Faculty of Life Sciences

JSS ACADEMY OF HIGHER EDUCATION & RESEARCH
(DEEMED TO BE UNIVERSITY) MYSURU

JSS Academy of Higher Education & Research

(Deemed to be University)

Re-Accredited "A+" Grade by NAAC

Sri Shivarathreeshwara Nagara Mysuru - 570015, Karnataka

Syllabus

M.Sc. NANOSCIENCE & TECHNOLOGY

As per UGC's Learning Outcome Based Curriculum Framework (LOCF) under the CBCS pattern

Implementation Year 2021-22 onwards

MSc

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M.Sc. Nanoscience & Technology

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Foreword

Nanoscience and Technology, an interdisciplinary subject, is “long awaited turning point” in science and technology in India. One of the means to bridge the gap between abundant natural resources and an increasing basic needs like potable water, food, affordable medicine, low cost diagnostic machinery, point-of-care therapies and so on, will only be possible by applying principles of nanotechnology in use. The initiative for nanotechnology research in India started in early 2000s. From then onwards, research in nanoscience and technology, is on upswing, given the fact of substantial investments by government of India. Several pharmaceutical companies, biomedical industry, agricultural and environmental sectors in India, have already deployed nanotechnology sectors. With this, it is predicted that by 2025, India will have a new transformative nanotechnology driven research and innovations. However, at an educational level, the number of students taking up postgraduate courses or higher studies through research or postdoctoral fellows in nanoscience, is still meager and this is due to the limited knowledge and understanding about of nanoscience and technology among the student populations in India. Therefore, to make an impact nationally, it is now required to make, educational awareness in nanoscience and technology at higher secondary school level and in pre-universities, investments in innovations and entrepreneurships in nanoscience & technology, nanotechnology translational science, process nanotechnology and infrastructure development. In order to make this happen, the MSc in Nanoscience and Technology course offered at JSS Academy of Higher Education & Research in Mysore, is an intense effort towards national awareness of nanotechnology initiative program. This two-year PG course offers, a range of subjects such as Cancer Nanotherapeutics, Process Nanotechnology, Biomedical Nanotechnology, Industrial Nanotechnology, Nanotoxicology, Nanomaterials in Dentistry, Nanotechnology in food industry, Nanoneutraceuticals and related courses along with basic of physics, chemistry, biochemistry and cell biology. In addition to the above subjects, students are sent to industrial internships. To nurture students in research environment, students take up independent research projects through which they gain hands-on industrial skills that make them “the future workforce in nanoscience and technology”. With all this in place, the best “out of the box thinking innovations” in science and technology, are often learnt through “interdisciplinary courses and programs” like Nanoscience and Technology.

Course Overview

Program Objectives

There is growing demand and a need to motivate young students towards nanotechnological applications that are facilitating other areas of science & technology subjects. MSc Nanoscience and Technology caters the needs for growing demand by pharmaceutical, biotech, cosmetic or drug delivery industries. The program is structured to accommodate graduated students with regular BSc, BSc (Hons.) and MSc (regular) with multiple entry and exit options. The courses are designed to apprehend the biomedical applications of nanostructured materials.

The course curriculum is designed to inculcate students with in-depth knowledge provided through discipline specific core papers, subject specific skills set enhancement and key transferable skills in nanostructured materials & application, synthesis, characterization and their cellular interactions. The students have choice to take up elective courses and interdisciplinary courses. This intense course curriculum will provide an overall subject oriented theory, tutorial and laboratory sessions in addition to industry internship/visits, compulsory courses, interdisciplinary courses.

The curriculum and syllabus for MSc Nanoscience and Technology conform to outcome based teaching learning process. In general, the several outcomes of this program have been identified and the curriculum and syllabus have been structured in such a way that each of the courses meets one or more of these outcomes. Student outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program. Further each course in the program spells out clear instructional objectives which are mapped to the student outcomes.

The student outcomes are:
(a) an ability to apply knowledge of biology, physics and chemistry
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design and fabricate nanostructures or process that meet the needs of medical, agricultural, environmental sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve biomedical problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of nanotechnological solutions in global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and advanced instrumentation tools necessary for practical applications.

Eligibility

A BSc graduate in any Science Biochemistry, Biotechnology, Environmental Sciences, Microbiology, Chemistry, physics (can be considered) with 50% passing marks.

BSc Hons in Biochemistry, Biotechnology, Microbiology, Food, Nutrition and Dietetics are eligible (any other subject with student counselling) with 60% passing marks.

MSc Nanoscience and Technology

Curriculum Structure

MSc Nanoscience and Technology

SEMESTER I								
Sl. No	**Study Components**	**Title of the Paper** / **Core Subject**	**Hours/ Week**	**Examination Scheme**				**Total Credits**
				Duration in hours	**CIA**	**Theory/ Practical**	**Maximum Marks**	
1	**DSC 1**	Fundamentals of Biochemistry	4	3	30	70	100	4
2	**DSC 2**	Fundamentals of Nanotechnology	4	3	30	70	100	4
3	**DSC 3**	Synthesis of Nanomaterials	4	3	30	70	100	4
4	**AECC**	Principles of Statistics	2	2	-	50	50	2
5	**SEC 1**	Entrepreneurship	2	2	-	50	50	2
6	**Practical 1**	Synthesis of Nanomaterials	4	3	15	35	50	2
7	**Practical 2**	Cell & Molecular Biology and basic human Anatomy & Physiology Lab	4	3	15	35	50	2
		Total Marks and Credits					**500**	**20**
SEMESTER II								
Sl. No	**Study Components**	**Title of the Paper** / **Core Subject**	**Hours/ Week**	**Examination Scheme**				**Total Credits**
				Duration in hours	**CIA**	**Theory/ Practical**	**Maximum Marks**	
1	**DSC 4**	Analytical Techniques	4	3	30	70	100	4
2	**DSC 5**	Biomedical Nanotechnology	4	3	30	70	100	4
3	**DSC 6**	Industrial Nanotechnology	4	3	30	70	100	4
4	**DSE I**	Nanotechnology for Regenerative Medicine **OR** Nanotechnology for Energy systems **OR** Cancer Nanotherapeutics	4	3	30	70	100	4
5	**DSE II#**	Dental Nanomaterials **OR** Nanosensors	4	3	30	70	100	4
6	**SEC II**	Path for Translational Science: Lab to Clinic	2	2	-	50	50	2
7	**Practical 3**	Analytical Techniques for Characterization of Nanomaterials	4	4	-	50	50	2
8	**Practical 4**	Surface modifications of Nanomaterials	4	4	-	35	50	2
		Total					**650**	**26**
Internship*								
SEMESTER III								
Sl. No	**Study Components**	**Title of the Paper** / **Core Subject**	**Hours/ Week**	**Examination Scheme**				**Total Credits**
				Duration in hours	**CIA**	**Theory/ Practical**	**Maximum Marks**	
1	**DSC 7**	Advanced Drug Delivery Systems	4	3	30	70	100	4
2	**DSC 8**	Clinical Pharmacology	4	3	30	70	100	4
3	**DSC 9**	Nanotoxicology	4	3	30	70	100	4

4	**DSE III#**	**3.1.** Nanocomposites **OR** **3.2.** Nanotechnology: Processing and Regulations.	4	3	30	70	100	4
5	**SEC III**	Bioprinting	2	2	-	50	50	2
6	**Practical 5**	Synthesis and Preclinical Testing	3	3	15	35	50	2
7	**Practical 6**	Nanotoxicity Testing	4	3	15	35	50	2
		Case Studies in Clinical nanopharmacology & nanopharmacokinetics **OR** Publication - Research /Review **OR** Internship*					50	2
		Total					**600**	**24**
SEMESTER IV								
Dissertation						12	**300**	**12**
Total Semester Marks and Credits							**2050**	**82**

***Internship – this is undertaken in between II and III semesters. A report is submitted along with IV semester dissertation.**

 # Students to choose one elective from DSE II and DSC III

Abbreviations used in curriculum design:

DSC – Discipline Specific Core.
DSE – Discipline Specific Elective.
AECC – Ability Enhancement Compulsory Course.
SEC – Skill Enhancement Course.
Students may choose any one elective course among the offered choice, specific to the discipline

Semester One

SYLLBUS

SEMESTER I

Subject Code	DSC 01 Fundamentals of Biochemistry	L	T	P	Credits
	Hours	04	0	0	04

Course Objectives: The course aims to highlight the role of biomolecules in structure and function of life. It spans over the significance and methodology involved in characterizing major biomolecules.

Learning Outcomes: Students will be exposed to the history of Biochemistry and key contributions of scientists. They will study the properties of carbohydrates, proteins, lipids, cholesterol, DNA, RNA, glycoproteins and glycolipids and their importance in biological systems. They will understand the process of fermentation and manufacture of Biodiesel. They will understand the methods of determination of amino acid and nucleotide sequence of proteins and DNA respectively.

