Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Nanoscience and Nanotechnology

(Faculty of Science & Technology)

F. Y. B. Sc. Nanoscience and Nanotechnology Syllabi in NEP

(Level 4.5)

National Education Policy Syllabus

To be implemented from Academic Year 2024-2025

Title of the program: B. Sc. (Nanoscience and Nanotechnology)

1) Programme Objectives :

The undergraduate (UG) degree course in Nanoscience and Nanotechnology aims to provide:

a) Knowledge and skills to undertake higher studies/research in Nanoscience and Nanotechnology and related interdisciplinary areas thereby enabling students' employment/entrepreneurship.

b) Critical and analytical thinking, scientific reasoning, problem-solving skills, communication skills and teamwork.

c) Competence and skill in solving both theoretical and applied Nanoscience and Nanotechnology problems.

d) In-depth knowledge in Nanoscience and Nanotechnology through understanding of key physical concepts, principles, theories and their manifestations.

e) Exposure to the latest advances in Nanoscience and Nanotechnology, allied disciplines and research.

f) A conducive learning environment to ensure cognitive development of students.

g) Sufficient subject matter competence and enable students to prepare for various competitive examinations such as UGC-CSIR NET/JRF, GATE, GRE, IIT-JAM, and Civil Services Examinations.

h) Moral and ethical awareness, leadership qualities, innovation and life-long learning.

i) Multicultural competence and multilinguist.

2) Program Outcomes :

The learning outcomes of the undergraduate degree course in Nanoscience are as follows:

1. Fundamental Knowledge: Students should acquire a solid understanding of the principles and concepts in nanoscience and nanotechnology. This includes knowledge of quantum mechanics, material science, chemistry, and physics at the nanoscale.
2. Experimental Skills: Students should gain hands-on experience in working with nanoscale materials and instruments, including microscopy techniques, nanofabrication, and characterization tools.
3. Interdisciplinary Approach: A B.Sc. program in Nanoscience and Nanotechnology should encourage interdisciplinary thinking and collaboration between various scientific fields, such as physics, chemistry, biology, and engineering.
4. Nanomaterials: Students should be able to identify and design nanomaterials with specific properties for various applications, such as electronics, medicine, and energy.
5. Safety and Ethical Considerations: Students should understand the safety and ethical implications of working with nanoscale materials and technologies.
6. Research Skills: The program should foster research skills, including the ability to design and conduct experiments, analyze data, and draw meaningful conclusions.
7. Problem-Solving: Graduates should be able to apply their knowledge and skills to solve real-world problems and address challenges in nanoscience and nanotechnology.
8. Communication: Students should develop strong communication skills, including the ability to present scientific findings and research effectively to both technical and non-technical audiences.
9. Nanotechnology Applications: Graduates should be familiar with various applications of nanotechnology in fields such as electronics, medicine, energy, and materials science.
10. Adaptability: Given the rapidly evolving nature of nanoscience and nanotechnology, students should be prepared to adapt to new technologies and discoveries in the field throughout their careers.
11. Advanced Education: The B.Sc. program may also prepare students for further education, such as pursuing a master's or Ph.D. in nanoscience or related fields.

Structure of Four Year-degree Program

Structure of the course for four years, the pattern of examination and question papers are as per Savitribai Phule Pune University:

Nanoscience and Nanotechnology as Major (Core) Subject and any other subject as Minor (each theory / practical paper has 2 credits).

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted	Lecture/Practical hours per week
I 4.5/100	I	NS-101-TH	Introduction to Nanoscience	02	02
		NS-102-PR	Nanoscience and Nanotechnology Laboratory-I	02	04
	II	NS-151-TH	Material Science	02	02
		NS -152-PR	Nanoscience and Nanotechnology Laboratory-II	02	04
II 5.0/200	III	NS -201-MJ	Physical Techniques for synthesis of Nanomaterials	02	02
		NS -202-MJ	Properties of Nanomaterials (Physical, chemical, Optical and Magnetic)	02	02
		NS -203-MJ	Nanoscience and Nanotechnology Laboratory-III	02	04
	IV	NS -251-MJ	Organic and polymer science of nanomaterials	02	02
		NS -252-MJ	Advanced Techniques for Characterization of Nanomaterials	02	02
		NS -253-MJP	Nanoscience and Nanotechnology Laboratory-IV	02	04
III 5.5/300	V	NS -301-MJ	Polymer and Composites	02	02
		NS -302-MJ	Nanophysics	02	02
		NS -303-MJ	Nanobiotechnology	02	02
		NS -304-MJ	Chemical and Biological Techniques for synthesis nanomaterials	02	02
		NS -305-MJP	Nanoscience and Nanotechnology Laboratory-V	02	04
		NS -306-MJP	Nanoscience and Nanotechnology Laboratory-VI	02	04
	VI	NS -351-MJ	Polymer Hetero-structure and their applications	02	02
		NS -352-MJ	Functional Nanomaterials	02	02
		NS -353-MJ	Applications of Nanobiotechnology-II	02	02
		NS -354-MJ	Application of Nanotechnology-III	02	02
		NS -355-MJP	Nanoscience and Nanotechnology Laboratory - VII	02	04

