University of Mumbai

No. AAMS_UGS/ICC/2022-23/ 124

CIRCULAR :-

Attention of the Principals of the Affiliated Colleges and Directors of the recognized Institutions in Faculty of Science & Technology is invited to this office circular No.UG/136 of 2016-17 dated 9th November, 2016 relating to the revised syllabus of Master of Engineering (Instrumentation and Control Engineering) (Sem.– I & IV) (CBCS) .

They are hereby informed that the recommendations made by the Ad-hoc Board of Studies in Instrumentation Engineering at its meeting held on 10th May, 2022 and subsequently passed in the Faculty and then by the Board of Deans at its meeting held on 5th July, 2022 vide item No. 6.36 (R) have been accepted by the Academic Council at its meeting held on 11th July, 2022 **vide** item No. 6.36 (R) and that in accordance therewith, the revised syllabus of M.E.(Instrumentation and Control) (Sem.– I & IV) (CBCS) (REV-2019 'C' Scheme) has been brought into force with effect from the academic year 2022-23.(The circular is available on the University's website www.mu.ac.in).

(Dr. Shailendra Deolankar)
I/c Registrar

MUMBAI – 400 032
20th October, 2022

To

The Principals of the Affiliated Colleges and Directors of the recognized Institutions in Faculty of Science & Technology.

A.C/6.36(R)/11/07/2022

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No. AAMS_UGS/ICC/ 2022-23/ 124

20th October, 2022

Copy forwarded with Compliments for information to:-

1) The Dean, Faculty of Science & Technology,
2) The Chairman, Ad-hoc Board of Studies in Instrumentation Engineering,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Director, Department of Information & Communication Technology,
6) The Co-ordinator, MKCL.

(Dr. Shailendra Deolankar)
I/c Registrar

Copy for information and necessary action :-

1. **The Deputy Registrar, College Affiliations & Development Department (CAD),**
2. **College Teachers Approval Unit (CTA),**
3. **The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
4. **The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA)**
5. **The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
6. **The Deputy Registrar, Executive Authorities Section (EA)**
   He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
7. **The Deputy Registrar, PRO, Fort, (Publication Section),**
8. **The Deputy Registrar, Special Cell,**
9. **The Deputy Registrar, Fort Administration Department (FAD) Record Section,**
10. **The Deputy Registrar, Vidyanagari Administration Department (VAD),**

Copy for information :-

1. **The Director, Dept. of Information and Communication Technology (DICT), Vidyanagari,**
   He is requested to upload the Circular University Website
2. **The Director of Department of Student Development (DSD),**
3. **The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**
4. **All Deputy Registrar, Examination House,**
5. **The Deputy Registrars, Finance & Accounts Section,**
6. **The Assistant Registrar, Administrative sub-Campus Thane,**
7. **The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
8. **The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
9. **P.A to Hon'ble Vice-Chancellor,**
10. **P.A to Pro-Vice-Chancellor,**
11. **P.A to Registrar,**
12. **P.A to All Deans of all Faculties,**
13. **P.A to Finance & Account Officers, (F & A.O),**
14. **P.A to Director, Board of Examinations and Evaluation,**
15. **P.A to Director, Innovation, Incubation and Linkages,**
16. **P.A to Director, Department of Lifelong Learning and Extension (DLLE),**
17. **The Receptionist,**
18. **The Telephone Operator,**

Copy with compliments for information to :-

19. **The Secretary, MUASA**
20. **The Secretary, BUCTU.**

AC – 11 July, 2022
Item No. – 6.36 (R)

Revised Syllabus for

M.E. (Instrumentation and Control)

(Sem. - I to IV)

(Choice Based Credit System)

(With effect from the academic year 2022-23)

University of Mumbai

Syllabus for Approval

Title of Course	M.E. (Instrumentation and Control)
Eligibility	passing a bachelor's degree in engineering as per the Ordinance 0.6242
Passing Marks	45%
No. of years/Semesters:	2 Years / 4 Semesters
Level:	P.G. / ~~U.G./ Diploma / Certificate~~
Pattern:	~~Yearly~~ / Semester
Status:	~~New~~ / Revised 2019 'C' Scheme
To be implemented from Academic Year:	With effect from Academic Year : 2022-23

Dr. Alice N. Cheeran
Chairman
of Ad-hoc Board of Studies
Instrumentation Engineering

Dr. Suresh K. Ukarande
Associate Dean,
Faculty of Science and Technology

Dr Anuradha Majumdar
Dean,
Faculty of Science and Technology

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome-based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. ItalsofocusesoncontinuousevaluationwhichwillenhancethequalityofeducationCredit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 2-3 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self-learning. Therefore, in the present curriculum skill-based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self-learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for M.E in Instrumentation and Control Engineering from the academic year 2022-2023.

Incorporation and implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill-based activities and project-based activities. Self-learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self-learning to learner. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
Member, Academic Council, RRC in Engineering
University of Mumbai

From Chairman's Desk

The overall technical education in our country is changing rapidly in manifolds. Now it is very much challenging to maintain the quality of education with its rate of expansion. To meet present requirement a systematic approach is necessary to build the strong technical base with the quality. Accreditation will provide the quality assurance in higher education and to achieve recognition of the institution or program meeting certain specified standards. The main-focus of an accreditation process is to measure the program outcomes, essentially a range of skills and knowledge that a student will have at the time of graduation from the program that is being accredited. Faculty of Science &Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome-based education in the process of curriculum development.

I, as a Chairman, Board of Studies in Instrumentation Engineering of University of Mumbai, am happy to state here that, Program Objectives (POs) were finalized for PG engineering program in Instrumentation Engineering, more than ten senior faculty members from the different institutes affiliated to University of Mumbai were actively participated in this process. NBA has defined the following three POs for a graduate of PG Engineering Program:

- PO1: An ability to independently carry out research /investigation and development work to solve practical problems.
- PO2: An ability to write and present a substantial technical report/document.
- PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Dr. Alice N. Cheeran
Chairman,
Board of Studies in Instrumentation Engineering,
Member - Academic Council, University of Mumbai

Dr. Mukesh D.Patil-Member BoS

Dr.Sharad P.Jadhav-Member BoS

Dr. Dipak D Gawali-Member BoS

Dr.M. J Lengare-Member BoS

Dr.Harish K. Pillai-Member BoS

Semester I

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
INC101	Advanced signal processing for Sensors	3	--	--	3	--	--	3
INC102	Higher Mathematics for Control Engineering/Robust control	3		--	3		--	3
INPE101	Program Elective 1	3	--	--	3	--	--	3
INPE102	Program Elective 2	3	--	--	3	--	--	3
INIE101	Institute Elective 1	3	--	--	3	--	--	3
INL101	Program Lab-I	--	2	--	--	1	--	1
INSBL101	Skill Based Lab-I	--	4[$]	--	--	2	--	2
Total		**15**	**06**	**--**	**15**	**03**	**--**	**18**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract / Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test-1	Test-2	Avg					
INC101	Advanced signal processing for Sensors	20	20	20	80	3	--	--	100
INC102	Higher Mathematics for Control Engineering	20	20	20	80	3	--	--	100
INPE101	Program Elective 1	20	20	20	80	3	--	--	100
INPE102	Program Elective 2	20	20	20	80	3	--	--	100
INIE101	Institute Elective 1	20	20	20	80	3	--	--	100
INL101	Program Lab-I	--	--	--	--	--	25	25	50
INSBL101	Skill Based Lab-I (MATLAB)	--	--	--	--	--	50	50	100

