KANNUR UNIVERSITY

(Abstract)

M.Sc. Nano Science and Nano Technology Programme - Regulations, Scheme and Syllabus (CBCSS)- implemented in the University Department w.e.f.2020 admission - Orders issued.

ACADEMIC C SECTION

Acad/C4/2959/2021 Dated: 30.03.2021

Read:-1. G.O. (Ms) No.389/2020/HEDN dated 05.11.2020

2. Minutes of the meeting of the syndicate held on 17.11.2020,vide item No.2020.543

3. U.O. No.Acad.A2/5565/ND&C/2008 Vol.II dated 31.12.2020

4. U.O.No.Acad/C3/22373/2019, dated 12.11.2020

5. Minutes of the meeting of the Experts Committee held on 16.01.2021

6. Minutes of the meeting of the Faculty members of Dept. of Chemistry, Dept. of Physics and Nano Science and Nano Technology held on 17.03.2021

7. Syllabus submitted by the Programme Co- ordinator dated 22.03.2021

ORDER

1. As per paper read (1) above, sanction was accorded by the Government to start New Generation Courses in the Teaching Departments of the University during academic year 2020-21.

2. The meeting of the Syndicate as per paper read (2) above resolved to start the newly sanctioned Programmes in Govt./Aided Colleges/University Departments from the academic year 2020-21

3. Accordingly, the Vice Chancellor, as paper read (3) above, accorded sanction for starting the New Generation Course in M.Sc. Nano Science and Nano Technology (CBCSS) in the Department of Chemistry at Swami Anandatheertha Campus, Payyannur.

4. Further, the Expert committee constituted to draft Regulation, Curriculum, Syllabus of New Generation Course in Nano Science and Nano Technology Programme under Choice Based Credit Semester System, prepared and approved the same as per paper read (5) above

5. Subsequently, the Programme Co-ordinator submitted the Regulation, Scheme and Syllabus of M.Sc. Nano Science and Nano Technology Programme under CBCSS, duly approved by the faculty members of Department of Physics & Chemistry, vide paper read (6), for implementation w.e.f 2020 admission on wards.

6. The Vice Chancellor, after considering the matter in detail and in exercise of the powers of the Academic Council conferred under section 11 (1) Chapter III of Kannur University Act 1996, accorded sanction to implement the Regulation, Scheme and Syllabus of the M.Sc. Nano Science and Nano Technology Programme under CBCSS in the Department of Chemistry at Swami Anandatheertha Campus, Payyannur w.e.f 2020 admission, subject to reporting to the Academic Council.

7. The Regulations, Scheme and Syllabus of the M.Sc.Nano Science and Nano Technology Programme under CBCSS are uploaded on the University website. (www.kannuruniversity.ac.in).

Orders are issued accordingly.

Sd/-

BALACHANDRAN V K

DEPUTY REGISTRAR (ACAD)

For REGISTRAR

To: 1. The Head, Department of Chemistry
2. The Head, Department of Physics
Swami Anandatheertha Campus, Payyannur

Copy To: 1. The Examination Branch (through PA to CE).
2. PS to VC / PA to PVC / PA to R
3. DR / AR 1/ AR II (Acad).
4. The Computer Programmer (for uploading in the Website)
5. SF / DF /FC

KANNUR UNIVERSITY
CIVIL STATION P.O.
KANNUR
Pin-670 002
THAVAKKARA

Forwarded / By Order

SECTION OFFICER

KANNUR UNIVERSITY

Regulation, Scheme and Syllabus

for

M.Sc. PROGRAMME

in

Nano Science and Nano Technology

Choice Based Credit Semester System

w.e.f 2020 Admission

KANNUR UNIVERSITY

MASTER OF SCIENCE PROGRAMME
IN NANO SCIENCE AND NANO TECHNOLOGY

Objective of the Course

This course introduces students to the emerging field of Nano Science. In the present course current industrial and research applications of Nano Science and technology taught by theory and experimental way. The new course is designed to incorporate the emerging trends in Nano Science and nanotechnology and its application in the developing and highly advanced fields like electronics, energy sector, material science and medical science etc.