		NS -356-MJP	Nanoscience and Nanotechnology Laboratory-VIII	**02**	**04**

List of major Electives:

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted	Lecture/Practical hours per week
III 5.5/300	**V**	NS-310-MJ	Thin film technology	**02**	**02**
		NS-313-MJP	Practical (Thin film technology)	**02**	**04**
	VI	NS-360-MJ	Physics of Nanomaterials	**02**	**02**
		NS-361-MJP	Practical (Physics of Nanomaterials)	**02**	**04**

List of Vocational Skill Courses (VSC):

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted	Lecture/Practical hours per week
I	**I**	NS-121-VSC	Environment- I	**02**	**04**
	II	NS-171-VSC	Environment- II	**02**	**04**
II	**III**	NS-221-VSC	Data Analysis & Computer Application	**02**	**04**
	IV	NS-271-VSC	C Programing Practical	**02**	**04**
III	**V**	NS-321-VSC	Basic Instrumentation in Nanotechnology	**02**	**04**
	VI	NS-371-VSC	Basic Instrumentation Skill Practical	**02**	**04**

Field Project (FP) / On Job Training (OJT)/ Community Engagement Project (CEP):

Year	Sem.	Code Number	Title of the paper (Theory / Practical)	Credits allotted	Lecture/Practical hours per week
II 5.0/200	**III**	NS-231-FP	Field Project	**02**	**----**
	IV	NS-281-CEP	Community Engagement Project	**02**	**--**

III 5.5/300	**V**	NS-331-FP/CEP	Field Project / Community Engagement Project	**02**	**---**
	VI	NS-381-OJT	On Job Training	**04**	**---**

Statistics as Minor Subject and any other subject as Major (each theory / practical paper has 2 credits)

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted	Lecture/Practical hours per week
II 5.0/200	**III**	NS-241-MN	Renewable Energy and Energy Harvesting	**02**	**02**
		NS-242-MNP	Data Analysis & Computer Application Practical	**02**	**04**
	IV	NS-291-MN	Basics of Industrial Nanotechnology-I	**02**	**02**
		NS-292-MNP	C Programming Practical	**02**	**04**
III 5.5/300	**V**	NS-341-MN	Basics of Industrial Nanotechnology-II	**02**	**02**

List of Generic / Open Electives (OE):

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted	Lecture/Practical hours per week
I 4.5/100	**I**	OE-101-NS	Chemical and Biological technique for synthesis of nanomaterial	**02**	**02**
	II	OE-151-NS	Basic Characterization Techniques	**02**	**04**
II 5.0/200	**III**	OE-201-NS	Carbon Based Nanomaterials	**02**	**02**
	IV	OEP-251-NS	Energy Conversion Devices and Applications	**02**	**04**

List of Skill Enhancement Courses (SEC):

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted	Lecture/Practical hours per week
I 4.5/100	**I**	SEC-101-NS	C-Programming	**02**	**04**
	II	SEC-151-NS	Basic Instrumentation Skill	**02**	**04**
II 5.0/200	**IV**	SEC-251-NS	Sensors and Detection Technology	**02**	**04**

Indian Knowledge System (IKS):

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted	Lecture/Practical hours per week
I 4.5/100	**I**	NS-101-IKS	Generic	**02**	**02**
II 5.0/200	**III**	NS-201-IKS	नॅनोविज्ञान (Nanoscience)	**02**	**02**

F.Y.B.Sc. (Nanoscience and Nanotechnology) (Sem-I)

NS 101 MJ : Introduction to Nanoscience

Lectures: 30 **(Credits-02)**

A) Course Objectives: This course aims to introduction of Mechanics.