Total	--	--	100	400	--	75	75	650

Semester II

Course Code	Course Name	Teaching Scheme(Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
INC201	State Estimation and Stochastic Processes	3	--	--	3	--	--	3
INC202	Advanced Process Control and Automation	3		--	3		--	3
INPE201	Program Elective 3	3	--	--	3	--	--	3
INPE202	Program Elective 4	3	--	--	3	--	--	3
INIE201	Institute Elective 2	3	--	--	3	--	--	3
INL201	Program Lab-II	--	2	--	--	1	--	1
INSBL201	Skill Based Lab-II (Python)	--	4$	--	--	2	--	2
Total		**15**	**06**	**--**	**15**	**03**	**--**	**18**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract / Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test-1	Test-2	Avg					
INC201	State Estimation and Stochastic Processes	20	20	20	80	3	--	--	100
INC202	Advanced Process Control and Automation	20	20	20	80	3	--	--	100
INPE201	Program Elective 3	20	20	20	80	3	--	--	100
INPE202	Program Elective 4	20	20	20	80	3	--	--	100
INIE201	Institute Elective 2	20	20	20	80	3	--	--	100
INL201	Program Lab-II	--	--	--	--	--	25	25	50
INSBL201	Skill Based Lab -II	--	--	--	--	--	50	50	100
Total		**--**	**--**	**100**	**400**	**--**	**75**	**75**	**650**

Note 1: Skill Based Lab- I and II are focused on learning through experience. SBL shall facilitate the learner to

acquire the fundamentals of practical engineering in his or her specialization in a project-oriented environment. The learning through skill-based labs can be useful in facilitating their research work and hence useful in early completion of their dissertation work.

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
INMP301	Major Project: Dissertation -I	--	20	--	--	10	--	10
Total		**00**	**20**	**00**	**00**	**10**	**--**	**10**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test-1	Test-2	Avg					
INMP301	Major Project: Dissertation -I	--	--	--	--	--	100	--	100
Total		**--**	**--**	**--**	**--**	--	**100**	**--**	**100**

Online Credit Courses

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
XXOCC301	Online Credit Course - I	--	--	--	--	--	--	3
XXOCC301	Online Credit Course - II	--	--	--	--	--	--	3
Total		**--**	**--**	**--**	**00**	**00**	**00**	**06**

Note 2: It is mandatory to complete the Online Credit Courses (OCC) available on NPTEL / Swayam /MOOC or similar platform approved by UoM. These two courses shall be completed in any semester I or II or III, but not later end of the Semester III. University shall make a provision that credits earned with OCC- I and OCC-II shall be accounted in the third semester grade-sheet with actual names of courses. The learner shall be allowed to take up these courses from his or her institute or organization/ industry where his / her major project is carried out. The students shall complete the courses and shall qualify the exam conducted by the respective authorities/ instructor from the platform. The fees for any such courses and the corresponding examination shall be borne by the learner.

Online Credit Course – I

The learner shall opt for the course in the domain of Research Methodology **or** Research & Publication Ethics or IPR. The opted course shall be of 3 credits of equivalent number of weeks.

Online Credit Course –II

The learner shall opt for the course recommended by Faculty Advisor/ Project Supervisor from the institute. The opted course shall be of 3 credits of equivalent number of weeks.

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
INMP401	Major Project: Dissertation -II	--	32	--	--	16	--	16
Total		**--**	**32**	**--**	**--**	**16**	**--**	**16**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test-1	Test-2	Avg					
INMP401	Major Project : Dissertation -II	--	--	--	--	--	100	100	200
Total		**--**	**--**	**--**	**--**	--	**100**	**100**	**200**

Total Credits: 68

Note 3: The Dissertation -II submission shall not be permitted till the learner completes all the requirements ME course.

Note 4: The contact hours for the calculation of load of the teacher for Major Project are as follows:
Major Project Dissertation I and II - 02 Hour / week / student

Guidelines for Dissertation-I

Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format. Guidelines for Assessment of Dissertation-I.

Dissertation-I should be assessed based on following points

· Quality of Literature survey and Novelty in the problem
· Clarity of Problem definition and Feasibility of problem solution
· Relevance to the specialization
· Clarity of objective and scope Dissertation-I should be assessed through a presentation by a panel of Internal examiners and external examiner appointed by the Head of the Department/Institute of respective Programme.

Guidelines for Assessment of Dissertation II

Dissertation II should be assessed based on following points:

· Quality of Literature survey and Novelty in the problem
· Clarity of Problem definition and Feasibility of problem solution
· Relevance to the specialization or current Research / Industrial trends
· Clarity of objective and scope
· Quality of work attempted or learner contribution
· Validation of results
· Quality of Written and Oral Presentation

Students should publish at least one paper based on the work in the referred National/ International conference/Journal of repute.

Dissertation II should be assessed by internal and External Examiners appointed by the University of Mumbai.

Subject Code	**Program Elective I**	**Subject Code**	**Program Elective II**
INPE1011	Advanced Biomedical Instrumentation	INPE1021	Robust Control
INPE1012	Advanced Measurement Techniques	INPE1022	Expert System
INPE1013	Advanced analytical instrumentation	INPE1023	Robotics and control

Subject Code	**Program Elective III**	**Subject Code**	**Program Elective IV**
INPE2011	Electronics System Design	INPE2021	Advanced Nuclear Instrumentation
INPE2012	Advanced Fiber Optics and laser Instrumentation	INPE2022	Machine learning and Deep learning
INPE2013	Rehabilitation Engineering	INPE2023	MEMS and Nanotechnology

Subject Code	Subject Name	Credits
ISC101	**Advanced Signal Processing for Sensors**	**03**

Course Objectives:

· To give students knowledge in the field of advanced signal processing systems required for processing the signals from various sensors.

· To give knowledge regarding applications of various types of sensors used for high resolution measurement of various parameters.

Course Outcomes:

· The students will be able to understand the methodology and design of electronic circuits utilized for processing the signals for various sensors.

Module	Detailed content	Hours
	Prerequisite: Knowledge in the field of transducers and sensors, Basic concepts in electronic signal processing	
1	**Classification of sensors and transducers:** Input and output characteristics of various transducers, variable resistance transducer and its equivalent circuit, potentiometers, their construction and performance, variable inductance and variable capacitance transducers, their construction and performance, Piezoelectric transducer.	06
2	**Design techniques for sensor signal conditioning:** Sensor and signal conditioning for strain, force, pressure, flow and temperature measurement, Bridge configurations, Amplifying and linearizing bridge outputs, Driving bridge circuits. Ratio metric techniques.	08
3	**High impedance sensors:** Photodiodes and high impedance charge output sensors, Signal conditioning of high impedance sensors, Chemical and Biosensors.	06
4	**Positioning, motion and temperature sensors:** LVDT, Hall effect magnetic sensors, optical encoder Accelerometer, RTDs, thermistors, thermocouples, semiconductors temperature sensors and their signal conditioning.	08
5	**Micro-sensors and smart sensors:** Construction, characteristics, and applications.	04

6	**Radioactivity detectors and Counting systems:** Gas filled, Scintillation and Semiconductor detectors, preamplifiers, Shaping amplifiers, Single Channel analyzer, Multi-channel analyzer.	07

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. H.K.P Neubert ―Instrument Transducers Oxford Herman University Press Eighth Impression 2008.

2. Ramon Pallas-Arenyand Johan G. Webster ―Sensor and Signal Conditioning‖ John Wiley, New York 1991.
3. Dan Sheingold-Editior ―Transducer Interfacing Handbook‖, Analog Devices Inc 1980
4. ―High Speed Design Technique‖ Analog Device Inc 1996
5. Jacoba Fraden ―Handbook of Modern Sensors ―2nd Edition, Springer-Verlag.New York 1996
6. Jerald G.Graeme ―Photodiode Amplifiers And Op-Amp Solution‖, Mc Graw Hill 1995
7. Harry L. Trietly, ―Transducers in Mechanical and Electronic Design‖, Marcel Dekker Inc 1986
8. Dan Shiengold, ―Non Linear Circuits Handbook‖, Analog Device Inc
9. Walt Kester-Editior, ―System Application Guide‖, Analog Devices Inc 1993
10. IMEGA, ―Temperature Measurement Handbook‖, Omega Instruments Inc
11. Henry Ott, ―Noise Reduction Technique In Electronic Systems‖, N.Y.John Wiley And Sons 1988
12. Ralph Morrison,‖Grounding And Shielding Technique‖, Fourth Edition,John Wiley,1998
13. G.F.Knoll ,―Radiation detection and measurement‖, John Wiely and Sons, 2nd edition, 1998.