Unit I. Carbohydrates: Monosaccharides: Configuration and conformation of monosaccharides, Reducing and optical properties of sugars, Derived monosacharides; Amino sugars. Disaccharides: Stability of glycosidic bond. Polysaccharides: Homopolysaccharides and heteropolysaccharides, Structural polysaccharide; Storage polysaccharides; Stearic factors in polysaccharides folding, sugar code and lectin, Glycosaminoglycans, mucopolysaccharides; Bacterial cell wall – proteoglycans and peptidoglycans. Glycoproteins.

Unit II. Amino acids: Nomenclature, classification, and buffering properties of amino acids, zwitterionic structure, reaction of amino acids, unusual amino acids, non-protein amino acids. Peptides: Features of the peptide bond, naturally occurring peptides; Hierarchy of protein structure. Tertiary and quaternary structures: Protein folding: Anfinsen's experiment. Bonds in protein folding. Chaperones in protein folding and Levinthal paradox. Denaturation and renaturation of proteins. Protein-protein interactions. Structures of myoglobin hemoglobin, immunoglobulin, collagen, chymotrypsin and keratin.

Unit III. Lipids: Classification and biological role. Fatty acids – Nomenclature of saturated and unsaturated fatty acids. Physiological properties of fatty acids. Acylglycerols: Mono, di and triglycerols. Saponification, saponification value, iodine value, acid value and significance. Phosphoglycerides: Structure and roles of lecithin, cephalins, phosphotidylinosital, plasmalogens, and cardiolipin. Sphingolipids: Structure and importance of sphingomyelin. Glycosphingolipids: Structure and importance of gangliosides and cerebrosides. Eicosanoids: Structures and Biological roles.

Unit IV. Nucleic Acids: Nitrogenous bases: Purines, Pyrimidines; nucleosides, nucleotides, unusual bases. Physiochemical properties of nucleic acids. Difference between RNA and DNA. Chemical reactions of DNA and RNA. Secondary structure of DNA. Watson and Crick model; B and Z DNA, other models of DNA structure. Supercoiling of DNA. Denaturation and renaturation of Nucleic acids. Melting of DNA, Tm; factors affecting Tm, Cot curve, classification of DNA based on cot curve. DNA protein interactions. Genetic Code, Chargaff's rule. Types and roles of RNA, Secondary structure of tRNA: cloverleaf model.

Recommended Textbooks and References:

Biochemistry by L. Stryer (1995) W.H. Freeman Press, San Francisco, USA.
Biochemistry, by Voet, D. and Voet, J.G. (2004). 3rd Edition, John Wiley & Sons,
Biochemistry by L. Stryer (1995) W.H. Freeman Press, San Francisco, USA.
Biochemistry, by Voet, D. and Voet, J.G. (2004). 3rd Edition, John Wiley & Sons, Inc.USA.

Subject Code	DSC 02 Introduction to Nanotechnology	L	T	P	Credits
	Hours	03	01	0	04

Course Objectives: By the end of this course, students will understand the creation of, characterization of, and manipulation of nanoscale materials, systems, and devices and how they can be exploited for new applications. Students will learn about exciting applications of nanotechnology at the leading edge of scientific research. Students will apply their knowledge of nanotechnology to a topic of personal interest in this course.

Course Outcomes: This is an interdisciplinary and emerging area. The students are taught the basics of nanotechnology and their applications in various fields. The course introduces the students to the new and novel applications to solve biomedical problems through nanotechnology.

Unit I. Introduction to Nanotechnology: Introduction and scientific revolution. Emergence of nanotechnology with reference to Feynman. Nanoscale objects and broad applications of nanotechnology.
Properties and classes of Nanomaterials: Fundamental properties of nanomaterials – Size dependent properties, Comparison of bulk to nanoscale systems. Surface to volume ratio, quantum confinement – quantum wells and wires. Optical – Surface Plasmon Resonance, size effect on optical properties, magnetic, mechanical, thermal, electrical & electronic properties.

Unit II. Classes of Nanomaterials: Classes based on dimensionality - Zero-dimensional, one-dimensional and two-dimensional nanostructures. Carbon Nanotechnology - carbon molecules and nature of carbon bonds. Carbon allotropes. Discovery of C60 molecules. Carbon nanotubes and their fabrication. Applications of carbon nanotubes. Metal based nanomaterials.

Unit III. Cell Biology: Ultra structure of a cell and functions of organelles. Cell membrane structure and function. Lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes. Mitosis and meiosis, steps in cell cycle and its control. General principles of cell communication and junctions, cell adhesion and roles of different adhesion molecules. Cellular transport – Endocytosis and exocytosis.

Unit IV. Interaction of nanoparticles with biological Systems: Nanoparticle interactions at the cellular level. Biomolecule-nanoparticle interaction, Vorman effect. Nanoparticle-protein corona formation. Composition of protein corona complex. Mechanism of adsorption of proteins on nanoparticles. Parameters affecting protein corona complex.

Reference Books:

1. Nanotechnology: Basic Science & Emerging Technologies, Mick Wilson, Kamali, Kannangara & Geoff Smith, Overseas Press India Private Limited, 2005.
2. Amorphous and Nanocrystalline Materials: Preparation, Properties and Applications," A. Inoue & K. Hashimoto (Eds.), Springer, 2001.3.
3. T. Pradeep, A Textbook of Nanoscience and Nanotechnology, Tata McGraw Hill Education Pvt. Ltd., 2012.
4. Hari Singh Nalwa, Nanostructured Materials and Nanotechnology, Academic Press, 2008
5. C. Dupas, P. Houdy, M. Lahmani, "Nanoscience: Nanotechnologies and Nanophysics", Springer-Verlag. Berlin Heidelberg, 2007.

Subject Code	DSC 03 Synthesis of Nanoscale Materials	L	T	P	Credits
	Hours	03	01	0	04

Course Objectives: The objective through this subject is to make students understand various methods for the synthesis of nanomaterials.

Learning Outcomes: Upon successful completion, students will have the knowledge and skills to: Understand various chemical and physical methods for the synthesis of diverse types of nanomaterials. Decipher information on the specific details of both bottom up and top-down synthesis. Gather information on the different types of nanomaterials and their potential applications.

Unit I. Basic concepts in Nanofabrication and Lithography: Nucleation - Homo and Heterogeneous nucleation, surface nucleation, growth, grain size distribution, nanoparticle transport in low density media, coagulation of nanoparticles, determination of grain size, aggregate formation, mass fractal morphologies.

Unit II. Physical Synthesis: Introduction; thin film deposition and fundamentals of film deposition; thermal evaporation; spray and flame pyrolysis; molecular beam epitaxy; pulsed laser deposition; sputter deposition; different types sputtering processes; thermal forming processes; plasma processes; physical methods for the preparation of nanotubes, properties of nanotubes; plasma arcing; laser methods; pyrolytic synthesis; zeolites, layered silicates.

Unit III. Chemical Synthesis: Chemical vapor deposition (CVD); plasma-enhanced CVD; low pressure plasma CVD; metal-organic CVD (MOCVD); photo-enhanced CVD; electron enhanced CVD; Laser induced CVD; atmospheric pressure CVD; reactive ion etching (RIE); electrochemical synthesis of nanostructures. Sol-gel processing; sol-gel synthesis methods for oxides; other inorganics and nano composites; silica gel; zirconia and Yttrium gel; alumino-silicate gel. Mechanochemistry: grinding and milling devices.

Unit IV. Top Down and Bottom Up approaches: Top-down approach to nanolithography; immersion lithography, EUV photolithography; phase shifting masks; x-ray lithography, including plasma x-ray sources; e-beam and focused ion-beam lithography; photo resist technologies for the nanoscale. Soft lithography; nanoimprint lithography; wet etching, dry etching (isotropic, anisotropic), pattern growth techniques.
Bottom-up approach. Self-assembly; self-assembled mono layers; spontaneous formation & ordering of nano structures. Langmuir Blodgett films; electrochemical self-assembly of oxide/dye composites and biomineralization.
Biological Methods for nanostructure synthesis: Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles

Reference Text Books:

1. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
2. W. Gaddand, D. Brenner, S. Lysherski and G.J. Infrate(Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002.
3. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.
4. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Imperial College Press, 2004.
5. J. George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.

Subject Code	AECC Principles of Statistics	L	T	P	Credits
	Hours	02	0	0	02

Course Objectives

- To train the students intensively in both theoretical and practical aspects of statistics, to bring them in contact with basic concepts and methods
- To create a problem-solving attitude with the aid of statistical methodology.

