University of Mumbai			
Class: S.E.	**Branch:** Instrumentation	**Semester:** IV	
Subject: Analytical Instrumentation (Abbreviated as AI)			
Periods per Week (60 min. each)	Lecture	04	
	Practical	02	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory	3	100
	Practical/Oral	---	---
	Oral	---	25
	Term Work	--	25
	Total	3	150

Module	Contents	Hours
1	**Overview & Introduction** Introduction to the analytical processes & Electromagnetic Spectrum.	02
2	**Basics of Spectroscopy** Laws of photometry- Light and its interaction with matter Introduction to Spectroscopic Methods Components of Optical Systems (viz. Radiation sources & detectors, filters & monochromators, signal processors & readouts.)	05
3	**Atomic Spectroscopy** Atomic absorption spectroscopy Atomic Emission Spectroscopy	05
4	**Molecular Spectroscopy** ***Electronic Transitions*** Introduction to UV-Visible molecular spectroscopy Applications of UV-Visible spectroscopy Fluorescence, phosphorescence and chemiluminescence's Raman scattering & Raman spectrophotometer ***Nuclear Transitions*** Nuclear Magnetic Resonance (NMR) ***Vibrational Excitation*** IR absorption spectroscopy Applications of Infrared Spectrometry	14
5	**Additional Instrumental Methods for Organic Structural Analysis** Mass Spectrometry	03
6	**Separation Science** Fundamentals of chromatographic separations Gas chromatography- Gas chromatograph & its components High performance liquid chromatography	06

7	**Industrial Gas Analyzers** Oxygen, Carbon dioxide, and NOx analyzers, Online Gas Analyzers. Nephalometer, Densitometer,	05
8	**Radio Chemical Instrumentation** Radio Chemical methods, radiation detectors- ionization chamber, Giger-Muller counter, proportional counter, scintillation counter, semiconductor detectors, pulse height analyzer, X-ray spectrometry, X-ray spectrum, X-ray spectrometry, X-ray diffractometers, X-ray absorption meter.	05

Theory Examination:

1. Question paper will consist of total 7 questions, of 20 marks each.
2. Only 5 questions need to be attempted.
3. Q.1 will be compulsory covering entire syllabus.
4. Remaining questions will be of mixed 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 marks 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 Laboratory Experiments:

1. Photoelectric Colorimeter
2. Nephalo-turbidity meter
3. Densitometer
4. Refractometer
5. Single beam Spectrometer for UV/VIS range.
6. Double beam Spectrometer for UV/VIS range.
7. Gas Chromatograph
8. Atomic absorption spectrometer
9. Balance Cell Calorimeter
10. Spectroflourimeter

Books Recommended:

1. Skoog, Holler, Nieman, *Thomson Principles of Instrumental Analysis*, Books-cole publications, 5th ed..
2. Willard, Merritt, Dean, Settle, *Instrumental Methods of Analysis*, CBS Publishers & Distributors, New Delhi, 7th ed..
3. Khandpur R. S., *Handbook of Analytical Instruments*, Tata McGraw–Hill Publications, 3rd ed..
4. Ewing Galen W., *Instrumental Methods of Chemical Analysis*, McGraw-Hill Book Company, 5th ed..
5. Braun Robert D., *Introduction to Instrumental Analysis*, McGraw-Hill Book Company.
6. Sherman R.E., *Analytical Instrumentation*, ISA Publication.

University of Mumbai			
Class: S.E.	**Branch:** Instrumentation	**Semester:** IV	
Subject: Application Software Practices-I			
Periods per Week (60 min.each)	Lecture	---	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	---	---
	Practical and Oral	---	25
	Oral	---	---
	Term Work	---	50
	Total	---	75

Module	Contents	Hours
1	Study of Visual Basic/VB6.0 as a tool for developing real time HMI (Human Machine Interface) for instrumentation applications. 1) Configuring and using Hyper Terminal. 2) Developing a Login form with password. 3) Developing a Dynamic Linked Library (DLL) for parallel port access using VC++ 6.0. 4) Using parallel port DLL for On-Off system. 5) Using MSCOMM.OCX for Serial communication. 6) Developing a real-time database using serial port and parallel port programs. 7) Developing different types of graphs for trend display, historical display. 8) Developing an ActiveX component for a) Tank System. b) Control Valve c) Pipe d) Any other system/component	

Practical/Oral Examination:

Practical 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.