Subject Code	Subject Name	Credits
ISC102	Higher Mathematics for Control Engineering	3

Course Objectives:

· To introduce different methods of solving systems of linear equations

· Introduce concept of Linear Vector Spaces

· To present the concept of Orthogonality and Quadratics Forms

Course Outcomes:

· Demonstrate ability to solve systems of linear equations

· Demonstrate ability to work with Vector Spaces

· Demonstrate ability to get least square solutions to systems

· Demonstrate ability to effect linear transformation

Module	Detailed content	Hours
	Prerequisite: Knowledge about Matrices, Matrix, ElementaryOperations, Determinants and Matrix Inverse	
1	**Linear Equations in Linear Algebra:** Systems of Linear Equations,Gaussian Elimination, Row Reduction , Echelon Forms , LU Factorization.	06
2	**Euclidean Vector Spaces:** Euclidean n-Space, Linear transformation from R^n to R^m, Properties of Linear Transformations from Rn to Rm,Linear Transformation.	06
3	**General Vector Spaces:** Real Vector Spaces, Subspaces, LinearIndependence, Basis and Dimension, Row Space, Column Space and Nullspace, Rank, Nullity and Change of basis.	07
4	**Eigenvalues and Eigenvectors:** Eigenvectors and Eigenvalues, The Characteristic Equation, Diagonalization, Eigenvectors and LinearTransformations, Complex Eigenvalues, Discrete Dynamical Systems.	07
5	**Orthogonality and Least Squares:** Inner Product, length and Orthogonality, Orthogonal Sets, Orthogonal Projections, The Gram-Schmidt Process, Least –Square Problems, Applications to Linear Models, Inner Product Spaces, Applications of Inner Product Spaces.	07

6	**Symmetric Matrices and Quadratic Forms:** Diagonalization of Symmetric Matrices, Quadratic Forms, Constrained Optimization, The Singular Value Decomposition, Application to Image Processing and Statistics.	06

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions

to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Anthanasios Papoulis, ―Probability, random Variable & Stochastic Processes‖ 3rd Edn, McGraw Hill, Inc 1995
2. Gantmacher, Feliks R.‖the theory of Matrices Vol.I and II‖ Chelsia Publishing Co.1959
3. Gantmacher F.R. ―Application of Theory of Matrices‖
4. Hoffman K. & R. Kunez, ―Linear Algebra‖ 2nd Edn, Printice Hall 1971
5. Howard Anton, ―Elementary Linear Algebra‖- Wiley Student End, 2011

Program Elective -I

Subject Code	Subject Name	Credits
INPE1011	Advanced Biomedical Instrumentation	03

Course Objectives:

- To introduce concepts of advanced biomedical instruments used in hospitals.
- To study the design considerations of various signal conditioning systems for measurement of Bio-signals like ECG, EEG and EMG.
- To study the concept behind various Advanced Medical imaging techniques.

Course Outcomes:

- The students should be able to understand the principle and working of various advanced biomedical instruments.
- The students should be able to design signal conditioning systems for bio-signal measurements.
- The students should be able to apply concepts of biomedical techniques for various applications.
- The students should be able to understand the concept and working of various advanced medical image acquisition and reconstruction techniques.

Module	Detailed content	Hours
	Prerequisite: Knowledge of Anatomy and Physiology of Human Systems, Knowledge of various Bio-signals and their basic Measurement techniques, Knowledge of basic principle of Medical Imaging Techniques	
1	**Instrumentation for Bio-Potential Recording:** Sensors, Biopotential Amplifiers like Chopper Amplifiers, Isolation Amplifiers and Advanced Instrumentation Amplifiers, Signal Conditioning Circuit designing for ECG, EEG and EMG, Multi-Channel Data Acquisition System**.**	10
2	**Diathermy in Medicine:** Electro Surgical Diathermy, Short Wave Diathermy, Microwave Diathermy and Ultrasound Diathermy, Lithotripsy.	05
3	**Cardiac and Neuro-Assist Devices:** Cardiac Pace Makers-constructional details and design, Internal and External Defibrillators with Design, Stimulation Electronics – Nerve and Muscle Stimulators**.**	06
4	**Telemetry and Telemedicine:** Introduction to Telemetry System, Types of Wireless, Power and Data Transmission System, Receiver and Transmitter specifications, Telemedicine.	06

5	**Advanced Medical Imaging Systems:** CT Scanning Systems – tube design, types of Gantries, Image Reconstruction Techniques in Tomography. MRI – Image Acquisition and Reconstruction Techniques. Nuclear Imaging – Scanners, Gamma Camera, Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT).	08
6	**Laser Application in Medicine:** Types of Lasers, Properties of Lasers and Interaction of Lasers with tissues, Basic Endoscope System and its characteristics.	04

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Jacobsons and Webster, ―Medicine and Clinical Engineering‖, PHI, 1981.
2. Carr and Brown, ―Introduction of Biomedical Equipment Technology‖, PHI, 1981.
3. Jacob Kline, ―Handbook of BioMedical Engineering‖, Academic Press, 1988.
4. J B Gupta, ―A course in Electronic and Electrical Measurement and Instrumentation‖, S K Kataria and Sons, 1999.
5. Steve Webb, ―The Physics of Medical Imaging‖, Taylor & Francis, New York, 1988.
6. Norris, A.C., ―Essential of Telemedicine and Telecare‖, Wiley, 2002.

Subject Code	Subject Name	Credits
INPE1012	Advanced Measurement Techniques	03

Course Objectives:

To provide knowledge to the students regarding various methods used for high resolution measurement of various parameters like voltage, current, resistance, inductance, capacitance, time, frequency and phase difference.

Course Outcomes:

· Understand principles and methods used for measurement of various parameters.

· Make use of proper methods of measurement depending upon requirement of resolution, accuracy and speed of measurement.

Module	Detailed content	Hours
	Prerequisite: Basic knowledge of electronic measurements, analog and digital circuits.	
1	**High resolution measurement for electrical components:** Analog and digital techniques for high resolution measurement of Resistance, Inductance, Capacitance. Various bridge circuits and auto balancing methods. Polar and Cartesian type impedance meters. Tan delta measurement.	10
2	**High resolution time measurement:** Philosophy of digital and microprocessor/microcontroller-based instruments.; Time measurement techniques: Time standards; Measurement of time interval between events, order of events, Vernier technique, very low time, period, phase, time constant measurements	06
3	**Frequency measurement techniques:** Frequency, ratio and product, high and low frequency measurements; Deviation meter and tachometer, Peak/valley recorder.;	06
4	**Programmable circuits:** Programmable resistors, amplifiers, filters; Programmable amplifiers as DACs	04
5	**Applications of ADCs and DACs:** Application of various types of ADCs and DACs in measurement techniques; DVM and its design; Voltage and current ratio measurements.	08
6	**Sampling theory and applications:** Modulation index meter, Sampling theory and its application in	05

	current, voltage, power and energy measurements.	

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. T. S. Rathore, ―Digital Measurement Techniques‖, Narosa Publishing House, 1996.
2. B. S. Sonde, ―Monographs on System Design using Integrated Circuits‖, Tata Mc-Graw Hill, 1974.
3. D. J. DeFatta, J. G. Lucas, ―Digital Signal Processing‖, J Wiley and Sons, 1988.