Learning Outcomes

- Apply to construct frequency distribution and graphical methods.
- To calculate and apply measures of location and measures of dispersion.
- Perform Test of Hypothesis and understand the concept of p-values

Unit I. Descriptive Statistics: Importance and Scope of Statistics, Data Types, Variables, Frequency Distribution, Graphical Representation Methods (Histogram, Bar Charts, Pie Charts), Measures of Center Tendency (Mean, Median, Mode,) and Dispersion (Standard Deviation, Variance) Advantages and Disadvantages.

Unit II. Probability: Basic Terminology: Trial, Events, Sample Space and Sample Points, Basic Laws of Probability, Types of Probability, Normal probability curve, Standard Normal Distribution, Bayes theorem - simple problems.

Unit III. Sampling Methods: Concept of Population, Sample, Sampling, Sample Size, Sampling Error, Advantages and Disadvantages of Sampling Method, Types of Random Sampling Methods – SRS, Stratified Random Sampling, Systematic Random Sampling and Cluster Sampling.

Unit IV. Testing of Hypotheses: Statistical Hypotheses-Null and Alternative, Level of Significance, Type I and Type II Error, P Value, Degrees of Freedom, Chi-Square Test, Student's t Test: One Sample T Test and Paired and unpaired t Test, Analysis of Variance. Correlation-Karl Pearson's and Spearman's rank correlation. Regression Analysis.

Reference Text Books:

1. Fundamentals of Biostatistics. Veer Bala Rastogi. Publisher: ANE Books. 2nd Edition, 2009.
2. Fundamentals of Mathematical Statistics, S.C. Gupta and V. K. Kapoor, Publisher: Sultan Chand & Sons (2014).
3. Fundamentals of Statistics. S.C. Gupta. Publisher: Himalaya Publishing House Pvt. Ltd.Edition.7th Edition, 2012
4. Introductory Statistics for Biology. R. E. Parker. Publisher: Cambridge University Press 2nd Edition, 1991.
5. Statistics for behavioural science. Chintamani Kar. Publisher**:** Dominant Publishers & Distributors (P) Ltd. (2015).

Subject Code	SEC I Entrepreneurship	L	T	P	Credits
	Hours	02	0	0	02

Course Objectives: The course objectives are two-fold: (1) to develop an awareness and understanding of the range, scope, and complexity of issues involved in starting a technology business; and (2) to gain insight into how entrepreneurs conceive, adapt, and execute strategies to create new, successful businesses.

Learning Outcomes: At the end of this subject, students should be able to: 1. Explore and experience the joy of creating unique solutions to market opportunities 2. Create and exploit innovative business ideas and market opportunities 3. Turn market opportunities into a business plan 4. Build a mind-set focusing on developing novel and unique approaches to market opportunities 5. Demonstrate and present successful work, collaboration and division of tasks in a multidisciplinary and multicultural team 6. Demonstrate understanding and application of the tools necessary to create sustainable and viable businesses.

Unit I. General concepts in Entrepreneurship: Concept of Entrepreneurship. Characteristics and functions of an entrepreneur. Need and Significance of Entrepreneurship Development in Global contexts. Entrepreneurship Development – concepts, Process, Experience and strategies. Dynamics of Entrepreneurship Development.

Unit II. Entrepreneurship Quality / Motivation: The Entrepreneurship – Myths and Misconception, qualities, Characteristics and role demanded of an Entrepreneur, Process of Developing Entrepreneur Qualities Enterprise Launching & Resources: Government Programmes, Policies, Incentive and Institutional Networking for Enterprise setting, steps of setting new Enterprise, Scanning Business Environment, Sensing Business opportunity & Identifying Product.

Unit III. Business Plan Preparation: Procedure & Steps, Market Survey & Demand Analysis, Growth, Modernization & Expansion of Enterprise.

Unit IV. Small Business and its management: Pre-feasibility study - Ownership - budgeting - project profile preparation - Feasibility Report preparation - Evaluation Criteria - Market and channel Selection-Product launching - Monitoring and Evaluation of Business- Effective Management of Small business.

Reference Text Books:

1. Journals Relevant for this Course: The Journal of Entrepreneurship – Sage publications
2. The International Journal of Entrepreneurship and Innovation – Sage publications
3. Strategic Entrepreneurship Journal - Wiley Online Library International Journal of Entrepreneurship and Small Business – Inter Science.

Subject Code	Practical 1. Synthesis of Nanomaterials	L	T	P	Credits
	Hours	0	0	04	02

List of Experiments:

1. Synthesis of different sized Ag nanoparticles by aqueous method, Size distribution studies using DLS
2. Synthesis of different sized Au nanoparticles by aqueous method, Size distribution studies using DLS
3. Green Synthesis of Nanoparticles.
4. Chemical synthesis of CdSe Quantum dots with different sizes.
5. Band gap estimation of CdSe quantum dots by using optical spectroscopy
6. Exciton and plasmon interaction studies of Au-CdSe system by using optical spectroscopy.
7. Sol-gel synthesis of ZnO nanoparticles.
8. Analysis of optical properties of ZnO nanoparticles
10. Synthesis of SiO_2 polysphere film and morphology characterization using an Optical Microscope.
11. Synthesis of zno nanoparticles by Wet Chemical Precipitation
12. Synthesis of zero valent iron nanoparticles(fe3+) by Wet Chemical Precipitation
13. Synthesis of Polymerosomes by Water Oil Emulsification Technique
14. Synthesis of cadmium sulphide nanoparticles by Sol-Gel Method
15. Synthesis of pva/peg film by Spin Coating
16. ZnO thin film fabrication by Dip Coating Method
17. Synthesis of silver nanoparticles
18. Synthesis of zns nanoparticles
19. Fabrication of copper nanoparticles by Electrodeposition Techniques
20. Synthesis of Cu/PVA nanofibers by Electrospinning
21. Nanoarray Fabrication by Oxide Dot Fabrication
22. Synthesis of silver nanofibers
23. Herbal nanopowder fabrication by Ball Milling
24. Circuit fabrication by Manual Lithography Techniques
25. Thin film Fabrication by Spray Pyrolysis
26.Thin film fabrication by Physical Vapour Deposition
27. Nanopowder fabrication by Chemical Vapor Deposition

Subject Code	Practical 2. Cell & Molecular biology and Basic Human Anatomy and Physiology	L	T	P	Credits
	Hours	0	0	04	02

List of experiments

1. Cell Culture Techniques: Biosafety levels, basic equipment's for cell culture. Aseptic work areas. Cell culture hood and its function. Cell culture – selecting appropriate cell lines and culturing techniques.
2. Tissues – Visual observation of tissue permanent slides.
3. Virtual - Electrophoresis: Brief Introduction to types of electrophoresis Paper, Starch and Gel. Principles for Gel Electrophoresis- Agarose and Polyacrylamide.
4. Virtual - Western Blotting techniques
5. Virtual - Flow Cytometry: Principles, methods and applications of flow Cytometry, Fluorescence activated Cell sorting, BrdU Incorporation, Cells cycle analysis, Cell Sorting.
6. Virtual ELISA techniques (Demo).

Semester Two

SEMESTER II

Subject Code	DSC 04 Analytical Techniques	L	T	P	Credits
	Hours	04	0	0	04

Course Objectives: The course will highlight on the various analytical techniques to characterize the nanomaterials. The students will also gain hands on experience with the instrumentations.

Course Outcomes: To make students understand the importance of characterization of the synthesized nanoparticles, underlying principles of analytical techniques that are commonly used for the evaluation of properties of nanomaterials and compare with bulk properties. These include surface analysis technique FTIR spectroscopy; optical properties evaluation by UV-Vis spectroscopy; crystallographic phase identification by XRD; thermal properties evaluation using TGA and DSC; microstructure investigation by Electron microscopy (SEM and TEM); surface area analysis by BET surface area analyser, particle size- surface charge analysis by DLS and zeta potential techniques.

Unit I: Spectroscopy: Electromagnetic spectrum, Basic concepts and instrumentation in spectroscopy techniques, operational principle and application for analysis of nanomaterials

UV-Vis Spectroscopy - Beer's Law - Deviations and limitations. Qualitative and Quantitative Spectroscopy. Instrumentation for UV-VIS spectroscopy and its applications.
Fluorescence spectroscopy: Principles of luminescence, Phosphorescence and Chemiluminescence and their applications.
IR Spectroscopy: Principles of IR and FTIR. Microwave Spectroscopy and Electron Spin Resonance Spectroscopy and their applications.
Photon Correlation Spectroscopy: Interaction of light with matter. Light scattering – static & dynamic scattering. Brownian motion and Stokes Einstein Equation, hydrodynamic radius, Z-Average and Zeta potential.
Circular Dichroism Spectroscopy: Definition of asymmetry & optical activity, Basic concepts of polarized light, types of polarized light, CD instrumentation, sample preparation and measurement. CD of proteins and interpretation. Applications of CD.