Books Recommended:

1. Soma Dasgupta, “Visual Basic Projects”, BPB Publications.
2. Christopher, “Visual Basic”.

University of Mumbai			
Class: S.E.	**Branch:** Instrumentation Engineering	**Semester:** IV	
Subject: Electrical Technology & Instruments (abbreviated as ETI)			
Periods per Week (60 min. each)	Lecture	05	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	---
	Oral	---	25
	Term Work	---	25
	Total	03	150

Module	Contents	Hours
1	**D.C. Machines** Constructional details, types (shunt, series & compound), generator action. emf equation, motoring action, significance of back emf, torque and speed equations, torque-armature current, speed-armature current and torque-speed characteristics of different types of motors, speed control, starter, applications. General specifications of D.C. Machine & their significance.	10
2	**Induction Motor** Rotating magnetic field, construction and principle of operation, slip, rotor frequency, torque-slip characteristic, relationship between slip and rotor copper loss, speed control, starting methods, motor ratings, General specifications of induction motor & their significance.	08
3	**Fractional Horse Power Motors** Construction and principle of operation of single phase induction motor, types of single phase induction motor (resistance split phase, capacitance split phase) and their applications. Shaded pole induction motor.	06
4	**Analog Meters** Construction & working principle of: ammeters, voltmeters, ohmmeters, power factor meter, energy meter, Q meters, D'Arsonaval galvanometers-PMMC & PMMI instruments. Shunts & multipliers-Measurement of phase & frequency, analog multimeters.	08
5	**Measurement of R, L, C** Measurement of medium, low and high resistance, megger.	10

	A.C. and D.C. potentiometers: A.C. Bridges, measurement of self and mutual inductances. Measurement of capacitance. Derivations and numericals related to all bridges.	
6	**Electronic Measuring Instruments** Electronic voltmeters, DVM and DMM, automation in voltmeters (ranging, zeroing, polarity indication).	05
7	**Input/Output devices** **a) Digital I/O devices**: punched card, paper tape, bar codes, line printer, ink-jet printer, digital tape recording, floppy disk. **b) Display devices**: LED, LCD, seven segment display driver, alpha numeric displays and recorders.	08
8	**Cathode Ray Oscilloscope** CRT. Types of CRO: Single beam, double beam, digital storage (DSO) and sampling. Brief comparison between CROs. Application in instrumentation and measurement.	05

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.

Oral Examination:

The oral examination will be based on the 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 Laboratory Experiments:

1. Speed control of DC shunt motor by armature voltage and flux control method.
2. Load test on DC shunt motor.
3. Load test on DC series motor.
4. Speed control of 3 phase slip ring induction motor by adding the external resistance in the rotor circuit.
5. Starting of induction motor by D.O.L., autotransformer, star/delta and rotor resistance starter.
6. Study of different types of fractional horse power motors.

7. Study of D.C. machine starter.
8. Study of Multi-meter& CRO: front panel controls & specifications.
9. Introduction, identification & testing of various components like resistors, capacitors, inductor, transistor, diode, various ICs.
10. Measurement of medium value resistance using bridge.
11. Measurement of small value resistance using bridge.
12. Measurement of Inductance by using bridge.
13. Study of D.C. Potentiometer.
14. Study of Megger.
15. Measurement of Capacitance using A.C. Bridges.
16. Measurement of phase & frequency using frequency meters & Synchroscope.
17. Applications of CRO (Measurements of phase & frequency & component testing).
18. Study of DVM.
19. Study of Recorders.
20. Study of Display Devices.
21. Study of spectrum/wave analyzer.