Subject Code	Subject Name	Credits
INPE1013	**Advanced Analytical Instrumentation**	**03**

Module	Detailed content	Hours
1	**Spectrophotometric /Gas analyzers** **I**R/NIR/UV/VIS analyzers – Cells, Detectors, Signal Processing, Calibration, Minimization of Interference and Comparative Analysis of Analyzers & Gaseous Components Detected Hydrocarbon analyzers - Flame Ionization Detectors, Principle of Operation Oxygen and NO/NO2 analyzers - Signal Processing, Calibration, Minimization of Interference, Applications Sampling Systems – Desirable Features, Filters, Flow and Pressure regulators, Coolers, Condensers, Vacuum Pumps, Blowback Cleaning System, Exhaust Practices.	**07**
2	**Electrochemical/Liquid Analyzers pH Analyzers –** Measurement and Compensation, Pre-amplifiers, Transmitters, Measurement cells. Conductivity Analyzer – Cells and Cell Constant, Effect of temperature on measurement calibration, acid and alkali titration measurement. Redox Analyzer - Principle of operation, components of analyzers and applications. Trace Oxygen and Residual Chlorine Analyzer - Principle of operation, components of analyzers and applications.	08
3	**Compositional Process Analyzer Gas and Liquid Chromatography –** columns, gas and liquid detectors, data processing, process chromatography, calibration and application. Mass Spectrometry – Components, different types, sampling systems, calibration and applications.	07
4	**Biomedical Spectroscopy** -Types of Biomolecules, different spectroscopic analysis techniques, principle of operation, components, data processing and applications, Blood gas analyzers	06

5	**Environmental Analyzers:** Waste Water Environmental Analysis, analyzer's principle of operations & components, calibration and applications.	04
6	**Nuclear Magnetic Resonance Spectroscopy**- Principle of operation, components, sensitivity enhancement techniques and different types of NMR Spectrometers with applications.	06

REFERENCES

1. B. G. Liptak, "Instrument Engineers' Handbook: Process Measurement and Analysis", Butterworth Hieneman, Boston, 1995.
2. D.M. Considine, "Process Instruments and Control Handbook", 4th edition, McGraw Hill New York, 1993.
3. K. J. Clevett, "Process Analyzer Technology", John Wiley & Sons, 1986, New York.

4. Gas Analysis – Book 14 Fisher Rosemount Educational Services.
5. G. K. Macmillan, "pH Measurement and Control", ISA 1994.
6. pH and Conductivity – Book 13 Fisher Rosemount Educational Services.
7. R.E. Sherman, "Analytical Instrumentation", TWI Press, Indiana, 1996.
8. Meyers, "Encyclopedia of Analytical Chemistry".
9. Instruction Manuals at http:// www.frco.com/proanalytic/library/publicmanuals.html.

Program Elective II

Subject Code	Subject Name	Credits
ISE1021	Robust Control	03

Course Objectives:

- To study the effect of disturbance, parametric uncertainties and model errors on the
- stability of the system.
- To study the robust control techniques such as a control based on Kharitonov theorem,
- internal model control and introduction to Quantitative feedback technique for the system
- with parametric uncertainties and external disturbances.
- To study the sliding mode control for asymptotic stability in presence of disturbances.

Course Outcomes:

- The students should be able to understand the robustness properties of the system against uncertainties.
- Students should be able to design robust control that overcomes parametric uncertainties.
- Students should be able to design the internal model control for uncertain systems.
- Students should be able to understand the concept of Quantitative feedback techniques.
- Students should be able to design the sliding mode control for uncertain systems.

Module	Detailed content	Hours
	Prerequisite: Regulators and Servo Mechanism, Concepts in State-space analysis, Controllability and Observability.	
1	**Introduction to Sliding Mode Control**: Main Concepts of Sliding Mode Control, Chattering Avoidance: Attenuation and Elimination, Concept of Equivalent Control, Sliding Mode Equations, The Matching Condition and Insensitivity Properties, Conventional Sliding Mode Controller Design	06
2	**Conventional Sliding Modes:** Introduction, Filippov Solution, Concept of Equivalent Control, State-Feedback Sliding Surface Design, Regular Form, Eigenvalue Placement, Quadratic Minimization, State-Feedback Relay, Control Law Design, Single-Input Nominal Systems, Single-Input Perturbed Systems, Relay Control for Multi-Input Systems.	08
3	**Interval Polynomials:** Kharitonov's Theorem: Kharitonov's Theorem for Real Polynomials, Kharitonov's Theorem for Complex Polynomials, Robust State Feedback Stabilization	06

4	**Internal Model Control (IMC):** Introduction to Model-Based Control, Practical Open-Loop Controller Design, Generalization of the Open-Loop Control Design Procedure, Model Uncertainty and Disturbances, Development of the IMC Structure, IMC Background, The IMC Structure, The IMC Design Procedure, Effect of Model Uncertainty and Disturbances, Improving Disturbance Rejection Design	07
5	**The IMC-Based PID Control**: Background, The Equivalent Feedback Form to IMC, IMC-Based Feedback Design for Delay-Free Processes, IMC-Based Feedback Design for Processes with a Time Delay, Summary of IMC-Based PID Controller Design for Stable Processes, IMC-Based PID Controller Design for Unstable Processes	08
6	**Introduction to Quantitative Feedback Theory:** Quantitative Feedback Theory (QFT), Why Feedback, QFT Overview, QFT Design Objective, Structured Parametric Uncertainty, Control System Performance Specifications, QFT Design Overview, QFT Basics, QFT Design, Insight to the QFT Technique, Open-Loop Plant, Closed-Loop Formulation, Benefits of QFT.	04

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. S. P. Bhattacharyya, H. Chapellat, and L. H. Keel. ―Robust control: the parametric approach," Upper Saddle River (1995).

2. Manfred Morari and Evanghelos Za_riou, ―Robust process control," Vol. 488. Englewood Cliffs, NJ, Prentice hall, 1989.

3. B. Wayne Bequette, ―Process Control: Modeling, Design and Simulation," Prentice Hall Professional, 2003.

4. Constantine H. Houpis, Steven J. Rasmussen and Mario Garcia-Sanz, ―Quantitative feedback theory: fundamentals and applications," CRC Press, 2005.

5. Oded Yaniv, ―Quantitative feedback design of linear and nonlinear control systems", Vol.509. Springer Science & Business Media, 2013.

6. Yuri Shtessel, Christopher Edwards, Leonid Fridman and Arie Levant, ―Sliding mode control and observation," New York, USA: Birkhuser, 2014.

7. Christopher Edwards and Sarah Spurgeon, ―Sliding mode control: theory and applications, CRC Press, 1998.

8. Dorf, Richard C., and Robert H. Bishop, ―Modern control systems," Prentice Hall, 2011

Subject Code	Subject Name	Credits
INEP1022	Expert Systems	03

Course Objectives:

- To give knowledge to the students regarding Neural Networks and their applications in control engineering.
- To familiarize the students with concepts in Fuzzy Logic and their applications in control engineering.

Course Outcomes:

- Students will be able to understand concepts in Neural Networks and their applications in control engineering.
- Students will be able to understand concepts in Fuzzy logic and their applications in control engineering.
- Students will be able to understand concepts in Artificial intelligent systems such as perceptrons.