Unit II. Structural Characterization: X-ray diffraction, Small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM). Brunauer-Emmett-Teller (BET) Surface Analyzer – principles of BET and applications.

Mechanical and Thermal Characterization: Thermogravimetric analysis, Differential scanning calorimetry, Glass transition temperature, Dynamic mechanical thermal analysis.

Unit III. Surface Characterization: X-ray Photoelectron Spectroscopy (XPS), Auger electron spectroscopy, Low Energy Ion Scattering Spectroscopy (LEISS), Secondary Ion Mass Spectroscopy (SIMS), Rutherford Backscattering Spectroscopy (RBS).

Unit IV. Advanced Instrumentation and Imaging: Raman and SERS, principle and applications. Biomedical SERS using nanoshells. Mass Spectrometry: Principles, ionization methods. Single and quadrupole, TOF. Mass spectroscopy applications in nanotechnology. Principles of NMR.

Reference Text Books:

1. Spectrometric Identification of Organic compounds - Robert M Silverstein, Sixth edition, John Wiley & Sons, 2012.
2. Principles of Instrumental Analysis - Doglas A Skoog, F. James Holler, Timothy A. Nieman, 5th edition, Eastern press, Bangalore, 2014.
3. Vogel's Text book of quantitative chemical analysis - Jeffery, Basset, Mendham, Denney, 5th edition, ELDS, 2011.
4. Chromatographic Analysis of Pharmaceuticals, John A. Adamovics, 2nd Edition. 2011
5. Practical Pharmaceutical Chemistry, Part two, A. H. Beckett & J. B. Stenlake – 4th Edition. 2017
6. Instrumental Methods of Chemical Analysis – B. K. Sharma – 9th Edition. 2010
7. Instrumental Methods of Analysis – Hobert H. Willard, 7th Edition. 2014.

Subject Code	DSC 05 Biomedical Nanotechnology	L	T	P	Credits
	Hours	04	0	0	04

Course Objectives: This course aims to develop your understanding of micro/nanotechnology for applications in biomedical field including nanomedicine, medical diagnostics, pathways to molecular manufacturing, molecular transport, and nanosensors for medical applications. The knowledge will prepare you for the potential further training in biomedical research, and development in bioengineering/medical industry.

Learning Outcomes: By the end of this chapter, the student is expected to learn, understand and describe the principles of biomedical nanotechnology. State the contents of biomedical engineering and identify the challenges of current technologies for a specific biological or medical problem and analyse these challenges. Overcome these challenges with nanotechnologies and present convincingly on the nanotechnologies.

Unit I. Structural DNA Nanotechnology: Structure of DNA. DNA origami and development, Dynamic DNA nanodevices - stimuli responsive DNA nanodevices, Delivery of DNA based nanodevices. Aptamers, DNA nanoswitches DNA nanozymes and self-replicating DNA nanostructures. Applications of DNA nanotechnology.

Unit II. Microfludics: Principles of miniaturization, theory of microfluidics. Diffusion of molecules and microscale mixing. Technological production of components – mixers and pumps. Fundamentals of electrical/electrochemical effect of microfluidics. AC and DC fields in microsystems: electrochemical osmosis, di-electrophoresis and electrophoresis. Soft Lithography, novel methods and fabrication of lab-on-chip device. Detection methods – electrical, optical and thermal. Diagnostic systems – medical systems. Separation, purification, concentration technologies. Simulation and design of mixing devices for chemical reactors.

Unit III. MEMS and NEMS Microfabrication: Historical Development of Microelectronics, Evolution of Microsensors, Evolution of MEMS, Emergence of Micromachines, Modeling - Finite Element Analysis, CAD for MEMS, Fabrication – ALD, Lithography Micromachining, LIGA and Micromolding, Saw-IDT Microsensor Fabrication, Packaging – Challenges, Types, Materials and Processes. Materials for mems and pro mems-silicon-metals and Polymers-Substrate Materials for MEMS Silicon-Quartz-Ceramics-Bulk Metallic Glasses-Sharp Memory alloys, Carbon based MEMS

Unit IV. Nanostructures for Imaging: Practical and theoretical aspects of imaging biological systems, from the cellular level through to whole-body medical imaging, basic

physical concepts in imaging. Major techniques using ionising and non-ionising radiation including fluorescence and multi-photon microscopy, spectroscopy, OCT, MRI, X-ray CT, PET, Confocal and SPECT imaging.

Reference Text Books:

1. Geschekke (2004). Microsystems Engineering of Alb-on-a-chip devices. Wiley.
2. Tabeling (2005). Introduction to Microfludics. Oxford publications.
3. Ken Gilleo. MEMS/MOEMS Packaging: Concepts, Designs, Materials and Processes. McGraw-Hill, 2005.
4. Marc Madou, Fundamentals of Microfabrication, CRC Press 1997.
5. MEMS and Microsystems design and manufacture, Tai-Ran Hsu, Tata Mc Graw Hill. 2011.
6. Sergey Edward Lyshevski, Nano- and Microelectromechanical Systems, CRC Press. 2000
7. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw-Hill 2001.

Subject Code	DSC 06 Industrial Nanotechnology	L	T	P	Credits
	Hours	04	0	0	04

Course Objectives: This objective if this course is to provide an understanding and importance about nanotechnology for students in various areas. The course will give an over view about the use of nanotechnology in textile, food, agriculture and other industries.

Learning outcomes: This course is application oriented. Students will learn the overview of wide range of applications of nanotechnology in various industries – electronic industries, textile, security systems, food and packaging.

Unit I: Nanophotonics: Photonics and Nanophotonics. Fundamentals and Principles of nanophotonics. Fabrication of nanophotonic device. Optical fabrication technology and application of nanophotonic devices, solar cells, OLED – SMOLED and PLED.

Unit II: Nanotechnology in Textiles industry: Nano-engineered textiles – water and oil repellence. Anti-static properties, wrinkle resistance, strength enhancement, UV-blocking, anti-bacterial properties. Conductive nanomaterials in textiles. Photonic technologies for textiles, Plasmonic textiles. Color tunable optical fibers. Sensing and drug release in textiles. Consolidation of nanotechnology in the textile market and textile industry related case studies.

Unit III. Nanotechnology in Forensics and defense systems: Use of carbon nanotubes for DNA analysis. Nano-trackers. Gold nanoparticles in drug facilitated crimes. Fluorescent nanoparticles to estimate time of death.
Defense: Military applications of Nanotechnology - Artificial intelligence materials – Propulsion. Vehicles - Propellants and Explosives – Camouflage distributed sensors – Amour protection - Conventional weapons - Soldier systems - Implanted systems, Body manipulation - Autonomous systems - Mini-/Micro robots - Bio-technical hybrids – Small satellites and Space launchers - Nuclear weapons - Chemical weapons – Biological weapons - Chemical/Biological protection. Mirage effect using carbon nanotubes

Unit IV. Nanotechnology in Agriculture and Food Production: Conventional agriculture practices and role of nanotechnology in modern day agriculture practices – nano-fertilizers and precision farming. Nanotechnology and shelf life of agricultural and food

products. Nanotechnologies for water quality and availability. Reverse osmosis using nanotechnology applications. Green nanotechnology and the role of good governance and policies for effective nanotechnology development.

Applications of Nanotechnology in Foods: Sensing, Packaging, Encapsulation, Engineering Food Ingredients to Improve Bioavailability – Nanocrystalline Food Ingredients – Nano-Emulsions -Nano-Engineered Protein Fibrils as Ingredient Building Blocks -Preparation of Food Matrices – Concerns about Using Nanotechnology in Food Production.

Reference Text Books:

1. P. J. Brown and K, Stevens, Nanofibers and Nanotechnology in Textiles. CRC Press, 2007.
2. YW. Mai, Polymer Nano composites. Woodhead publishing, 2006.
3. W.N. Chang. Nanofibres fabrication, performance and applications. Nova Science Publishers Inc, 2009.
4. Joseph H. Koo. Polymer Nanocomposites, Processing, characterization and Applications, McGraw-Hill. Prasand, V. (2020).
5. Role of nanomaterials for forensic investigation and latent fingerprinting- a review. Journal of Forensic Science. 65 (1), 26-36.

Subject Code	DSE I 1.1. Nanotechnology for Regenerative Medicine	L	T	P	Credits
	Hours	03	01	0	04

Course Objectives: The objective of this subject is to provide extensive theoretical knowledge in stem cell technologies and tissue engineering. The aim of this subject is to prepare students to build up their research acumen in stem cell technology so that they can readily integrate into the scientific workforce in stem cell industry and meet the needs of highly qualified technical personnel

Learning Outcomes: It is expected that the students will gain knowledge about stem cell technology and increasing applications of nanotechnology in stem and tissue engineering. Stunts will learn major components of tissue engineered scaffolds. The students will also learn the need for regenerative medicine and role of nanomaterials in mimicking the extracellular matrix.