The following are the aim of the course

• To teach the advanced and emerging area of Nano Science and technology topics
• Create infrastructure for carrying out frontiers of research in Nano Science and technology
• Encourage and train human resources for intellectual property generation and explore newer areas of research
• To practice the students in laboratories on the synthesis and development of nanomaterial through different methods
• Attract and nurture young minds for taking up Nano Science R&D as career
• Undertake capacity building of human resource development in Nano Science and nanotechnology development
• Provide conducive environment for creation of commercializable technologies.
• Collaborate with national and international researchers/industries for the development of high-end technologies

How this proposal comes exclusively under Innovative Scheme

Nano Science and technology can actually revolutionize a lot of electronic products, procedures, and applications. The areas that benefit from the continued development of nanotechnology when it comes to electronic products include nano transistors, nano diodes, OLED, plasma displays, quantum computers, and many more. Nano Science and technology can also benefit the energy sector. The development of more effective energy-producing, energy-absorbing, and energy storage products in smaller and more efficient devices is possible with this technology. Such items like batteries, fuel cells, and solar cells can be built smaller but can be made to be more effective with this technology.

Another industry that can benefit from nanotechnology is the manufacturing sector that will need materials like nanotubes, aerogels, nano particles, and other similar items to produce their products with. These materials are often stronger, more durable, and lighter than those that are not produced with the help of nanotechnology. In the medical world, nanotechnology is also seen as a boon since these can help with creating what is called smart drugs. These helps cure people faster and without the side effects that other traditional drugs have. Will also find that the research of nanotechnology in medicine is now focusing on areas like tissue regeneration, bone repair, immunity and even cures for such ailments like cancer, diabetes, and other life threatening diseases.

Specify whether the course belongs to emerging or hi-tech areas or in the areas of national and global priorities.

Nano Science and technology as a new and emerging research and educational area which revolutionize and finds application in the area of electronics, catalysis, material science, solar cells, biomedicals and materials for energy and environmental applications. Nanotechnology requires strong government stimulation for capability creation as like some of the other knowledge based sectors. India has been able to create a 'research ecosystem' in nanotechnology through multiagency involvement, directed government programmes. Institutes across the world are getting involved in this area; specialized institutes with advanced facilities are being created, specialized university courses at different levels are need to be developed. Novel initiatives have been taken to allow researchers and students spread across the country to have access to advanced instruments. More concentrated efforts and linkages are need to be established with universities, research organizations and Industries to create Nano Science and applications.

ii. Describe in details specific possible themes which can be taken up for research.

Special importance has been given to the following titles.

1. Nanomaterials
2. Solar cell application
3. Materials for energy and environmental sector
4. Catalysis
5. Nanoporous materials
6. Composite materials
7. Micro electronic-mechanic materials
8. Advanced materials

9. Optoelectronics
10. Biomaterials
11. Laboratories of instrumental characterizations of materials and fabrications of nanostructured devices are also planned
12. Nanophotonics

Describe the nature, scope, scientific importance, practical usefulness of the new course.

In Nano Science, the researcher conducts a systematic investigation of each material, in terms of its structure, properties, processing, and performance. The research often leads to new applications of known materials and the creation of new materials with desired properties.

On a fundamental level, this field relates the properties and performance of a material to its atomic-scale structure and the different phases it can go through. The major factors that determine the structure and properties of a material are the nature of its constituent chemical elements and the way in which the material was processed into its final form. The course will be a step to the students to the emerging research areas of Nano Science and nanotechnology.

i Bringing innovation and excellence in teaching or research or both

Kannur University desires to develop world class knowledge base and skills in Nano Science and Technology. Kannur University plans to undertake comprehensive development efforts in teaching and R&D in Nano Science and Technology. In addition, plans are afoot to conduct integrated research in collaboration with the natural sciences such as chemistry and physics in areas that are of Nano Science relevance. We also wish to establish cooperation agreements with scientists of other countries and private sectors in Nano Science and technology research area.

ii To give a solution to the local/regional/global problems by training of the required human resources for:

a. Generating possible employment opportunities for the students in the area.

As nanoscale science and technology come to have an increasing impact on many aspects for our daily lives, the opportunities for careers are expanding rapidly. A major challenge nanotechnology is having is the education and training of a new generation of skilled workers.

In areas, as diverse as designing medical diagnostic devices to building better batteries, from creating cosmetics to enhancing energy efficient windows, from auto and plane manufacturing to researching the nature of matter itself, knowledge

of nanoscale science and technology will be increasingly important during upcoming years and decades.

b. Serve industry, Govt. / other organizations which are possible users or are sponsoring agencies for courses and to mobilize industry / other organizations to know their requirements.

Nanoscale phenomena underlie many of the properties and interactions of matter, and thus the sciences of physics, chemistry, and biology. However, nanoscale science is an interdisciplinary field – one where science and engineering intersect. Studying science or engineering and paying attention to the developments in Nano Science and technology that advance these fields can provide you with a solid foundation for any broad range of careers.