Module	Detailed content	Hours
	Prerequisite: Basic knowledge in computer science and Control Engineering	
1	**Introduction to Neural Networks:** Artificial Neural Networks: Basic properties of Neurons; Neuron Models; Feedforward networks - Perceptrons; Widrow-Hoff LMS algorithm; Multiplayer networks - Exact and approximate representation; Back propagation algorithm; variants of Back propagation; Unsupervised and Reinforcement learning; Symmetric Hopfield networks and Associative memory; Competitive learning and self-organizing networks, Hybrid Learning; Computational complexity of ANNs.	08
2	**Neural Networks Based Control:** ANN based control: Introduction: Representation and identification; modeling the plant, control structures - supervised control, Model reference control, Internal model control, Predictive control: Examples - Inferential estimation of viscosity a chemical process; Auto - tuning feedback control; industrial distillation tower.	06
3	**Introduction to Fuzzy Logic:** Fuzzy Controllers: Preliminaries -Fuzzy sets and Basic notions - Fuzzy relation calculations - Fuzzy members - Indices of Fuzziness - comparison of Fuzzy quantities -Methods of determination of membership functions.	06
4	**Fuzzy Logic Based Control:** Fuzzy Controllers: Basic construction of fuzzy controller - Analysis of static properties of fuzzy controller - Analysis of dynamic properties of fuzzy controller - simulation studies - case studies - fuzzy control for smart cars.	08

5	**Neuro - Fuzzy and Fuzzy:** Neural Controllers: Neuro - fuzzy systems; A unified approximate reasoning approach - Construction of role bases by self-learning : System structure and learning algorithm - A hybrid neural network based Fuzzy controller with self-learning teacher. Fuzzified CMAC and RBF network based self-learning controllers.	06
6	**Artificial Neural Networks:** Supervised Learning: Introduction and how brain works, Neuron as a simple computing element, The perceptron, Backpropagation networks - architecture, multilayer perceptron	05

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Bose & Liang, — Artificial Neural Networks —, Tata Mcgraw Hill, 1996
2. Kosco B, — Neural Networks and Fuzzy Systems : A Dynamic Approach to Machine Intelligence, Prentice Hall of India, New Delhi, 1992.
3. Klir G.J. and Folger T.A., Fuzzy sets, — Uncertainty and Information — , Prentice Hall of India, New Delhi, 1994.
4. Simon Haykin - — Neural Networks —, ISA, Research Triangle Park, 1995

Subject Code	Subject Name	Credits
INPE1023	Robotics and Control	03

Course Objectives:

- To introduce robot terminologies and robotic sensors
- To educate on direct and inverse kinematics
- To introduce robot control techniques

Course Outcomes:

- Students would be able to understand the concepts behind various robotic sensors and manipulators.
- Students would be able to understand the kinematics and control strategies behind robot movement.
- Students would be able to apply robots for various applications.

Module	Detailed content	Hours
	Prerequisite: Knowledge of basic control strategies, Knowledge of working of basic controllers, Knowledge of basic programming languages like C, C++	
1	**Robot Organization:** Coordinate transformation, kinematics and inverse kinematics, Trajectory planning and remote manipulation.	06
2	**Robot Hardware:** Robot sensors, Proximity sensors, Range sensors, Visual sensors, Auditory sensors, Robot manipulators, Manipulator dynamics, Manipulator control, Wrists, End efforts, Robot grippers.	09
3	**Robot and Artificial Intelligence:** Principles of AI, Basics of learning, Planning movement, Basics of knowledge representations, Robot programming languages.	08
4	**Robot Vision System:** Principles of edge detection, determining optical flow and shape, Image segmentation, Pattern recognition, Model directed scene analysis.	06
5	**Robot Control System:** Linear control schemes, joint actuators, decentralized PID control, Computed torque control, force control, hybrid position force control, Robot control using voice and infrared.	06
6	**Robot Application:** Overview of robot applications. Prosthetic devices. Robots in material handling, processing assembly and storage.	04

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.

Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Koren, ―Robotics for Engineers‖, McGraw Hill International Company, Tokyo, 1995.
2. Vokopravotic, ―Introduction to Robotics‖, Springer, 1988.
3. Rathmill. K., ―Robot Technology and Application‖, Springer, 1985.
4. Charniak and McDarmott, ―Introducation to Artificial Intelligence‖, McGraw Hill, 1986.
5. K. S. Fu, R. C. Gonzally, C.S. G. Lee, ―Robotics Control, Sensing, Vision and Intelligence‖, McGraw Hill Book Company, 1997.
6. Barru Leatham, Jones, ―Elements of Industrial Robotics‖, Pittmann Publishing, 1987.
7. Mikell P. Groover, Mitchell Weiss, Roger. N. Nagel, Nicholas G. Odrey, ―Industrial Robotic Technology Programming and Applications‖, McGraw Hill Book Company, 1986.

Subject Code	Subject Name	Credits
INL101	**Program Lab-I**	**01**

	Title
1	Linearizing circuit for ―single element‖ varying bridge.
2	Kelvin sensing system to drive remote bridges.
3	Active low pass, band pass and high pass filters for transducer signal processing.
4	Use of high-resolution ADC for transducer signal processing.
5	Simulation of boiler start-up process control using PLC
6	Simulation of paint manufacturing process using PLC
7	Study of SCADA (HMI) software

NOTE: Perform any six experiments from above list and two experiments from Department Elective Course.

Term work: Term work consists of performing 08 practicals mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of

internal and external examiners.

Subject Code	Subject Name	Credits
INSBL101	**Skill Based Lab -I**	**01**

Expt no.	Title
1	Experiments in MATLAB/Scilab for Computation of Eigenvalues, Eigen vectors, different types of norms etc.
2	QR Decomposition
3	LQ Decomposition
4	Gram Schmidt Orthogonalization
5	Design the sliding mode control for SISO systems
6	Design the IMC controller for the — a) First order delay system b) First order NMP system
7	Design PID controller based on IMC controller
8	Design state feedback control for interval systems.

NOTE: Perform any six experiments from above list and two experiments from Department Elective Course.

Term work: Term work consists of performing 08 practical mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of

internal and external examiners.

Sem-II

Subject Code	Subject Name	Credits
INC201	State Estimation and Stochastic Processes	03

Course Objectives:

- To study the concept of Stochastic Processes, Monte Carlo Simulation and fractional calculus
- To study the concept of Kalman filtering

Course Outcomes:

- The students should be able to understand the Stochastic Properties of random variables in terms of pdf.
- Students should be able to understand the concept of stochastic processes
- Students should be able to understand concept of least square estimation
- Students should be able to realize the significance of Kalman filter and its applications to linear and nonlinear systems.

Module	Detailed content	Hours
	Prerequisite: Knowledge about concept of probability and Random Variable, Knowledge about concept of state and state space models of systems	
1	**Random Variables:** Introduction to Random Variables, Probability Distribution Function, Probability Density Function, Exponential Distribution, Gaussian Distribution, Binomial Distribution, Poisson Distribution, Two Dimensional Random Variables, Joint Probability, Marginal Density Function, Conditional Probability and Independence, Correlation, Covariance, Introduction to n-dimensional Random Variables.	**10**
2	**Stochastic Processes:** Definition, Statistics of Stochastic Processes, Types of Stochastic Processes, Random Walk, Markov Process, Brownian Motion, Poisson Process, Concept of Monte Carlo Simulation, Monte Carlo Simulation of Stochastic Processes such as Random Walk. Correlation functions, Power Spectrum, White Noise, Linear Systems with Stochastic input.	**08**
	Parameter Estimation: Point Estimation, Optimal Estimates, Acceptable Estimates, Least Squares Estimation: The deterministic point of view (Gauss), Sequential Bayes Theorem, Linear Minimum	

3	Mean-square-error Estimation: Vector case sequential MMSE Estimation.	**08**
4	**The Discrete-time Kalman Filter:** Propagation of states and covariances, Derivation of the discrete-time Kalman filter, Kalman filter properties, Divergence issues	**05**
5	**Nonlinear Kalman Filtering:** The extended Kalman Filter, The Unscented Kalman Filter, General Unscented transformations, The Simplex unscented transformation, The spherical unscented transformation, Introduction to Particle filtering	**05**
6	**Fractional Calculus:** Introduction to Fractional Calculus, Functions for the Fractional Calculus, Riemann-Liouvelli fractional derivative(Left Hand Definition), Caputo definition of fractional derivative (Right Hand Definition), Fractional random walk, Application of fractional calculus to engineering systems	**03**

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project**.**

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Starks and Woods, ―Probability and Random Processes with applications to Signal Processing, Phi, 2002.
2. Simon Haykins, ―Adaptive filter theory‖, Pearson 2012
3. W.C.Van Etten, ― Introduction to Random signals and noise‖, Wiley 2009
4. G.N. Saridis, ― Stochastic Processes, Estimation and Control‖, Wiley 1995
5. Meditch. J., ― Stochastic Linear Estimation and Control‖, Tata Mcgraw Hills, 1969
6. Paupolis, ―Probability , Random Variables and Stochastic Processes, Mc-Grawhill, 1995
7. Shantanu Das, ―Functional Fractional Calculus‖ 2nd Edn, Springer Verlag, Germany, 2012
8. Dan Simon, ―Optimal State Estimation‖ – Wiery 200**6**

Subject Code	Subject Name	Credits
INC202	Advanced Process Control and Automation	03

Course Objectives:

· To study the concepts of process modeling

· To study the effect of constraints and interaction between different loops

· To study the sizing of PLC and DCS.