Unit I. Stem Cells Technology: Stem cells and their properties. Classification and types. Stem cell differentiation in lineages. Stem cell culturing methods. Ethical and legal issues in use of stem cells. Potential benefits of stem cell technology

Unit II. Nanotechnology for stem cell culture: Nanoparticles for stem cell isolation, stem cell tracking, regulation in microenvironment, macromolecule delivery systems and regulation of stem cell behavior and nanoparticles for stem cell imaging.

Unit III. Nanotechnology in Tissue Engineering: Introduction to tissue engineering and extracellular matrix. Biomaterials in tissue engineering and micro & nanoscale structuring. Osteoinductive and osteoconductive biomaterials - bioactive glasses, metal based, polymers, composites, carbon nanotubes. Surface and biomechanical properties.

Unit IV. Nanotechnology for Regenerative medicine: Scaffolds - Three dimensional and bio-mimicking scaffolds. Electrospinning techniques for tissue scaffolding for tissue regeneration. Spheroids and Organoid formations and bioreactors. Relevant case studies and research.

Reference Text Books:

1. Stem cell biology and Gene Therapy by Peter Quesenberry., First Edition, Wiley-Liss, 1998.
2. Embryonic Stem cells – Protocols by Kursad Turksen., Second Edition Humana Press, 2002.
3. Stem Cells: From Bench to Bedside by Ariff Bongso, Eng Hin Lee., World Scientific Publishing Company, 2005.
4. Stem cells in clinic and Research by Ali Gholamrezanezhad., Intech, 2013.

Subject Code	DSE I 1.2 Nanotechnology for Energy Systems	L	T	P	Credits
	Hours	04	0	0	04

Learning Objectives: The students from physic background and all interested students, are encouraged to learn about the importance of non-conventional energy systems and a key role played by nanotechnology in developing cost effective energy systems.

Learning Outcomes: It is expected that the student will gain knowledge on nanotechnology based alternative energy systems. The student will get to learn about advanced materials for renewable & green energy and energy storage techniques. The students will learn the role of nanotechnology in improving the efficiency in energy usage.

Unit I. Solar radiation and Renewable Energy: Solar radiations – its availability and as a source of energy. Mechanism for its entrapment. Measurements and limits of solar energy entrapment. Flat plate collectors and solar concentrators. Photovoltaic device, dye sensitized solar cells, silicon technology for solar cells – first, second and third generation solar cells. Photo electrochemical cells for hydrogen production. Energy challenges, Development and implementation of renewable energy technologies. Nanotechnology enabled renewable energy technologies. Energy storage and conversion devices. Solar/photovoltaic cells as a source of green energy.

Unit II. Design of photovoltaic cell: Design and Implementation aspects of photovoltaic energy generation and consumption; Solar cell technologies (Si-wafer based, Thin film, GaAs based, dye-sensitized, PESC and organic solar cells), Efficiency of solar cells and photovoltaic array analysis, Photovoltaic system design (stand alone and grid connected) and applications.

Unit III. Hydrogen Storage Technology and fuel cell: Hydrogen storage methods, Metal hydrides, hydrogen storage capacity, hydrogen reaction kinetics. Carbon free cycle. Gravimetric and volumetric storage capacitor. Hydrogen air systems.

Unit IV. Fuel cell: General design features, fuel cell performance, the MEA and current/voltage curve, MEA components and the fuel cell stack. Sizing of a fuel cell stack, stack configuration, uniform distribution of reactants inside each cell, heat removal from a fuel stack and stack clamping. Fuel cell modelling and fuel cell design. Fuel cell systems with fuel processor, electrical subsystems and system efficiency. Fuel cell Applications - Transportation applications, stationary power, backup power and fuel cells for small portable

Reference Text Books:

1.Energy systems and nanotechnology by Dharmendra Tripathi and RK Sharma. Springer Publications. 2021. ISBN: 978-981-16-1256-5
2. Nanotechnology for Energy and Environmental Engineering by Lalita Ledwani. Springer Publications. 9783030337735. 2020.
3. Nanomaterials in Energy Devices by Jun Hieng Kiat. CRC Press LLC. 1498763510. 2017.
4. Nanoenergy. Nanotechnology Applied for Energy Production. **Souza,** Flavio L**., Leite**, Edson R (Eds.). 10.1007/978-3-319-62800-4. 2018.
5. Fuel Cell Technology Hand Book, Edited by Gregor Hoogers, CRC Press.
6. PEM Fuel Cells: Theory and practice by Frano, Elsevier Academic Press.
7. Fuel cells principles and applications by B. Viswanathan and M. Aulice Scibioh, Universal Press. (India) Private Limited, Hyderabad.
8. Fuel Cell Systems Explained, second edition, by James Larminie and Andrew Dicks, John Wiley & Sons Ltd.

Subject Code	DSE I 1.3. Cancer Nanotherapeutics	L	T	P	Credits
	Hours	03	01	0	04

Course Objectives*:* This course mainly aims on highlighting the advances in cancer nanotherapeutics. The main objective of this course is to impart knowledge on cancer developmental stages, Drug Delivery Concepts in nanoscience for cancer, latest advances in cancer nanotherapeutics.

Learning Outcome: It is expected that the students learn the molecular processes in cancer development, the conventional therapies for cancer and the role of nanomedicine that has improved cancer therapies.

Unit I: Biology of cancer development: Different forms of cancer, principles of carcinogenesis, and principles of cancer metastasis and clinical significance. Metastatic cascades, basement membrane disruption. Three step theory of invasion. Signalling mechanism and tumor microenvironment. Oncogenes and identification of oncogenes. Cell cycle and its regulation, apoptosis, DNA damage and repair mechanism, cell death, epigenetic regulation of gene expression. Types of cancer therapies, Mutations and drug resistance.

Unit II. Precision Cancer Nanotherapy: Enhanced Permeation and Retention based therapies. Passive and active targeting in solid tumors and cancer. Pathophysiological principles and physicochemical aspects of delivery systems. Multifunctional nanoparticles for cancer therapy and neutron capture therapy of cancer: nanoparticles and high molecular weight boron delivery agents. Investigational and approved nanomedicine products. Doxil and abrexane formulation, mechanism of action, internalization and pharmacokinetics. Cancer nanotherapeutics in clinical trials. Molecular-targeted nanotherapies for cancer - Nanoparticles based siRNA therapies and Immunotherapies.

Unit III. Nanotechnology in Hyperthermia based cancer therapy: Over view of hyperthermia, whole body hyperthermia, basics of hyperthermia cancer treatment, nanoparticle mediated hyperthermia in cancer therapy. Gold and magnetic nanoparticles for hyperthermia. Neel and Brownian relaxation in magnetic nanoparticles.

Unit IV. Chemo and radio sensitization using nanotechnology: Chemo/radio-sensitive and resistant, tumors, novel approaches to sensitize tumors, thermal chemo-sensitization, chemo and radio sensitization strategies, radio-sensitizing chemotherapy. Nanoparticles in radiotherapy, nanoparticles based brachytherapy spacers, hydrogel spacers, and smart brachytherapy spacers for combined chemo-radiotherapy and drug eluting brachytherapy spacers.

Reference Text Books:

1. Cancer Chemotherapy. Dr. Rajat Kheri. Edition 2011, VDM, Verlag Publishers.
2. Nanoparticle-Based Medicines: A Review of FDA-Approved Materials and Clinical Trials to Date. 2016, A review.
3. George C. Prendergast, 2015, Molecular Cancer Therapeutics: Strategies for Drug Discovery and Development. Wiley.
4. Rajaventhan Srirajaskanthan, Victor R. Preedy, 2017 Nanomedicine and Cancer. CRC Press
5. Anshu Mathur, 2016 Nanotechnology in Cancer, 1st Edition. Elsevier

Subject Code	SEC II. Path for Translation Science: Lab to Clinic	L	T	P	Credits
	Hours	02	0	0	02

Course Objectives: The course will focus on the nanotechnology based drug development process. It will discuss the development of nanoparticles drug formulation from conception in a lab to production, patenting, patent laws in India. The course will also give an insight into entrepreneurship development, startups, economics and manufacturing and production stages.

Learning Outcomes: This course discusses the strategies needed for successful commercialization of nanoscale products. The students learn about business development, capital generation for business, IP rights, Patent aspects and economics of product development. At the end of the course, the student will be able to demonstrate a command on all aspects involved in commercialization of nanotechnology-based product.

Unit I. Drug Development as model for technology transfer: Modern aspects of drug discovery, process of drug discovery and development. In vitro and in vivo and GLP testing.

Unit II. Technology Transfer Process: Invention Disclosure, evaluation, patent application, Assessment and marketing, Licensing of patents and commercialization.