1) To study basic concept of Nanoscience.
2) To import knowledge of generation of Nanotechnology, Nanometrology, Electromagnetic Nanoengineering.

B) Learning Outcomes (CO): Upon completion of this course student will able to

1) Understand basic laws in Nanoscience.
2) Use of Mathematics in Nanoscience.
3) Can solve problems in Nanoscience.
4) Can study applications of Nanoscience

C) Instructional Design :

1) Lecture method
2) Tutorial method
3) Seminars

D) Evaluation Strategies :

1) Descriptive and objective written examination
2) Assignments
3) Seminars, Orals, Viva.

E) Course Contents:

Chapter-1	**Introduction**	**Lectures = 7**
	Nano and Nature, Nanoscopiccolours (Butterfly wings), Bioluminescence (Fireflies), Tribology (Geckos Sticky feet, lotus-leaf effect etc.) in nature, the development of nanoscalescience: Size scale, Nanotechnology timeline, pre-18th Century; 19th Century, 20th Century, 21th Century.	
Chapter-2	**Generation of Nanotechnology**	**Lectures = 7**
	Classification of Nanomaterials, OD, 1D, 2D and 3D types of nanomaterials (Quantum dots,Quantum wires, Carbon Nano Tubes, Bucky balls, Quantum confinement (Quantum size effect), Fullerences etc.)	
Chapter-3	**Nanometrology**	**Lectures = 7**
	Background to Nanometrology, Background to nanomanufacturing, the nano perspective,The Quantum triangle, Nanomechanical tools, Standards for Nanotechnology, , list of measurement techniques (SET, TEM, AFM), Applications of Nanometrology	

Chapter-4	**Electromagnetic Nanoengineering**	**Lectures = 9**

	Electronics and Nanoelectronics, Microelectronics, Nanoscale electronics, The Surface Plasmonresonance, Colour generation from Nanoparticles and nanostructures, Application of nanoplasmonics, Introduction to Nanophotonics, Introduction to Nanobiotechnology	

f) Reference Books:

1. Fundamentals of Nanotechnology, CRC press, by G.L. Hornyak, J.J. Moone, H.F. Tihhale, J. Dutta
2. Fundamental of Nanoscience by Sulbha Kulakarni
3. Introduction to Nanoscience and Nanotechnology, G. L. Hornyak, H. F. Tibbals, J. Dutta, J. J. Moore CRC Press 2008
4. Nanotechnology: Principles and practices, 3rd Edition, Sulabha K. Kulkarni, Capital Publishing Company 2015
5. Fundamentals of Nanotechnology, G.L. Hornyak, J.J. Moone, H.F. Tihhale, J. Dutta, CRC press.
6. Nanotechnology :Technology Revolution of 21st Century by Rakesh Rathi, published by S.Chand.
7. Introduction to Nanoscience, Stuart Lindsay, Oxford University Press: 2010.
8. Introduction to Nanomaterials and nanotechnology by Vladimir Pokropivny, RynnoLohmus, Irina Hussainova, Alex Pokropivny and Sergey Vlassov
9. Nanomaterials by A.K. Bandyopadhyay; New Age International Publishers
10. Nanotechnology by Mark Ratner and Daniel Ratner, Pearson Education

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F.Y.B.Sc. (Nanoscience and Nanotechnology) (Sem-I)

NS 103 MJP: Nanoscience and Nanotechnology Laboratory-I

Lectures: 30 **(Credits-02)**

Section I:

Sr. No.	Title of the experiment
1	To study the working of UV-Visible spectrophotometer.
2	Synthesis of Silver nanoparticles by using biological method.(Mango leaves)
3	To study the Absorption spectrum of Silver nanoparticles.(mango leaves extract)
4	Synthesis of Silver nanoparticles by Chemical Route.
5	To Prepare Metal Oxide Thin film by using SILAR Method.
6	To Prepare Cadmium sulphide thin film by using chemical bath deposition method.
7	To study the Absorption spectrum of $FeCl_3$ solution.
8	To study the X-ray diffraction pattern.

Section II: Additional Activities to be conducted during the semester .

1. Mini Projects with report.
2. Study tour / industrial visit / Field visit with report.
3. Demonstration of Hydrothermal method.
4. Demonstration of Spray Pyrolysis method.

