week (Each 60 min.)	Lecture	03	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical	02	25
	Oral	---	---
	Term Work	---	25
	Total	05	150

Module	Content	Time
1.	**Introduction:** Number system, Binary, Octal, Hexadecimal and other. Conversion from One system to another, Binary, BCD and Hexadecimal.	2hrs
2.	**Binary Codes**: Weighted Reflective, Sequential, Gray, Error detecting codes, Odd, Even parity, Hamming Codes, Alphanumeric, Morse, Teletypewriter ASCII, EBCDIC codes, Converting Binary to Gray & Gray to Binary and XS3.	2hrs
3.	**Boolean Algebra Logic Gates**: AND, OR, NOT, XOR, XNOR, operation NAND, NOR used of the universal gate for Performing different operation. Laws of Boolean algebra. De- Morgan's theorems. Relating a Truth Table to a Boolean Expression. Multi level circuits.	4hrs
4.	**Combinational Circuits**: K-MAPS and their use in specifying Boolean Expressions, Minterm, Maxterm SOP and POS Implementation. Implementation a logic function using universal gates. Variable entered maps For five and six variable functions Quine McClusky tabular techniques.	6 hrs
5.	**Combination Logic Circuit Design:** Designing code converter circuits e.g. Binary to Gray, BCD to Seven Segments, Parity Generator. Binary Arithmetic circuits: Adders, Subtractors (Half and full) BCD adder-Subtractor, carry Lookaheard adder, Serial adder, Multiplier, Magnitude Comparators, Arithmetic Logic units.	6 hrs
6.	**Use of Multiplexers in Logic Design:** Multiplexer (ULM) Shannon`s theorem. ULM trees. De- Multiplexers, Designing using ROMs and ULMs. Hazards in combinational circuits.	4 hrs
7	**Sequential Logic Circuits**: Comparison of Combinational & Sequential Circuits, Multi-vibrators (Astable, Monostable And Bistable) Flip-Flops. SR, T, D, JK, Master Slave JK, Converting one Flip-Flop to another, Use	5 hrs

	of Denounce switch. Counter Modulus of a counter, Ripple counter, Up/Down Counter, Designing sequential counters using gate IC and counter IC by drawing state transition Diagram & state transition table. Ring counter Johnson counter, twisted ring counter, Pseudo Random number generator, Unused states and locked conditions.	
8.	**Registers:** Serial input serial output, serial input parallel output. Left Right shift register, Use of register ICs for sequence generator and counter.	3 hrs
9	**Memories:** RAM, ROM the basic cell IC bipolar, CMOS, RAM dynamic RAM cell. Magnetic core NVRAM, bubble memory, CCD, PAL, PLA.	4 hrs
10.	**Logic Families:** RTL, DTL, TTL, schotkey clamped TTL, Tristate gate ECL, IIL, MOS device CMOS Comparison of logic families, interfacing different families. TTL with CMOS, NMOS, TTL, ECL, & TTL, IIL, & TTL.	2 hrs

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Practical & Oral Examination:

Practical exam will be based on entire list of experiments performed.

Term work:

Term work consists of minimum eight assignments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Assignments and Journal) :10 marks
Test (at least one) :10 marks
Attendance (Practical and Theory) :05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

List of Experiments:

1. To study the various logic gates and verify their truth table.
2. Realization of a given logic gate using universal gates (NOT, AND, OR):
   i) NAND gate.
   ii) NOR gate
3. Conversion from binary to gray code and gray to binary code.
4. Realization of a given function:
   i) Using all types of gate ICs
   ii) Using NAND gates only
   iii) Using NOR gates only
5. To study NAND Gate IC characteristics

6. To study J-K Flip-Flop using IC 7476.
7. To design & implement mod N synchronous up/down counter.
8. To design a two-bit comparator using gates.
9. To design a ring counter using D Flip-Flop.
10. Design of full adder using gates and decoder.
11. Realization of a function using Multiplexer.

Text Books:

(1) R.P.Jain, "Modern Digital Electronics," Tata McGraw Hill, Latest reprint
(2) M Morris Mono, "Digital Design," Prentice Hall International- Latest reprint.
(3) Malvino & Leach, "Digital Principal and Applications", Tata McGraw Hill, 1991.

Reference Books:

(4) Malvino, "Digital Electronics", Tata McGraw Hill, 1997.
(5) James Bignell & Robert Donovan, "Digital Electronics", Delmar, Thomas Learning, 2001.
(6) Alan b. Marcovitz, "Introduction to Logic Design ", McGraw Hill International 2002.