Unit III. Preclinical and Clinical Research: Ethics and designing animal testing, PK/PD, animal toxicity studies. Clinical study protocols and study plans & requirements, human ethical clearance and phase trials.

Unit IV. FDA Regulations: IND and NDA filing, proposed labeling, Safety updates, Drug abuse information, Patent information, any data from studies that may have been conducted outside the United States. Institutional review board compliance information.

Reference Text Books:

1. Clinical and Translation Science by David Robertson. Academic Press. ISBN 9780128021118. 2016.
2. Principles of translational medicine in science by Mike Wehling. Academic press ISBN 9780323999625. 2021.
3. Pharmaceutical Medicine and Translational Clinical Research by Divya Vohora, Gursharan Singh. Academic press. ISBN 0128020989. 2017.
4. Preclinical Development Handbook. Editor(s): Shayne Cox Gad Ph.D., D.A.B.T. Print ISBN:9780470248461. 2008

Subject Code	DSE II. 2.1. Dental Nanomaterials	L	T	P	Credits
	Hours	02	0	0	02

Course Objectives: The objective of this interdisciplinary subject is to make all students aware of role of nanotechnology for the managements and treatment of dental pathologies and restoration of dental esthetics.

Learning Outcomes: The students will learn about applications of nanotechnology in dental pathologies. Encourage students for advancement of nano-dental research.

Unit I. Nano dentistry: Over view of pathological issues in dentistry. Nanodentistry as a bottom up approach. Paradigm shift in dental applications.

Unit II. Nanomaterials for Restorative and Conservative Dentistry: Dental caries and types. Prevention measures and re-mineralization. Nanocomposites for restoration. Fluoride based nanocomposites for restoration.

Unit III. Dental Restoration using nanomaterials: Nano-ionomers/cements, nanoparticle reinforced resin based composites, Resin matrix – Bis GMA and TEGDMA, UDMA. Epoxy resin nanocomposites. Nano fillers, nano-hybrids and coupling agents and their mechanical properties. Antibacterial nano-therapy ZnO, TiO_2, Zr and AuPs, silver and phosphate nanoparticles as antimicrobial and caries preventers. Phosphate nanoparticles for caries prevention. Nano-phosphates and microbial adhesion.

Dental intervention: Nanomaterials based enodontic sealers. Nanomaterials for dental tissue regeneration and skeletal applications of silica nanoparticles in modelling and remodeling. Nanocomposite surface coatings and mechanics.

Unit IV. Nanomaterials for periodontics and prosthodontics: Nanomaterials for bone regeneration, Osteo-inductive and osteo-conductive nanomaterials. Nanomaterial based implants and implant surfaces. Nanomaterials as biofilm disruptors. Nanomaterials for periodontal therapeutics for ex GTR, GBR membrane, nanosensor, materials for laser dentistry. Dental stomatitis and metal alloy combinations for dentures.

Smart Dental Materials and clinical case studies: Resin-modified nano-glass ionomer composites, Nanoparticles-based GIC, bioactive nanomaterials. Nano-resorbable materials and theranostic nanoparticles and pain management. Application of. nano-impression materials and artificial teeth and newer dentin nanomaterials. Biomimetic for dentistry. Case studies on the use of nanoparticle based dental materials

References Text Books:

1.Emerging Nanotechnologies in Dentistry. 2nd Edition. Processes, Materials and Applications. Karthikeyan Subramani Waqar Ahmed. ISBN**:** 9780128122914. Elsevier.
2. Applications of Nanocomposite Materials in Dentistry by Abdullah M Asiri. Elsevier Science. ISBN: 9780128137598. 2018.

Subject Code	DSE II. 2.2. Nanosensors	L	T	P	Credits
	Hours	02	0	0	02

Course Objectives: This subject offers a survey of timely concepts in the rapidly emerging field of nanotechnology for medicine. This course will introduce basic principles underlying nanodevices and nanosensors technology for therapeutic purposes.

Learning Outcomes: Upon completion of this subject, a student will have basic knowledge on fabricating bionanosensors.

Unit I. Sensors: Definition of sensors; main elements of sensors; similarities between living organisms and artificial sensors; working mechanism of physical sensation (seeing, hearing, and feeling) and chemical sensation (smelling and tasting); the parameters used for characterizing the performance of sensors: accuracy, precision, sensitivity, detection limit, dynamic range, selectivity, linearity, resolution, response time, hysteresis, and life cycle.

Unit II. Nanosensors: Introduction to sensors. Characteristics and terminology - static and dynamic characteristics. Micro and nano-sensors, Fundamentals of sensors, biosensor, micro fluids, Packaging and characterization of sensors, Sensors for aerospace and defense. Organic and inorganic nanosensors – Metal & metal oxide based, quantum dot, nanowire, nanotube, mass sensitive nanosensors. Nanomaterials and nanostructured films, Nanoscale electronic and ionic transport. Sensor for bio-medical applications. Nanoparticle-biomaterial hybrid systems for sensing applications and Gas sensor.

Unit III. Biosensors: Magnetic Nanoparticles for Imaging and Therapy, Photodetectors, Nanophotonics. Nanoelectronic Devices. Biosensors, Clinical diagnostics, generation of biosensors. Nanomaterial based biosensors. Biosensors based on nucleotides and DNA.Electron transfer of biomolecules.

Unit IV. Biomolecules as nanosensors: Role of protein in nanotechnology, protein nanodevices, antibodies in sensing - antibody in nanoparticle conjugates. Enzymes in sensing & ezyme nanoparticle hybrid sensors. Nanosensors based on Nucleotides and DNA – Structure of DNA and DNA protein conjugate based sensors.

Reference Text Books:

1. Kourosh Kalantar – Zadeh, Benjamin Fry, “Nanotechnology- Enabled Sensors”, Springer,
2. H. Rosemary Taylor, “Data acquisition for sensor systems”, Chapman & Hall, 1997.
3. Jerome Schultz, Milan Mrksich, Sangeeta N. Bhatia, David J. Brady, Antonio J. Ricco, David
4 R. Walt, Charles L. Wilkins, “Biosensing: International Research and Development”, Springer,
5. Ramon Pallas-Areny, John G. Webster, “Sensors and signal conditioning” John Wiley & Sons, 2001. 6. Vijay.K. Varadan, Linfeng Chen, Sivathanupillai, “Nanotechnology Engineering in Nano and Biomedicine”, John Wiley & Sons, 2010.3.

SEMESTER II – PRACTICALS

Subject Code	Practical 3. Analytical Techniques	L	T	P	Credits
	Hours	0	0	04	02

List of Instrumentation techniques for Training

1. UV/VIS Spectroscopy and Spectrophotometry: Spectrophotometric Analysis of Potassium Permanganate Solutions.
2. Calibration curve preparation using UV and HPLC.
3. FTIR analysis of bulk and nanomaterials
4. Thin Layer Chromatography and Column Chromatography
5. HPLC method development
6. Dynamic Light Scattering techniques
7. Principles of Circular Dichroism
8. SEM and TEM - Virtual Labs
9. Mass Spectrometry - Real time or virtual labs
10. Principles of NMR
11. Differential Scanning Calorimetry and TGA measurements
12. Imaging systems for cells and small animals.

Subject Code	Practical 4. Surface Modifications of Nanomaterials	L	T	P	Credits
	Hours	0	0	04	02

1. Surface modification of silica nanoparticle using dichlorodimethylsilane for preparation of self-cleaning coating.
2. Surface modification of PLGA nanoparticles by carbopol to enhance mucoadhesion.
3. Preparation, Characterization, and Surface Modification of Trifluoroethyl Ester-Terminated Silicon Nanoparticles
4. A Gold Nanoparticle-based Lab Experiment Sequence to Enhance Learning in Biomedical Nanotechnology.
5. Surface Modification of Magnetic Iron Oxide Nanoparticles for imaging purposes.
6. Surface modification and phase transfer of nanoparticles.
7. Self-Assembly of Gold Nanoparticles at the Surface of Amine- and Thiol-Functionalized Boron Nitride.
8. Surface Modification of CuS Nanoparticles
9. Surface-modified nanoparticles and nano-filled antibacterial dental adhesive resins.
10. Bio conjugation experiments.

Semester Three

III SEMESTER

Subject Code	DSC 07 Advanced Drug Delivery Systems	L	T	P	Credits
	Hours	03	01	0	04

Objectives: The objective of this subject is to make students learn about fundamentals of drug delivery systems. To study the materials and techniques used in delivery systems and to learn about Recent development in the area of devices and therapy

Learning Outcomes: Upon successful completion of this subject, a student will be able to understand the concepts of various routes of conventional and nano-drug delivery systems. The student will also get an idea about pharmacology of nanotherapeutics given for various diseases.

Unit I. Principles of Drug Delivery Systems: Modes of drug delivery. Kinetics of drug delivery, controlled drug delivery – site specific delivery, Strategies for site specific, stimuli responsive, time and rate controlled delivery of drugs. Antibody and metabolism based drug delivery systems. Drug release kinetics with mathematical modelling.