Text Books:

1. Sawhney A. K., *Electrical & Electronics Measurement & Instrumentation,* Dhanpat Rai & Co.Pvt Ltd.
2. Nagrath I. J., Kothari D. P., *Electrical Machines*, 2nd ed., Tata McGraw Hill, New Delhi 1997.

Reference Books:

1. Guru Bhag S., Hiziroglu Huseyin R., Electric Machinery & Transformers, 3rd ed., Oxford University Press, New Delhi 2007.
2. Say M. G., *The performance and Design of Alternating Current Machines*, 3rd ed., CBS Publisher and Distributor, Delhi, 1983.
3. Taylor Openshaw, *FHP Motors*, Addison Wesley 1976.
4. Kalsi H. S., *Electronics Instrumentation*, Tata McGraw Hill, New Delhi 1997.
5. Khandpur R. S., *Preventive Maintenance & Troubleshooting*, Tata McGraw Hill, New Delhi 1997.
6. Cooper W.D., Helfrick A.D., *Electronic Instrumentation and Measurement Techniques*, Prentice Hall of India Limited, New Delhi.
7. Rangan C. S., Sharma G. R., Mani V. S., *Instrumentation Devices & Systems*, 2nd ed., Tata McGraw Hill, New Delhi 1997.
8. Rathore-Narosa T. S., *Digital Measurement Techniques*.
9. Oliver & Cage, *Modern Electronic Measurements & Instrumentation,* MGH.
10. Bouwens A. J., *Digital Instrumentation,* MGH.
11. Technical Manuals of DSO: APLAB, Scientific, HP etc.
12. Technical Manuals for Virtual CRO.

University of Mumbai			
Class: S.E.	**Branch:** Instrumentation	**Semester:** IV	
Subject: Feedback Control System (Abbreviated as FCS)			
Periods per Week (60 min.each)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	02	50
	Oral	---	---
	Term Work	---	25
	Total	05	175

Module	Contents	Hours
1	**Introduction** Definition of control system and related terms, open loop and closed loop system, examples. Development of automatic control systems, classification of control system, examples.	5
2	**Mathematical Models of Physical Systems** Definition of physical systems, principle of superposition and homogeneity, linear/non-linear, time variant/time invariant systems. Types of dynamic model, linear elements of electrical and mechanical systems, differential equations of physical systems-mechanical systems, electrical systems, thermal systems, fluid systems, pneumatic systems. Analogous systems.	10
3	**Transfer Function and Feedback Characteristics** Definition of transfer function, sinusoidal transfer function, transfer functions of physical systems, block diagram algebra, reduction rules, signal flow graphs-definition, construction, properties, and Mason's gain formula ,sensitivity of closed loop and open loop system, effect of feedback, effect of disturbances signals, regenerative feedback with examples	15
4	**Servomechanism** Definition of servomechanism, block diagram of servo systems- AC servo system , DC servo system, servo components- potentiometer, synchros, AC servomotor, DC servomotor, AC/DC Tachometer, servo amplifiers.	5
5	**Time Response Analysis** Standard test signals, pulse and impulse function, step function, ramp function, parabolic function, sinusoidal function, dynamic response, time response of first order	10

	system, time response of second order system, specifications, steady - state error, system types and error constants, effect of adding zeros and poles to a system, design specifications of second order system- desired close loop pole location and the dominant condition.	
6	**Stability Analysis and Root Locus** Concept of stability, definitions, bounded input-bounded output stability, relative stability, necessary and sufficient conditions for stability, Routh stability criterion, relative stability analysis, root locus technique, applications, concept, construction of root loci, root loci of different systems.	10
7	**Frequency Response and Stability Analysis** Correlation between time and frequency response, polar plots, Bode plots, log magnitude versus phase plots, Nyquist stability criterion, frequency response specifications, stability analysis using-bode, polar, log-magnitude versus phase plots, definitions and significance of gain margin and phase margin, sensitivity analysis in frequency domain	10