Study tour: Participate study tour (Industry/Oganization/Research Institute/Research organization/ Small scale industry/University Department) with study tour report equivalent to 2-experiments.

Note: Students have to perform total 10-experiments.

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F.Y.B.Sc. (Nanoscience and Nanotechnology) (Sem-II)

NS 151 MJ: Materials Science

Lectures: 30 **(Credits-02)**

Learning Outcomes:

A) Course Objectives: This course aims to introduction of Material Science.

3) To study basic Principle of Solids.
4) To import knowledge of Structure and bonding, different type of solids, phase diagram and crystal structure.

B) Learning Outcomes (CO): On successful completion of this course students will be able to do the following:

1. To understand the general information about material science.
2. To understand the materials and its properties.
3. To demonstrate quantitative problem solving skills in all the topics covered

C) Instructional Design :

1) Lecture method
2) Tutorial method
3) Seminars

D) Evaluation Strategies :

1) Descriptive and objective written examination
2) Assignments
3) Seminars, Orals, Viva.

E) Course Contents:

Chapter-1	**Structure and Bonding**	**Lectures = 8**
	Arrangements of atoms in solids, two dimension crystal structure, three dimension crystalstructure, Bonding in solids, Bonding and antiboding states, Electronic structure of solids.	
Chapter-2	**Different types of Solids**	**Lectures = 6**

	Single phase alloys, Semiconductors, insulators and oxide materials, Composites, Polymers,Porous materials, Aerogels, Core-Shell particles	
Chapter-3	**Phase Diagram**	**Lectures = 8**
	Basic term system, Surrounding, Component, Coordinates, Phase equilibrium, Phasediagram definition, Lever rule, Gibb's Phase rule, Phase diagram of suger- water and NaCl-water. Types of Phase diagram, Pb-Sn phase diagram	
Chapter-4	**Crystal Structure**	**Lectures = 8**
	Lattice, Basis, Crystallographic planes and directions. Simple, bcc and fcc crystalstructure.	

f) Reference Books:

1. Materials science and Engineering -V. Raghvan.
2. Elements of Materials science and Engineering - H. Vanvlach (4^{th} Edition)
3. Nanotechnology - S.K. Kulkarni (3^{rd} Edition).
4. Introduction to Nanoscience and Nanotechnology, G. L. Hornyak, H. F. Tibbals, J. Dutta, J. J. Moore CRC Press 2008
5. Nanotechnology: Principles and practices, 3rd Edition, Sulabha K. Kulkarni, Capital Publishing Company 2015
6. Fundamentals of Nanotechnology, G.L. Hornyak, J.J. Moone, H.F. Tihhale, J. Dutta, CRC press.
7. Nanotechnology :Technology Revolution of 21st Century by Rakesh Rathi, published by S.Chand.
8. Introduction to Nanoscience, Stuart Lindsay, Oxford University Press: 2010.
9. Introduction to Nanomaterials and nanotechnology by Vladimir Pokropivny, RynnoLohmus, Irina Hussainova, Alex Pokropivny and Sergey Vlassov
10. Nanomaterials by A.K. Bandyopadhyay; New Age International Publishers
11. Nanotechnology by Mark Ratner and Daniel Ratner, Pearson Education

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F.Y.B.Sc. (Nanoscience and Nanotechnology) (Sem-II)

NS 152 MJ Nanoscience and Nanotechnology Laboratory-II

Lectures: 30 **(Credits-02)**

Section I:

Sr.No	Title of the Experiments
1	To study the working of IR/FTIR spectroscopy.
2	Synthesis of Metal Oxide nanoparticles by using Hydrothermal method.
3	To Prepare of Lead sulphide thin film by using chemical bath deposition method.
4	Synthesis of Metal Oxide nanoparticles by using Wet Chemical method.
5	To Prepare Metal Oxide Thin film by using Electrochemical Method.
6	Analysis of graphene using Raman Spectroscopy.
7	To study of Characterization technique Scanning Electron Microscopy (SEM).
8	To study of Characterization technique Transmission Electron Microscopy (TEM).

Section II: Additional Activities to be conducted during the semester

1. Mini Projects with report.
2. Study tour / industrial visit / Field visit with report.
3. Demonstration of Screen printing technique.
4. Demonstration of Chemical Bath deposition

Study tour: Participate study tour (Industry/Oganization/Research Institute/Research organization/ Small scale industry/University Department) with study tour report equivalent to 2-experiments.