· To study the knowledge about safety Instrumented Systems and advances in intrinsic safety.

Course Outcomes:

· The students should be able to design the process and behavioral model of the process.

· The students should be able to select appropriate control configuration to minimize interaction between different loops

· The students should be able to design PLC and DCS based systems.

· The students should be able to calculate Safety Integrity Level for a given process.

Module	Detailed content	Hours
	Prerequisite: Basic knowledge of Process control and automation tools such as PLC, DCS and SCADA	
1	Process Dynamics and Control: Fundamentals of process modeling, Design for process modeling and behavioral model, Linearisation of model equations- Level process, evaporation and chemical reactor model. Dynamics of CSTR, Heat exchanger and evaporator.	06
2	Multivariable control: Constraint Control, SISO constraint control,Signal selectors, Relative gain analysis, steady state decoupling, dynamic decoupling.	05
3	Integrated Automation: Process and factory automation, PLC, DCS and SCADA- programming, selection and sizing, PLC networking, PLC-HMI interfacing, Installation and troubleshooting.	10
4	Buses and Networks: Introduction to networks in Industrial Automation, PLC Proprietary and open networks, hardware selection for Fieldbus systems, Fieldbus advantages and disadvantages, Limitations of open networks. Design and installation of Field Bus oriented Industrial Communication Networks- Foundation Fieldbus, Profibus PA, Devicenet, As-i segments in Hazardous and Non-Hazardous area.	08

5	**Safety Instrumented System:** Life cycle model of Safety Instrumented System, technologies, SIL calculation methods, SIL-calculation of PFD, RRF etc., Phases of SIS overall implementation and reliability.	**06**
6	Advanced intrinsic safety: Entity concept, FISCO, High power trunk, Dynamic arc recognition and termination technology with advantages and disadvantages.	**04**

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Myke King, ―Process control-A practical approach‖, John Wiley, !st edition,2011.
2. Bela G Liptak, ― Instrument Enginner‘s Handbook-Process software and digital networks‖, CRC press, ISA,3rd edition,2002.
3. Bela G Liptak, ―Optimisation of Unit operaion‖, ISA.
4. Bela G Liptak, ― Instrument Enginner‘s Handbook-Process Control‖, Chilton Book Company, 3rd edition.
5. Gary Dunning, ―Introduction to Programmable Logic controller‖, Thomas Learning, edition, 2001.
6. Thomas Hughes, ―Programmable Logic Controller‖, ISA Publication.
7. Stuart A. Boyer, ―SCADA supervisory control and data acquisition‖, ISA Publication.
8. George Stephanopoulos, ―Chemical process control‖, PHI-1999
9. Paul Gruhn, Harry L cheddie, ― Safety Instrumented System: Design, Analysis and justification‖, ISA, 2nd edition, 2006.
10. Ian Verhappen, Augsto Periria, ―Foundation fieldbus‖, ISA,2006

Program Elective- III

Subject Code	Subject Name	Credits
INPE 2011	Electronics Systems Design	03

Course Objectives:

· To provide students with knowledge to design basic electronic systems.

· To make students aware of practical design considerations like noise reduction, grounding techniques, shielding and isolation which are required to design high performance electronic instrumentation systems.

Course Outcomes:

· Students will be able to understand practical design considerations such as Noise reduction, Shielding and grounding techniques, Isolation and Power management associated with design of electronic systems.

· Students will be able to design Analog, Digital and Mixed signal processing circuits required for electronic systems.

Module	Detailed content	Hours
	Prerequisite: Basic knowledge of analog and digital electronic circuits.	
1	**Design of linear integrated circuits and their applications:** Linear and log amplifiers, peak detect and milli volt rectifier circuits, analog switches and multiplexers, current and voltages references and their stability	06
2	**Instrumentation and special operational amplifiers:** Advanced instrumentation amplifier and various designs to improve dynamic range and reduce power dissipation. High speed OP-amps CMOS OP-amps Micro power amplifiers low noise and chopper stabilized OP-amps	07
3	**Nonlinear integrated circuits:** Comparators, voltage to frequency and frequency to voltage converters switched capacitor circuit ‘s filters. Analog filters, Sample and hold circuits.	06
4	**Converters:** D.C to D.C converters. Mixed signal processing. High speed and high-resolution DACs and A/D converters. Various techniques of A/D conversion. flash, successive approximation, multi slope ADC. Delta sigma ADC.	08

5	**Noise reduction techniques:** Design of mixed signal processing circuits, grounding and isolation techniques R.F shielding, Power supply noise reduction and filtering, Over voltage and ESD protection.	08
6	**Power Management:** Power management issues in low power portable systems, Linear and switch mode regulators.	04

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination

References:

1. E.Allen Douglas R.Holberg, ―CMOS Analog Circuit Design‖, Philip Oxford , University Press 2004
2. Kevin M.Daugherty, ―Analog To Digital Converter‖, Tata McGraw Hill Inc 1995
3. Manual: High Speed Design Technique- Analog Devices Inc 1996
4. Dan Shiengold, ―Non-Linear Integrated Circuits Handbook‖, Analog Devices.
5. Ralph Morrison,‖Grounding And Shielding Technique‖, Fourth Edition,John Wiley,1998

Subject Code	Subject Name	Credits
INPE2012	Advanced Fiber Optics and LASER Instrumentation	03

Course Objectives:

- To expose the students to the concepts of instrumentation based on optical fibers and lasers along with their properties.
- To provide sufficient knowledge about the extensive utilization of optical fibers and lasers in Industries.

Course Outcomes:

- Understand the principle of optical fibers, its losses, sources and detectors and their importance.
- Understand the operation of lasers in detail.
- Master the various principles of optical fiber used for different parameter measurement.
- Perceive the significance of the intensive use of laser and optical fiber in Industrial applications.