Unit II. Targeted nanoparticles for Drug Delivery: Classification of targeted drug delivery systems, Nanoparticles surface modification – bio conjugation and PEGlytion, Antibody cell specific targeting. Multifunctional gold nanoparticles for drug delivery

Unit III. Polymers Drug Carriers: Classification of polymers based nanoparticles**.** Dendrimers- Synthesis -Nanoscale containers- Dendritic Nanoscafold Systems- Biocompatibility of Dendrimers, Gene transfection. pH based targeted delivery- chitosan and alginate. Copolymers in targeted drug delivery- PCL, PLA, PLGA.
Lipid Based Nanocarriers: Liposomes, niosomes and solid lipid nanoparticles. Ligand based delivery by liposomes and cubosomes.

Unit IV. Smart Drug Delivery Systems: Thernostic metal nanoshells, photothermally modulated drug delivery, hydrogel composites, nanoporus microsystems for islet cell replacement. Molecular derived therapies – transdermal drug delivery using low frequency sonophoresis. Nanoporus implants for controlled drug delivery.

Reference Text Books:

1. Drug Delivery and Targeting, A.M. Hillery, CRC Press, 2002.
2. Drug Delivery: Engineering Principles for Drug Therapy, M. Salzman, Oxford University Press, 2001.
3. Drug Delivery: Principles and Applications, B. Wang, Wiley Intersceince, 2005.
4. Nanoparticle Technology for Drug Delivery, Ram B. Gupta, Uday B. Kompella Taylor & Francis, 2006.
5. Srinivasan A. 2013. Industrial and Engineering Chemistry. ACS publications

Subject Code	DSC 08 Clinical Pharmacology	L	T	P	Credits
	Hours	03	01	0	04

Course Objectives: The objective through this subject is to give an understanding of drug interaction with body when it enters inside, drug metabolism, mechanism of action and excretion from body. A comparison will be made between conventional and nano-formulated drugs in vivo.

Learning Outcomes: After successful completion of the course student will be able to understand the concepts and applications of pharmacology, pharmaceutics, pharmacodynamics of nanotherpies and will be able to apply knowledge gained in developing various formulations as per requirements. The student will also be able to analyse various evaluation parameters for oral, parenteral, topical.

Unit I. Pharmacokinetics Profiles: Principles of pharmacokinetics – ADMET. Drug Administration, drug transport across membrane, drug absorption, distribution, biotransformation and excretion. Bioavailability and first pass metabolism. Clinical Pharmacokinetics and compartment models – compartment and non-compartment models.

Unit II. Pharmacodynamics: Relationship between drug exposure and effect. Drug-receptor interaction, generation of effects, factors affecting dose-response relationship, Classes of receptors, signal transduction and its pharmacological modulation. Comparison of Pharmacokinetics (PK) and Pharmacodynamics (PD) of Free and Encapsulated Drug in Nanoparticles. *In vivo* case studies of nanoformulated drugs. Factors that influence pharmacokinetics of nanodrugs. Pharmacokinetics and Pharmacodynamics issues in Nanotechnology

Unit III. Protein and tissue binding: Tissue distribution and permeability. Factors affecting protein binding, kinetics of protein binding, determination of rate constant and different plots (direct and reciprocal). Implication of protein binding on pharmacokinetic parameters. Kinetics of proteins binding, clinical significance of protein-drug binding. Drug interactions: introduction, the effect of protein binding interactions, the effect of tissue-binding interactions, cytochrome p450-based drug interactions and drug interactions linked to transporters**.**

Units IV. Nanopharmacology: Definition, nano-pharmacology targets and drug targeting to particular organs. Target drug interactions and monitoring the interaction outcomes. Bioequivalence and clearance.

Recommended Text books:

1. Applied Biopharmaceutics & Pharmacokinetics, by Shargel, L., S. Wu-Pong
2. Biopharmaceutics and Pharmacokinetics: An Introduction by Notari, R. E.
3. Introduction to Biopharmaceutics, by Gibaldi, M.
4. Biopharmaceutics and Relevant Pharmacokinetics, by Wagner, J. G.
5. Textbook of Biopharmaceutics and Clinical Pharmacokinetics by Niazi, S.K.
6. Handbook of Bioequivalence Testing, by Niazi, S. K.
7. Modeling in Biopharmaceutics, Pharmacokinetics, and Pharmacodynamics: Homogeneous
and heterogeneous Approaches, by Macheras, P. and A. Iliadis
8. Comparative Pharmacokinetics: Principles, Techniques and Applications, by Riviere, J.

Subject Code	DSC 09 Nanotoxicology	L	T	P	Credits
	Hours	03	01	0	04

Course Objectives: The objective through this subject is to make students learn and understand various concepts of toxicity, and its effects. To help them gain knowledge about the toxicity in Nanoscience, and their effects on Human. To enhance knowledge on the nanotoxicology - prevention and remedies. To understand and comprehend the toxicology of nanomaterials and responsibility when using nanotechnology in medicine or any other area of research.

Learning Outcomes: It is expected that the student will get knowledge on nanotoxicology and their effects on human and animals. The student will acquire knowledge about various prevention methods. Students will gain knowledge on remedies.

Unit I. Introduction to Toxicology: Concept of Toxicology-Types of toxicity based on route of entry, nature of the toxin. Toxicodynamics–Dose vs Toxicity Relationships. Toxicokinetics – ADME, LADMET hypothesis. Genotoxicity and carcinogenicity – Mechanisms and Tests. Organ toxicity – Respiratory, dermal, hepato, neuro and nephro toxicity.

Unit II. Nanotoxicology: Characteristics of Nanoparticles that determine Potential Toxicity. Bio-distribution of nanoparticles. Interaction of Nanoparticles with Biomembrane and genes. Evaluation of Nanoparticle transfer using placental models. Nanomaterial toxicity – Pulmonary, dermal, hepato, neuro, ocular and nephro; Estimation of Nanoparticle Dose in Humans. In vitro toxicity studies of ultrafine diesel exhaust particles; Toxicity studies of carbon nanotubes.

Unit III. Protocols in Toxicology Studies: Methods for toxicity assessment – Cyto, Geno, hepato, neuro, nephrotoxicity. Assessment of toxicokinetics. Assessment of oxidative stress and antioxidant status.

Unit IV. Animal Models and Risk Assessment & Execution: Types, species and strains of animals used in toxicity studies. Dosing profile for animal models. Studies on toxicology, pathology and metabolism in mouse and rat. Laws and Regulations Governing Animal Care and Use in Research. Risk assessment of Nanoparticle exposure. Prevention and control of nanoparticles exposure. Regulation and recommendations.

Reference Text Books:

1. A Reference handbook of nanotoxicology by M. Zafar Nyamadzi 2008. 2. Andreas Luch, Molecular, Clinical and Environmental Toxicology Volume. Clinical Toxicology', Birkhauser Verlag AG 2010.
2. John H. Duffus, Howard G. J. Worth, 'Fundamental Toxicology', The Royal Society of Chemistry 2006.
3. Lucio G. Costa, Ernest Hodgson, David A. Lawrence, Donald J. Reed, William F. Greenlee, 'Current Protocols in Toxicology', John Wiley & Sons, Inc. 2005.
4. Nancy A. Monteiro-Riviere, C. Lang Tran., 'Nanotoxicology: Characterization, Dosing and Health Effects', Informa Healthcare publishers, 2007.
5. P. Houdy, M. Lahmani, F. Marano, 'Nanoethics and Nanotoxicology', Springer-Verlag Berlin Heidelberg 2011. 7. Shayne C. Gad, 'Animal models in toxicology', Taylor & Francis Group, LLC 2007.
6. Nanotoxicology - Interactions of Nanomaterials with Biological Systems by Yuliang Zhao and Hari Singh Nalwa. ISBN: 1-58883-088-8. Case Studies in Nanotoxicology and Particle Toxicology. Antonietta M. Gatti and Stefano Montanari. ISBN 978-0-12-801215-4. 2015.

Subject Code	DSE III. 3.1. Nanocomposites	L	T	P	Credits
	Hours	04	0	0	04

Course Objectives: The objective is to learn about Fundamentals of nanocomposites and to study the materials and techniques used preparation of composites and to learn about recent developments and commercial applications nanocomposites.

Learning Outcomes: It is expected that the students will gain knowledge in basics of nanocomposites. Students will gather idea about materials and techniques used preparation of composites. Students will acquire information about recent trends of nanocomposites application and various fields.

Unit I. Basics of nanocomposites: Nomenclature, properties, features and processing of nanocomposites. Sample preparation and characterization of structure and physical properties. Designing, stability and mechanical properties and applications of super hard nanocomposites.