Theory Examination:

1. Question paper will consist of total 7 questions, of 20 marks each.
2. Only 5 questions need to be attempted.
3. Q.1 will be compulsory covering entire syllabus.
4. Remaining questions will be of mixed 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 Laboratory Experiments:

1. To study the caracteristics of:
    a. Synchros Transmitter and Receiver.
    b. Synchro as an error detector.
2. To study DC position control system.
3. To find characteristics of AC servo motor.
4. To study the operation of stepper motor.
5. To study time response of Type 0, 1, 2 systems.
6. To study the frequency response of First and Second order systems.
7. To study the effect of damping factor on the performance of second order system.
8. To study the effect of time constant on performance of 1st order system.

Note: For Experiment No. 5 to 8 the hardware results must be verified using simulation softwares like MATH CAD/MATLAB/SCILAB/OCTAVE or equivalent.

Books Recommended:

1. Nagrath I. G., Gopal M., *Control System Engineering*, New Age International (P) Ltd. Publishers 2000.
2. Gopal M., *Control Systems Principles and Design*, Tata McGra-Hill Publishing Co. Ltd. New delhi, 1998.
3. Nise Norman S., *Conrol Systems Engineering,* 3rd ed., John Wiley and Sons, Inc. - 2000.
4. Lewis Paul H., Chang Yang, *Basic COntrol Systems Engineering*, Prentice Hall International, Inc. 1997.
5. Kuo Benjamin C., *Automatic Control Systems,* 6th ed., Prentice Hall of India, New Delhi - 1993.

University of Mumbai			
Class: S.E.	**Branch: Instrumentation**	**Semester: IV**	
Subject: Transducer-II			
Periods per Week (60 min. each)	Lecture	04	
	Practical	02	
	Tutorial	-	
		Hours	Marks
Evaluation System	Theory	3	100
	Practical/Oral	2	50
	Oral	---	25*
	Term Work	---	25
	Total	5	200

***Oral examination will be based on the object-oriented Industrial visit report.

Module	Contents	Hours
1	**Flow Measurement** **Introduction to fluid flow**: properties of fluid, types of fluid, dimensionless numbers, types of fluid flow, fluid pressure measurement using manometer (U tube-types, well type, inclined type, micro-manometer), continuity equation, Bernoulli's equation, hydrostatic law, Pascal's law, flow through pipes- major & minor losses, flow measurement through open channel-weirs & notches. Materials used for flow sensors, performance of materials, corrosion resistors, erosion, effect of vapour pressure, cavitation & flashing. **Head type**: orifice, venturi, nozzle, pitot tube, characteristics of head type flow meters. **Variable Area type:** Rotameter and its type. **Other flow meters**: Turbine, electromagnetic, ultrasonic, positive displacement, anemometers, mass flow meters, solid flow measurements.	20
2	**Strain Measurement** Introduction, types of strain gauge, gauge factor calculation, materials for strain gauge, resistance strain gauge bridges, temperature compensation and applications of strain gauges**.**	06
3	**Pressure Measurement** Pressure scales, units & relations, classification, elastic elements- bourdon tube, diaphragm, bellows. Calibration using dead weight tester. **Elastic materials**: Properties and selection of elastic materials for elastic transducers like diaphragm, bourdon tube, bellows, Piezo-electric and magnetostrictive materials. **Electrical**: Capacitive, piezo-electric, variable reluctance. LVDT, strain gauge. **High Pressure measurement**: Bulk modulus cell, Bridgeman type,capsule. **Differential pressure measurement**: Force balance, motion balance, DP Cell, semiconductor strain gauges.	10