Note: Students have to perform total 10-experiments.

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F.Y.B.Sc. (Nanoscience and Nanotechnology) (Sem-I)

OE 101 NS : Chemical and Biological technique for synthesis of nanomaterial

Lectures: 30 **(Credits-02)**

A) Course Objectives :

This course aims to introduce Chemical and Biological technique for synthesis of nanomaterial to the students. Objectives are

1. To Study the basic concepts of chemical method for synthesis of nanomaterials.
2. To Study the basic concepts of biological method for synthesis of nanomaterials.

B) Learning Course Outcomes : Upon Completion of this course, the students will be able to ,

1. Understand the basic concepts of synthesis method .
2. This synthesis methods are applicable to prepare nanomaterials in material research.

C) Instructional Design :

1. Lecture Method 2) Tutorial Method 3) Seminars 4) Use of Multimedia
5) Creation of online resources

D) Evaluation Strategies :

1. Descriptive Written Examination 2) Assignments 3) Seminars, Viva

E) Course Contents:

Chapter-1	**Synthesis of Nanomaterial (Chemical Method)**	**Lectures = 7**
	Colloids and colloids in solution, Nucleation and growth of nanoparticles, Synthesis of metal and semiconductor nanoparticle by colloidal routes, Langmuis- Blodgett (L-B) method, sol-gel method.	
Chapter-2	**Synthesis of nanomaterial (chemical Methods):**	**Lectures = 9**
	Hydrothermal synthesis, Solvothermal synthesis, Sonochemical Synthesis, Solvothermal synthesis, Sonochemical Synthesis methods, Microwave synthesis, Synthesisusing micro-reactor or Lab-or-chip spray pyrolysis, successive ionic Layer adsorption andreaction(SILAR), Electrodeposition,	
Chapter-3	**Synthesis of nanomaterial (Chemical Methods)**	**Lectures = 9**
	Chemical vapour deposition, Metallorganic chemical vapour deposition (MOCVD), Plasmaenhanced chemical vapour deposition(PECVD), Vapour-Liquid- Solid(ULS) method,Metal Oxide frameworks(MoF), Kirkindall effect and method.	

Chapter-4	Synthesis of nanomaterial (Biological methods)	Lectures = 7
	Introduction, Synthesis using microorganisms, Synthesis using plant extract, Use of proteins, Templates like DNA, S-tayer synthesis of nanoparticles using DNA.	

F) References :

1. Hari Singh Nalwa, "Encyclopedia of Nanotechnology", USA 2011
2. James A. Schwarz, Cristian I. Contescu, Karol Putyera, "Dekker encyclopedia of nanoscience and nanotechnology" CRC Press, 2004.
3. Introduction to Nanoscience and Nanotechnology, CRC Press, G. L. Hornyak, H. F. Tibbals, J. Dutta, J. J. Moore
4. Nanotechnology: Principles and practices, 3rd Edition, Sulabha K. Kulkarni,Capital Publishing Company

OE-151-NS Basic Characterization Techniques

Lectures: 30 **(Credits-02)**

Unit 1: TDA, DSC, Fluorescence, Confocal Microscopy: (10 Lectures)

Working Principle, Block diagram of instrument, function and role of each block, Output form and its analysis, applications, Illustration by giving at least one typical example.

Unit 2: Scanning Electron Microscope (SEM) and Energy Dispersive Analysis of X-rays (EDAX): (10 Lectures)

SEM: Working Principle, Block diagram of instrument, Function and role of each block, Interaction of electron beam, Output form and its analysis, limitations, applications. Different versions of SEM: FESEM, Environmental SEM, Biological sample preparation, Importance and applications.

EDAX: Working Principle data analysis and applications.

Unit 3: Transmission Electron Microscope (TEM): (12 Lectures)

Construction, Working Principle, Image formation, Different Operational Modes: Bright field and Dark field imaging, High Resolution (HR) / Lattice mapping imaging, Selected Area Electron Diffraction (SAED), Illustration by showing typical TEM images obtained using the various operational modes

Sample preparation for TEM, Sample preparation for cross sectional view, Applications.