Unit II. Metal Based Nanocomposites: Metal-metal nanocomposites, some simple preparation techniques and their properties. Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Fractal based glass-metal nanocomposites, its designing and fractal dimension analysis. Electrical property of fractal based nanocomposites. Core-Shell structured nanocomposites.

Unit III. Polymer Based Nanocomposites: Preparation and characterization of di-block Copolymer based nanocomposites; Polymer carbon nanotubes based composites, their mechanical properties, and industrial possibilities. Nano-reinforcements and matrix materials.

Unit IV. Nanocomposite materials: Natural nanocomposite systems, organic-inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposite material; Use of synthetic nanocomposites for bone, teeth replacement.

Reference Text Books:

1. Carbon Nanotubes (Carbon, Vol 33) - M. Endo, S. Iijima, M.S. Dresselhaus 1997.
2. Diblock Copolymer, - Aviram (Review Article), Nature, 2002
3. Electromagnetic and magnetic properties of multi component metal oxides, hetero
4. Introduction to Nanocomposite Materials. Properties, Processing, Characterization-Thomas E. Twardowski. 2007. DEStech Publications. USA.
5. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun 2006.
6. Nanometer versus micrometer-sized Particles-Christian Brosseau, Jamal BeN Youssef, Philippe Talbot, Anne-Marie Konn, (Review Article) J. Appl. Phys, Vol 93, 2003
7. Physical Properties of Carbon Nanotubes- R. Saito 1998.
8. The search for novel, superhard materials- Stan Vepriek (Review Article) JVST A, 1999

Subject Code	DSE III 3.2 Nanotechnology: Processing and Regulation	L	T	P	Credits
	Hours	02	0	0	02

Course Objective: The objective of this subject will be learn about methods in nanotechnologies from lab to clinic and towards commercialization.

Learning Outcomes: The students will learn about methods for commercialization of nanotechnology and regulations for nanotechnology products.

Unit I. Process Engineering of Nanotechnology: Methods for production of nanoparticles. Processes and parameters. Features and limitations in scale up technology.

Unit II. Nanomedicine Production: Production of polymeric nanoparticles production methods – nano crystallization – nanoprecipitation, microfludizer & milling technologies. Extrusion and supercritical fluid technology and salting out.

Production of lipid nanoparticles - High-pressure homogenization, microemulsion technique, solvent emulsification evaporation and diffusion, ultrasonication methods. PLGA preparation and manufacturing technologies.

Unit III. Nanobiologics: Protein therapeutics and scale up. Biologics, biosimilars and biopharmeceuticals production.

Unit IV. Regulation of Nanomedicine: Regulatory demands of nanotechnology. European union regulations on nanomedicine. Indian guidelines for nanomedicine. Nanomedicine landscape and challenges.

Reference Text Books:

1. W.R. Cornish, Intellectual Property, Sweet & Maxwell, London (2016)
2. P. Narayana, Patent Law, Wadhwa Publication.
3. Patent Law and Policy: Cases and Materials, Robert Patrick Merges, LexisNexis Matthew Bender, 2011, ISSN: 1422480305
4. A Practical Guide to Patent Law, Brian C. Reid, Sweet & Maxwell, 2014, ISSN: 9780421656307.
5. Global Patent Litigation, Strategy and Practice, Prof. Willem Hoyng, 2016, Kluwer Law. International, 2016, ISSN: 978-9041124609.
6. The Law of Patents – with a special Focus on Pharmaceuticals in India, Feroz Ali Khader, LexisNexis Butterworths, Nagpur, 2017, ISSN: 8180381501, 9788180381508.

Subject Code	SEC III Bioprinting	L	T	P	Credits
	Hours	02	0	0	02

Course Objectives: Bioprinting is a latest scientific advancement. Students will get basic understanding of function of a bioprinter and its operation

Learning Outcomes: It is expected that the students will theoretically learn the fabrication of bioprinted patterns and will appreciate its application in the fabrication of artificial organs.

Unit I. Bioprinting: 3D Bioprinting – Introduction and principles of bioprinting. Pre and post processing methods. Use of biomaterials in bioprinting. Biomaterials and their tyoes. Biomaterials and cell compatibility.

Unit II. Types of Bioprinters: 3D Bioprinting technologies: ink jet based. Pressure assisted, Laser assisted, Solenoid valve based, Acoustic jet based. Challenges and future development of 3D bioprinting. Piston based and screw based extrusion systems.

Unit III. Bioinks: Types of bioinks and their broad applications, quality tests for bioinks – sterility, endotoxin levels, pH, cell viability, viscosity, degree of methacrylation and gelling point. Pre and post processing steps. Scaffold based and scaffold free bioprinting.

Unit IV. Applications of Bioprinting: Applications in drug development, *in vitro* testing, wound healing, bioprinting organs. Basic understanding of bioreactors. Application in microfluidics.

Reference Text Books:

1. Bioprinting: Principles and Applications by Wai Yee Yeong and Chee Kai Chua. World Scientific Publishing. 1st edition 2015. ISBN-13: 978-9814612104.
2. Bioprinting by Maika Mitchell. Paperback ISBN: 9780128053690. Academic Press. 2017.
3. 3D Bioprinting: Fundamentals, Principles and Applications by Ibrahim Ozbolat. Elsevier Academic Press. ISBN: 978-0-12-803010-3. 2016.
4. 3D Bioprinting: Principles and Protocols by. Jeremy M. Crook. 978-1-0716-0519-6.

SEMETER III PRACTICALS

Subject Code	Practical 5. Synthesis and preclinical testing of nanomaterials	L	T	P	Credits
	Hours	0	0	04	02

1. Pharmacology: Animal handling, route of administration of drugs, dose response relationship, acute toxicity testing of drugs, analgesic activity of a compound, estimation of protein and hematological parameters.
2. Study the dissolution behavior/ drug release pattern of various conventional, sustained release, enteric coated and nano-particulate dosage form an establishment of dissolution kinetics. Study of various factors affecting dissolution/ drug release.
3. Study of drug protein binding and effect of competitive agent on binding kinetics.
4. Protein binding studies.

Subject Code	Practical 6. Toxicology Testing	L	T	P	Credits
	Hours	0	0	04	02

1. Laboratory Methods for toxicity testing in invertebrate and small vertebrate models
2. Laboratory analysis of toxins
3. CPCSE guidelines for toxicity testing in small animals
4. Toxicity testing – inhalation, dermal, topical preparations, oral testing
5. Mutagenicity and carcinogenicity tests
6. One and two generation toxicity testing
7. Toxicokinetics studies in blood and dose toxicity testing
8. Experimental Neurotoxicity studies in rodents
9. Experimental Embyro toxicity studies
10. Experimental Nanotoxicity studies.

Semester Four

Accepts of method validation: observation and collection of data, methods of data collection, sampling methods, data processing and analysis strategies and tools, data analysis with static package (Sigma STAT, SPSS for student t-test, ANOVA, etc.), hypothesis testing.

DISSERTATION

Course Type	Marks	Credits	L	T	P	C
Project	300					12

The student shall carryout, a semester long project work under the supervision/mentorship of identified guide (internal or external or both). The project work shall be compiled and submitted in the form of dissertation as per the format. The project work shall be original research work related to the programme or case studies that provide an analysis of specific research questions/socio-economic issues, etc. leading to a dissertation as partial fulfilment of the degree.

Question Paper Pattern

MODEL QUESTION PAPER **QP CODE:**

JSS Academy of Higher Education & Research, Mysuru
(Deemed to be University)
First Semester M.Sc., (Program) (RS-1) Examination - Year
Subject:

Note: *Draw neat, labeled diagrams wherever necessary.*
Your answers should be specific to the questions asked.

Time: 03 Hours **Max Marks: 70**

I. LONG ESSAYS (Answer any TWO of the following) **2x15=30 Marks**

1.
2.
3.

II. SHORT ESSAYS (Answer any FIVE of the following) **5x6=30 Marks**

4.
5.
6.
7.
8.
9.
10.

III. SHORT ANSWERS (Answer all the following) **5x2=10 Marks**

11.
12.
13.
14.
15.

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MODEL QUESTION PAPER **QP CODE:**

JSS Academy of Higher Education & Research, Mysuru

(Deemed to be University)

First Semester M.Sc., (Program) (RS-1) Examination - Year

Subject:

Note: *Draw neat, labeled diagrams wherever necessary.*

Your answers should be specific to the questions asked.

Time: 02 Hours **Max Marks: 50**

I LONG ESSAYS (Answer any TWO of the following) **2x10=20 Marks**

1.
2.
3.

II SHORT ESSAYS (Answer any FIVE of the following) **5x4=20 Marks**

4.
5.
6.
7.
8.
9.
10.

III SHORT ANSWERS (Answer all the following) **5x2=10 Marks**

11.
12.
13.
14.
15.

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