4	**Vacuum Measurement** Units & relations, McLeod gauge, Pirani gauge, thermocouple gauge, hot cathode ionization gauge, Knudsen gauge. Calibration using dead weight tester.	04
5	**Electro-chemical Sensors** Terminology, equations, units. PH measurement-electrodes, measuring circuits, maintenance, temperature compensation, calibration. Conductivity measurement- probes and measuring circuits. Viscosity measurement: types. ORP Measurement.	06
6	**Force, Torque and Power Measurement** **Force measurement**: strain gauge, LVDT, piezoelectric. **Torque**: Torsion bar, strain gauge. **Power**: Dynamometer, instantaneous power measurement, alternator power measurement.	08
7	**Miscellaneous Transducers** Position, speed, velocity, acceleration, vibration, sound, humidity, and moisture measurement.	06

Theory Examination:

1. Question paper will consist of total 7 questions, of 20 marks each.
2. Only 5 questions need to be attempted.
3. Q.1 will be compulsory covering entire syllabus.
4. Remaining questions will be of mixed 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, industrial visit report 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.

Oral Examination Based on object–oriented Industrial Visit

Visit to a process industry & calibration institute to study transducer specification & calibration procedures. The student should submit the detailed report containing the list of seen transducers with their specifications & calibration procedures.

The transducer specification should be studied with respect to following points

i) Interpreting manufacturer specification sheets.
ii) Transducer type
iii) Operating principle
iv) Accuracy
v) Linearity
vi) Hysteresis
vii) Environmental operating limits

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

List of Laboratory Experiments:

1. Strain gauge characteristics and weight measurement.
2. Measurement of pressure using bellows, diaphragm, bourdon tube.
3. Test & calibration of pressure gauges using dead weight tester.
4. Measurement of flow using orifice/venturi tube/pitot tube.
5. Measurement of flow using rotameter.
6. Study and characterization of PH meter.
7. Study and characterization of conducticity meter.
8. Humidity measurement.
9. Viscosity measurement.

Books Recommended:

1. Doebin E.D., *Measurement system,* 4th ed..
2. Liptak B.G., *Instrument engineer's handbook- Process measurement and analysis*.
3. Douglas M. Considine, *Process Instruments & controls Handbook*, Mc Graw Hill.
4. Sawney A.K., *Electrical and Electronic Measurement and Instrumentation*, Dhanpatrai And Co.
5. Curtis Johnson, *Process Control Instrumentation Technology*, 5th ed..
6. Rangan, Mani, Sarma, *Instrumentation Systems and Devices*, 2nd ed., Tata Mc Graw Hill.
7. Nakra B.C., Cahudhary K.K., *Instrumentation Measurement and Analysis*, Tata Mc Graw Hill.
8. Andrew Williams, *Applied Instrumentation in process industry*, vol-I, Gulf publishing company.
9. Bansal R.K., *Fluid Mechanics & Hydraulic Machines*, Laxmi publications.
10. David W. Spitzer, *Industrial Flow Measurement*, ISA Publication.

University of Mumbai			
Class: S.E.	**Branch:** Instrumentation	**Semester:** IV	
Subject: Engineering Mathematics-IV (Abbreviated as EM-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. **Line Integral**, Greens Theorem for plane regions and properties of line integral, Stoke's theorem, Gauss's Divergence theorem (without proof) related identities and deductions.	22
2	**Matrices :** **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. **Systems of homogeneous** and non-homogeneous equations, their consistency and solutions. **Brief revision** of vectors over real fields, inner product, norm, linear independence and orthogonality of vectors. **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. **Quadratic forms**, Congruent and orthogonal reduction of quadratic form, rank, index, signature and class value of quadratic form.	30

3.	**Probability and Statistics :** Concept of probability, conditional probability. Baye's theorem (without proof). **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, **Curve fitting** Correlation, Karl Pearson coefficient & Spearman's rank correlation coefficient (without proof), regression, lines of regression.	23

Theory Examination:

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

Books Recommended:

1. Wartikar P.N. / Wartikar J. N., *Textbook of Applied Mathematics*, Pune Vidyarthi Griha Prakashan, 1981.
2. Shastri S.S., *Engineering Mathematics,* Prentice Hall.
3. Shantinarayan, *Matrices*, S. Chand & co.
4. Gupta Kapoor, *Mathematical Statistics*.