Module	Detail content	Hours
	Prerequisite: Awareness of light theory, Basics of fiber optics, Basics of Physics of Laser, Basics of measurement in Instrumentation.	
1	**Optical Fibers and their properties:** Ray theory, Principle of light propagation through a fiber, different types of fibers and their properties, Transmission characteristics of optical fiber, Absorption losses, Scattering losses, Dispersion losses, Non-linear phenomena.	07
2	**Optical sources and Detectors:** LED, LD, PIN, APD their characteristics, modulation circuits, optical detection principle, LED coupling to fiber	05
3	**Fiber Optic Sensors:** Principle of fiber optic sensors, classification, principle of intensity modulated sensors, phase modulated sensors, wavelength modulated sensors, distributed optical fiber sensing	06
4	**Optical Fiber Measurement:** Measurement of numerical aperture, refractive index profile, OTDR. concepts of temperature, flow, pressure and level measurement.	08

5	**Laser Fundamentals:** Fundamental characteristics of lasers,3 and 4 level lasers, its properties, modes, resonator configuration, Q switching and mode locking. Types of lasers: solid, liquid and gas.	06
6	**Industrial & Biomedical Application of Lasers:** Laser for measurement of distance, length velocity, acceleration, Material processing, Laser heating, welding, melting and trimming of materials. Laser instruments for surgery, Application of Laser for removal of tumors, brain surgery, oncology, plastic surgery.	07

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Gerd Keiser, ―Optical Fiber Communication‖, McGraw Hill
2. John M Senior, ―Optical Fiber Communications Principles and Practice‖,3rd edition, Pearson
3. D.A.Krohn, ―Fiber Optic Sensors- fundamentals and applications ‖3rd edition, ISA
4. I. John and Harry, ―Industrial lasers and their applications‖, McGraw Hill
5. John Crisp, ―Introduction to Fibre Optics‖, an imprint of Elseveir Science,1996
6. John F Ready, ―Industrial applications of Lasers, Academic Press,1978

Subject Code	Subject Name	Credits
INPE2013	Rehabilitation Engineering	04

Course Objectives:

- To develop an understanding of the principle and working of various rehabilitation aids.
- To give information about the application of various recent rehabilitation aids.
- To give information about rehabilitation medicine and Advocacy.

Course Outcomes:

- The students will be able to understand the principle and working of various rehabilitation aids.
- The students will be able to understand the design considerations of various rehabilitation aids.
- The students would be able to select which rehabilitation aid to apply for challenged people based on their medical conditions.
- The student would be aware of the various legal considerations while selecting a rehabilitation aid.

Module	Detailed content	Hours
	Prerequisite: Knowledge of Anatomy and Physiology of Human Systems, Knowledge of various basic stimulation techniques, Knowledge of basic concept of human-assist devices.	
1	**Prosthetic and orthotic devices:** Hand and arm replacement, different types of models for externally powered limb prosthetics, feedback in orthotic system, material for prosthetic and orthotic devices, mobility aids.	08
2	**Auditory and speech assist devices:** Types of deafness, hearing aids, application of DSP in hearing aids, cochlear implants	05
3	**Visual aids:** Retinal Implants, Types of retinal implants – Epi-retinal and subretinal, design and working, applications of retinal implants. Ultrasonic and laser canes, Intraocular lens, Text voice converter, screen readers.	08
4	**Medical stimulator:** Muscle and nerve stimulator, Location for Stimulation,Functional Electrical Stimulation, Sensory Assist Devices.	08
5	**Rehabilitation medicine:** Physiological aspects of Function recovery, psychological aspects of Rehabilitation therapy.	06

6	**Advocacy:** Legal aspect available in choosing the device and provision available in education, job and in day-to-day life.	04

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Rory A Cooper, ―An Introduction to Rehabilitation Engineering‖, CRC press, 2006.
2. Joseph D.Bronzino, ―The Biomedical Engineering Handbook‖,Third Edition,CRC Press,2006
3. Levine.S.N.Editor, ―Advances in Bio Medical Engineering and Medical Physics‖, Inter University Publication, New York 1968.
4. Albert M.Cook and Webster J.G, ―Therapeutic Medical devices‖, Prentice Hall Inc., New Jersey, 1982.
5. Reswick.J, ―What is Rehabilitation Engineering, Annual review of Rehabilitation-volume2‖, Springer-Verlag, New York 1982.

Program Elective -IV

Subject Code	Subject Name	Credits
INPE2021	Advanced Nuclear Instrumentation	03

Course Objectives:

· To give students knowledge in the field of nuclear instrumentation, which is used for various hi-tech applications including field of nuclear research, nuclear reactors, accelerators and nuclear medical instruments

Course Outcomes:

· The students should be able to understand the design and working of advanced nuclear instruments used in nuclear research, nuclear reactors and other related nuclear fields.
· Students will be able to apply the concepts for basic design of nuclear instruments.

Module	Detailed content	Hours
	Prerequisite: Basic concepts of Radioactivity, Measurement of Radioactivity.	
1	**Nuclear instrumentation for research:** Radiation detectors for high resolution nuclear pulse spectroscopy, HPGE, Ge(Li), Si(Li) detectors, high resolution Multi Channel Analyzers, Nuclear ADCs, Wilkinson, Gatti's sliding scale technique, various modes of Multi-Channel Analyzer, portable spectroscopy systems and their design. Timing spectroscopy, Time Pick-off circuits, TDCs, TACs, spectrum stabilization.	12
2	**Instrumentation for reactors:** Log and linear amplifiers, in core and out of core instrumentation, Neutron detector, BF3 detector, Fission counters, nuclear instrumentation for pressurized water reactors, boiling water reactors, self-powered detectors, fast Neutron detection and spectroscopy.	08
3	**Detection of very low radio-activity:** Liquid scintillation counting systems, noise reduction by coincidence detection. Counting interferences in LSC, Methods of quench corrections.	03
4	**Instrumentation for accelerators:** Various types of accelerators, detectors and electronics used.	03

5	**Nuclear medical instrumentation:** Functional imaging, design and construction of imaging systems gamma camera, PET SPET. Calibrations and testing of various nuclear instruments and systems.	10
6	**Instrumentation for astrophysics experiments:** Detection of cosmic events, detector arrays and trigger systems	03

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. G.F.Knoll ,―Radiation detection and measurement‖, John Wiely and Sons, 4th edition, 2010.
2. P.W. Nicolson, ―Nuclear electronics‖, John Wiely,1998.
3. Gerald. J.Hine, James A Sorenson, ―Instrumentation in nuclear Medicine‖, Vol II, Academic press,1974
4. Ramesh Chandra, ―Nuclear Medicine Physics‖, Williams and Wilkins,1998.
5. Irving Kaplan ―Nuclear Physics.‖, Narosa Publishing House.1992

Subject Code	Subject Name	Credits
INPE2022	Machine Learning and Deep Learning	03

Course Objectives:

To give students knowledge in the field of Machine learning and Deep learning, which find extensive applications in various fields, ranging from predictive analytics, medical diagnosis, image processing, control engineering.

Course Outcomes: Students would be able

- To explain the basic concepts and techniques of Machine Learning.
- To have a thorough understanding of the Supervised and Unsupervised learning techniques
- To study the various probability-based learning techniques
- To understand the concepts of deep learning

Module	Detailed content	Hours
	Prerequisite: Basic concepts of Expert systems and artificial intelligence	
1	**Introduction:** Types of Machine Learning, Supervised Learning: concept of working of brain and the neuron, Perspectives and Issues in Machine Learning, Linear Discriminants – Perceptron – Linear Separability – Linear Regression	08
2	**Linear models:** Multi-layer Perceptron, Propagating Forwards, Propagating Backwards: Back Propagation Error – Multi-layer Perceptron in Practice – Examples of using the MLP – Overview – Deriving Back-Propagation – Radial Basis Functions and Splines, Concepts of RBF Network.	06
3	**Tree and Random Forest model:** Decision Trees, Constructing Decision Trees, Classification and Regression Trees, Ensemble Learning, Boosting, Bagging, Different ways to Combine Classifiers, Random Forest algorithm	06
4	**Probabilistic Model:** Probability and Learning, Basic Statistics, Gaussian Mixture Models, Nearest Neighbor Methods (kNN), Unsupervised Learning – Clustering, K means Algorithm, Vector Quantization.	06
5	**Dimensionality Reduction:** Linear Discriminant Analysis, Principal Component Analysis, Factor Analysis, Independent Component Analysis,	06

	Locally Linear Embedding, Least Squares Optimization, Genetic algorithms	
6	**Deep learning:** Basic concept of Deep learning, Optimization in deep learning, non-convex optimization for deep networks, Stochastic Optimization, Generalization in neural networks, Recurrent networks, LSTM, Recurrent Neural Network Language Models	07

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", First Edition, Cambridge University Press, 2012
2. Ethem Alpaydin, "Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series)", Third Edition, MIT Press, 2014
3. Jason Bell, "Machine learning – Hands on for Developers and Technical Professionals", First Edition, Wiley, 2014.
4. Tom M Mitchell, "Machine Learning", First Edition, McGraw Hill Education, 2013.
5. Stephen Marsland, "Machine Learning – An Algorithmic Perspective", Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.