Unit 4: Magnetic measurements (10 Lectures)

Vibrating Sample Magnetometer (VSM) – Construction, Working and applications, Introduction to Superconducting Quantum Interference Device (SQUID) – Construction, Working and Applications.

Reference Books:

1. Encyclopedia of Material Characterization Edited by C. Richard Brundle, Charles A. Evans, Shaun Wilson, Butterworth, London.
2. Handbook of Microscopy, Applications in Materials Science, Solid State Physics and Chemistry, Edited by D. van Dyck, J. van Landuyt and G. van Tendeloo VCH,UK.
3. Handbook of Instrumental Techniques for Analytical Chemistry, Edited by Frank A. Settle, Printice Hall, PTR, New Jersey, USA.
4. Instrumental Methods of Analysis, by Willard, Merritt, Dean and Settle, CBS Publishers & Distributors; 7^{th} edition (2004)
5. Bharat Bhusan, “Springer Handbook of Nanotechnology”, springer, Newyork, 2007.
6. Hari Singh Nalwa, “Encyclopedia of Nanotechnology”,USA 2011.
7. James A. Schwarz, Cristian I. Contescu, Karol Putyera, “Dekker encyclopedia of Nanoscience and Nanotechnology” CRC Press, 2004.

SKILL ENHANCEMENT COURSE

F.Y.B.Sc. (Nanoscience and Nanotechnology) (Sem-I)

SEC-101-NS C Programming

Lectures : 30 **Credits: 2**

1. Concepts of programming: **(4 L)**

Definition and Properties of algorithms, Algorithm development,

Flow charts- symbols and simple flowcharts.

Flow charts and Algorithms for Kinematic equations, Free fall, Equation of state, Factorial of a number.

Types of programming language: Lower, middle and higher level languages.

2. C Programming **(16 L)**

Structure of C program, Character set, key words, Constants andvariables, Variable names, Data types and their declarations, Symbolic Constants.

Input/output functions: scanf ( ), printf ( ), getchar ( ), putchar ( ), getch ( ), gets ( ), puts ( ). Operators and Expressions: Arithmetic Operators, Relational Operators, LogicalOperators, Assignment Operators, Conditional Operator.

Formatted input/output

Control statements: If, if else, while, do while for loop, nested control structures (nested if, nested loops), break, continue, switch- case statement, goto statement. Use of Library functions: e.g. mathematical, trigonometric, graphics.

3. Arrays and Pointers in C **(4 L)**

Arrays: 1-D, 2-D and String

Examples: Arranging numbers in descending and ascending order, Sum of matrices, multiplication of matrices.

Concept of Pointers

4.Graphics in C: **(6L)**

Some simple graphic commands- Line, Circle, Arc, Ellipse, Bar.

Reference Books:

1. Programming in C- (Schaum's series) Gottfreid TMH

2. Programming in C- Balgurusami Prentice Hall publications

3. Let us C- YashwantKanetkar BPB publications

4. Programming with C- K.R. Venugopal, S. R. Prasad, TMH.

5. Introductory methods of numerical analysis-S. Sastry Prentice Hall

6. Computer oriented numerical methods – V. Rajaraman.

SKILL ENHANCEMENT COURSE

SEC 151 NS Basic Instrumentation Skills(Sem-II)

Lectures : 30 **Credits: 2**

1) Basic of Measurement:

Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Multimeter: Block diagram and working of a digital multimeter. Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

2) Electronic Voltmeter

Principles of voltmeter, Construction (block diagram only). Specifications of an electronic Voltmeter and their significance. AC millivoltmeter: Type of AC millivoltmeters: Amplifier-rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance.

3) Cathode Ray Oscilloscope:

Block diagram of basic CRO. Construction of CRT, Electron gun,electrostatic focusing and acceleration (Explanation only-no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation,synchronization. Front panel controls. Specifications of a CRO and their significance.

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

4) Signal Generators and Analysis Instruments:

Block diagram, explanation and specificationsof low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.

Reference Books:

1) A text book in Electrical Technology - B L Theraja - S Chand and Co.

2) Performance and design of AC machines - M G Say ELBS Edn.

3) Digital Circuits and systems, Venugopal, 2011, Tata Mc Graw Hill. Logic circuit design, Shimon
P. Vingron, 2012, Springer.

4) Electronic Devices and circuits, S. Salivahanan & N.
S.Kumar, 32012, Tata Mc-Graw Hill

5) Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008,
SpringerElectronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India