KANNUR UNIVERSITY

REGULATIONS FOR POST GRADUATE PROGRAMMES UNDER CHOICE BASED CREDIT SEMESTER SYSTEM IN THE DEPARTMENTS/SCHOOLS EFFECTIVE FROM 2020 ADMISSION

1. SCOPE

1.1 These Regulations shall apply to all the Post Graduate programmes, including P.G. Diploma and Certificate Courses conducted by the Departments/Schools of Kannur University

1.2 Choice based Credit Semester System presupposes academic autonomy, cafeteria approach in academic environment, semester system, course credits, alphabetical grading and interdepartmental academic collaboration. There shall be a Department Council consisting of all the Permanent/Contract teachers of the Department. The Head of the Department shall be responsible for admission to all the programmes offered by the Department including conduct of entrance tests, verification of records, admission and evaluation. The Department Council will deliberate on courses and specify the distribution of credits semester wise and course wise. For each course, it will specify the number of credits for lectures, tutorials, practicals etc.

1.3 These regulations shall come into effect from 2020 admission onwards and supersede all other Regulations unless otherwise prescribed.

2. DEFINITIONS

2.1 Curriculum Committee means the Committee constituted by the Vice-Chancellor under these Regulations to monitor the running of Choice based Credit Semester System. One of the Senior Professors shall be the Convener of the Curriculum Committee coordinating the various academic activities

2.2 Department/Centre/School means Department/Centre/School instituted in the University as per Kannur University Statutes.

2.3 '**Academic Programme**' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department.

2.4 '**Course**' means a segment of a Programme limited to one semester in a subject.

2.5 '**Programme Structure**' means a list of courses (Core, Elective, and Open Elective)

that makes up an Academic Programme, specifying the syllabus, credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity with University Rules

2.6 '**Core Course**' means a course that a student admitted to a particular programme must successfully complete to receive the degree, and which cannot be substituted by any other course.

2.7 '**Elective Course**' means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre.

2.8 '**Open Elective**' means an elective course which is available for students of all programmes, including students of same department. Students of other Departments may opt these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.

2.9 '**Credit**' means the value assigned to a course which indicates the level of instruction. Normally, one hour lecture per week equals 1 Credit; 2/3 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course

2.10 '**SGPA**' means Semester Grade Point Average calculated for individual semester.

2.11 '**CGPA**' is Cumulative Grade Points Average calculated for all courses completed by the students in the last year of the course by clubbing together SGPA of four semesters

3. ELIGIBILITY FOR ADMISSION

3.1 Bachelor's degree in any of the subjects such as Physics and Chemistry with not less than 55% marks in aggregate (excluding languages). Those who are awaiting final year B.Sc. results also can apply but they have to fulfill the eligibility criteria before the admission. Eligible relaxation in the percentage of marks will be given to candidates belonging to SC and ST. Reservation policies of the University/State are followed for admission.

3.2 Candidates who have passed their qualifying examination from Universities outside Kerala and candidates, who have passed their degrees with different nomenclature from the Universities within Kerala, should submit Recognition/Equivalency Certificate while seeking admission.

4. ADMISSION

4.1. As per the regulations prescribed by the University Departments for each Progamme from time to time. However, blind/deaf candidates are not eligible for admission to the course.

4.2 Admission to the PG programme of the University departments shall be made purely on the basis of Entrance Examination. Newspaper notification in this regard has to be made in the month of May itself. Entrance Examination is mandatory for all the departments even if the numbers of applicants are less than the sanctioned strength. If the number of candidates admitted based on the Entrance Exam is less than the sanctioned strength, the concerned department can fill the vacancy by making necessary press release by fulfilling the reservation norms on the basis of the marks obtained in the qualifying examination.

4.3 There should be uniformity in the date of starting the courses and conducting the End Semester Examination of different PG programmes of the University.

5. REGISTRATION

5.1 Every Department/School shall have Permanent / Contract faculty members as Student Advisors. Each student at the time of admission will be assigned to an advisor by the Department Council. He/she will advise the student about the academic Programme and counsel on the choice of courses depending on the student's academic background and objective. The student will then register for the courses she/he plans to take for the semester before the classes begin.

5.2 The Department offering any course shall prescribe the maximum number of students that can be admitted taking into consideration the facilities available. The Department Council will be the authority to fix the optional that can be offered for a Programme while ensuring that sufficient choice is given to each student in all semesters other than Semester 01. Elective courses for the next semester will be announced within 10 days of the end of the previous semester.