Subject Code	Subject Name	Credits
INPE2023	MEMS and Nanotechnology	03

Course Objectives:

- To give students adequate knowledge regarding quantum mechanics to understand principles utilized in Nanotechnology and MEMS.
- To familiarize the students with advanced technologies used in fabrication of nano materials and MEMS.

Course Outcomes:

- Students will be able to understand concepts in quantum mechanics used in nanotechnology
- Students will be able to understand technologies used in fabrication of nano materials and MEMS.

Module	Detailed content	Hours
	Prerequisite: Basic knowledge in quantum mechanics and material science.	
1	**Introduction:** Introduction to nanotechnology and Nanomaterials, How It All Began: Synthesis of carbon buckyballs, List of stable carbon allotropes extended, fullerenes, metallofullerenes, solid C_{60}, bucky onions, nanotubes, nanocones.	04
2	**Quantum Mechanics :** Review of classical mechanics, de Broglie's hypothesis, Heisenberg uncertainty principle Pauli Exclusion Principle, Schrödinger's equation, Properties of the wave function, Application: quantum well, wire, dot, quantum cryptography Solid State Physics and Nanodevices-Structure and bonding, Application: carbon nanotube, Electronic band structure Electron statistics, Application: Optical transitions in solids, Semiconductor quantum dots, photonic crystals.	10
3	**Nanomaterials - Fabrication, MEMS and NEMS nanotubes synthesis:** Bottom-up vs. top-down approach, Epitaxial growth, Self-assembly, Modeling and Applications Production Techniques of Nanotubes Carbon arc bulk synthesis in presence and absence of catalysts High-purity material (Bucky paper) production using Pulsed Laser Vaporization (PLV) of pure and doped graphite High-pressure CO conversion (HIPCO) nanotube synthesis based on Boudoir Reaction Chemical Vapor Deposition (CVD).	06
4	**Nanomaterials:** Characterization and commercial processes of synthesis of nonmaterial, Nanoclay, Nanoinroganic materials, Nanocarbon Tubes CNT, Applications of nanomaterials in water treatment, polymers,atalysis etc	07

	Structural, XRD, TEM, SEM, STM, AFM.	
5	**MEMS Technology:** Introduction to Microelectromechanical Systems (MEMS), Microsensors and Micro-actuators, Micromachining, System modeling and Simulation, different types of MEMS sensors and actuators.	06
6	**Micro Electromechanical Systems:** MEMS: Micro-transducers Analysis, Design and Fabrication, Microprocessor-Based Controllers and Microelectronics**,** Micro-switches, Micro-actuators for Electromechanical systems.	06

Assessment:

Internal: Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. K. Eric Drexler, ―Nanosystems: Molecular Machinery, Manufacturing, and Computation‖, 1992 .
2. Mark Ratner & Daniel Ratner, ―Nanotechnology: A Gentle Introduction to the Next Big Idea‖, November 2002 Read reviews.
3. Nitaigour Premchand Mahalik, ―MEMS‖, Tata McGraw Hill, New Delhi, 2007.
4. K. K. Appukuttan, ―Introduction to Mechatronics‖, Oxford Higher Education, 2003.
5. Nitaigour Premchand Mahalik, ―Mechatronics‖, Tata McGraw-Hill, 2003

Subject Code	Subject Name	Credits
INL201	Program Lab-II	01

Expt No.	Title
1	Simulation of batch reactor control using PLC with GUI
2	Study of Ethernet network communication
3	Study of Modbus communication
4	Simulation of furnace control using PLC with GUI
5	Simulation of Heat exchanger feedback control scheme using DCS
6	Simulation of cascade control scheme using DCS
7	Simulation of feedforward control scheme using DCS
8	Simulation of boiler level control using DCS

NOTE: Perform any six experiments from above list and two experiments from Department Elective Course.

Term work: Term work consists of performing 08 practical mentioned above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by a pair of internal and external examiners.

Subject Code	Subject Name	Credits
INSBL201	**Skill Based Lab -II**	**01**

Expt.	Title
1	Implement Linear Regression with example
2	Implement logistic regression with example
3	Implement Principal component analysis for dimensionality reduction
4	Implement Support Vector Machine with example
5	Implement Decision tree classification techniques
6	Implement Random Forest algorithm for an example
7	Implement clustering techniques with example
8	Implement any one deep learning algorithm for an example

NOTE: Perform any six experiments from above list and two experiments from Department Elective Course.

Term work: Term work consists of performing 08 practicals mentioned above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by a pair of internal and external examiners.

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
INMP301	Major Project: Dissertation -I	--	20	--	--	10	--	10
Total		**00**	**20**	**00**	**00**	**10**	**--**	**10**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test-1	Test-2	Avg					
INMP301	Major Project: Dissertation -I	--	--	--	--	--	100	--	100
Total		**--**	**--**	**--**	**--**	--	**100**	**--**	**100**

Guidelines for Dissertation-I

Students should do a literature survey and identify the problem for Dissertation and finalize in consultation with the Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt to provide solutions to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format. Guidelines for Assessment of Dissertation-I.

Dissertation-I should be assessed based on following points

· Quality of Literature survey and Novelty in the problem
· Clarity of Problem definition and Feasibility of problem solution
· Relevance to the specialization
· Clarity of objective and scope Dissertation-I should be assessed through a presentation by a panel of Internal examiners and external examiner appointed by the Head of the Department/Institute of respective Programme.

Online Credit Courses

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
XXOCC301	Online Credit Course - I	--	--	--	--	--	--	3
XXOCC301	Online Credit Course - II	--	--	--	--	--	--	3
Total		**--**	**--**	**--**	**00**	**00**	**00**	**06**

Note 2:

It is mandatory to complete the Online Credit Courses (OCC) available on NPTEL / Swayam /MOOC or similar platform approved by UoM. These two courses shall be completed in any semester I or II or III, but not later end of the Semester III. University shall make a provision that credits earned with OCC- I and OCC-II shall be accounted in the third semester grade-sheet with actual names of courses. The learner shall be allowed to take up these courses from his or her institute or organisation/ industry where his / her major project is carried out. The students shall complete the courses and shall qualify the exam conducted by the respective authorities/ instructor from the platform. The fees for any such courses and the corresponding examination shall be borne by the learner.

Online Credit Course – I

The learner shall opt for the course in the domain of Research Methodology **or** Research & Publication Ethics or IPR. The opted course shall be of 3 credits of equivalent number of weeks.

Online Credit Course –II

The learner shall opt for the course recommended by Faculty Advisor/ Project Supervisor from the institute. The opted course shall be of 3 credits of equivalent number of weeks.

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
INMP401	Major Project: Dissertation -II	--	32	--	--	16	--	16
Total		**--**	**32**	**--**	**--**	**16**	**--**	**16**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test-1	Test-2	Avg					
INMP401	Major Project: Dissertation -II	--	--	--	--	--	100	100	200
Total		**--**	**--**	**--**	**--**	--	**100**	**100**	**200**

Guidelines for Assessment of Dissertation II

Dissertation II should be assessed based on following points:
· Quality of Literature survey and Novelty in the problem
· Clarity of Problem definition and Feasibility of problem solution
· Relevance to the specialization or current Research / Industrial trends
· Clarity of objective and scope
· Quality of work attempted or learner contribution
· Validation of results
· Quality of Written and Oral Presentation

Students should publish at least one paper based on the work in the referred National/ International conference/Journal of repute.

Dissertation II should be assessed by internal and External Examiners appointed by the University of Mumbai.