5.3 The student has to complete the prescribed prerequisites for the course before registration. The student within a maximum of 10 working days after the commencement of the classes can change the Optional Course with the consent of Head of the Department in consultation with the Advisor.

5.4 The Department shall make available to all students a bulletin listing all the

courses offered in every Semester specifying the Credits, list of topics the course intends to cover, the name of the instructor, the timetable and examination schedule. This will be made available in the last week of each semester after it is approved by the Department Council, the Dean and the Vice Chancellor.

6. COURSE STRUCTURE

6.1 Three kinds of Courses are offered - Core, Elective and Open Elective Courses (including MOOC courses). Core Courses are offered by the Department conducting the Programme. Elective / Open Elective Courses are offered either by the Department conducting the Programme or by any other Department of the University or via MOOC.

6.2 Elective Courses are offered by the Department concerned. Open Elective Courses will be offered by other Departments/Centres/Institutions as options. Open Elective Courses can be opted in any of the Semesters during the entire Programme other than the first semester. The maximum students that can be admitted to an Open Elective Course is limited to forty (40) except for MOOC courses. If the student intake in a department is more than 40, then the maximum number of students that can be admitted to an Open Elective Course is equal to the student intake.

6.3 Every Course offered by the University Department is identified by a unique course code. Where first two letters denote Programme name (MS for Master of Science). Next three letters denote subject. This is followed by semester number such as 01, 02, 03,04. After semester number single alphabet stands for Core (C). Elective (E) and Open Elective course (O). The last two digits denote the serial number of the course in that category (C, E or O) in that programme. MSNST01C02 MS – Master of Science, NST-Nano Science and Technology, 01 – First Semester C – Core 02– Serial number of the Core course of the programme

6.4 Any course including a core course of one Department can be offered as an Open Elective Course to students of other Departments

6.5 The minimum duration for completion of a two-year PG Programme is four (4) Semesters and the maximum period for completion is eight (8) Semesters from the date of registration. The minimum duration for completion of a one year PG programme in any subject is two (2) semesters and the maximum period for completion is four (4 semesters) four years from the date of registration.

6.6 No regular student shall register for more than 24 credits and less than 16 credits

per Semester, subject to the provisions of the Programme concerned.

6.7 The total credits required for the successful completion of a four semester Programme will be between 72 to 80. For science subjects core credits should not exceed 70 per cent.

6.8 The Department Council shall design the Core, Elective and Open Courses including the detailed syllabus for each Programme offered by the Department. The Department Council shall have the freedom to introduce new courses and/or to modify/redesign existing Courses and replace any existing Course with a new Course to facilitate better exposure and training for the students, with the approval of the Faculty Council and the Academic Council.

7. EVALUATION

7.1 Evaluation of the students shall be done by the Faculty member who teaches the Course on the basis of Continuous Evaluation and an End Semester Examination. The proportion of the distribution of marks among End Semester Examination and Continuous Evaluation shall be 60:40. 10 percent of the scripts, subject to a minimum of 5 scripts per course will be valued by an External Examiner. If there is an average difference of more than 15 per cent in the marks awarded by the Internal and External Examiner, the scripts will be valued by one internal and external examiner; the scripts will be valued by one Internal and one External examiner together.

7.2 Continuous Evaluation includes Assignments, Seminars, periodic written examinations etc.

7.3 The allocation of marks for each component under Continuous Evaluation shall be in the following proportions:

Theory		Practical	
Components	% of marks	Components	% of marks
Test papers	40% (16 marks)	Tests	75% (30 marks)
Tutorial with viva, Seminar presentations,	40% (16 marks)	Record	25% (10 marks)

Discussion, Debate etc			
Assignment	20% (8 marks)		
Total Internal marks	40	Total internal marks	40

7.4 Mode of assessment i.e., administering of Test or Tutorial will be decided by individual departments

7.5 A copy of all records of Continuous Evaluation shall be maintained in electronic format in the Department and shall be made available for verification by the University.

7.5 Performance of each student in an assessment shall be intimated to him/her within two weeks of the conduct of test/ submission of assignment/ report.

8. CONDUCT OF THE END SEMESTER EXAMINATION

8.1 The End Semester Examinations of each semester will be conducted by the Controller of Examinations. It will be the responsibility of the Department to maintain a sufficient balance of different levels of questions in the Question Bank. The tabulation registers of each Semester shall be prepared and maintained by the Examination Branch. There shall be a minimum of one external examiner to ensure transparency in the conduct of examinations. The external examiners will be faculty members appointed from other Colleges/Departments of this University or from other Universities. The duration of End Semester Examination shall be specified in the curriculum.

8.2 The Board of Examiners will function as the Pass Board and will be called the Subject Examination Board with the Head of the Department/or a nominee of the Vice Chancellor when there is no University Department offering that Programme as its Chair

9. ATTENDANCE

9.1. The minimum attendance required for each Course shall be 60% of the total number of classes conducted for that semester. Those who secure the minimum attendance in a semester alone will be allowed to register for the End Semester Examination.

Condemnation of attendance to a maximum of 10 days in a Semester subject to a maximum of two spells within a Programme will be granted by the Vice-Chancellor. Benefit of Condemnation of attendance will be granted to the students on health grounds, for participating in University Union activities, meetings of the University Bodies and participation in extracurricular activities on production of genuine supporting documents with the recommendation of the Head of the Department concerned. A student who is not eligible for Condemnation shall repeat the Course along with the subsequent batch.

10. GRADING

10.1 An alphabetical Grading System shall be adopted for the assessment of a student's performance in a Course. The grade is based on a 6 point scale. The following table gives the range of marks %, grade points and alphabetical grade.

Range of Marks %	**Grade Points**	**Alphabetical Grade**
90-100	9	A+
80-89	8	A
70-79	7	B+
60-69	6	B
50-59	5	C
Below 50	0	F

10.2 A minimum of grade point 5 (Grade C) is needed for the successful completion of a Course. A student who has failed in a Course can reappear for the End Semester Examination of the same Course along with the next batch without taking re-admission or choose another Course in the subsequent Semesters of the same programme to acquire the minimum credits needed for the completion of the Programme. There shall not be provision for improvement of CE and ESE. A student can sit the ESE again is she/he has successfully completed the CE requirements in a subsequent semester subject to the maximum durations permitted.

10.3 Performance of a student at the end of each Semester is indicated by the Semester Grade Point Average (SGPA) and is calculated by taking the weighted average of

grade points of the Courses successfully completed. Following formula is used for the calculation. The average will be rounded off to two decimal places.

CGPA = Sum of (grade points in a course multiplied by its credit)

Sum of Credits of Courses

10.4 At the end of the Programme, the overall performance of a student is indicated by the Cumulative Grade Point Average (CGPA) and is calculated using the same formula given above.

10.5. Empirical formula for calculating the percentage of marks will be

% Marks = (CGPA x 10) +5.

10.6 Based on the CGPA overall letter grade of the student and classification shall be in the following way.

CGPA	**Overall Letter Grade**	**Classification**
8.5 and above	A+	First Class with Distinction
7.5 and above but less than 8.5	A	
6.5 and above but less than 7.5	B+	First Class
5.5 and above but less than 6.5	B	
5 and above but less than 5.5	C	Second Class

10.7 Appearance for Continuous Evaluation (CE) and End Semester Evaluation (ESE) are compulsory and no Grade shall be awarded to a candidate if he/she is absent for CE/ESE or both.

10.8 A student who fails to complete the Programme/Semester can repeat the full Programme / Semester once, if the Department Council permits to do so. Absence in an examination will be marked zero.

10.9 No student shall be allowed to take more than eight/twelve consecutive Semesters for completing a four/six Semester Programme from the date of enrolment.

11. GRADE CARD

11.1. The Controller of Examinations shall issue the grade cards of all semesters and the consolidated grade card and certificates on completion of the programme, based on the details submitted by the Heads of the Departments concerned. This will be in

digital form only.

11.2. The Grade Card shall contain the following

a) Title of the Courses taken as Core, Elective & Open Elective.
b) The credits associated with and grades awarded for each Course.
c) The number of credits (Core /Elective / Open) separately earned by the student and the SGPA.
d) The total credits (Core / Elective / Open) separately earned by a student till that Semester.

11.3. The consolidated grade statement issued on completion of the Programme shall contain the name of the Programme, the Department/School offering the Programme, the title of the Courses taken, the credits associated with each Course, grades awarded, the total credits (Core /Elective/Open) separately earned by the student, the CGPA and the class in which the student is placed. Rank Certificates will be issued based on CGPA calculated at the end of the last semester of that Programmes.

12. DEPARTMENT COUNCIL

12.1 All the Permanent and Contract teachers of the Department shall be the members of the Department Council.

12.2 The Department Council subject to these Regulations shall monitor every academic programme conducted in the Department.

12.3 Department Council shall prescribe the mode of conduct of courses, conduct of examinations and evaluation of the students.

12.4 An elected student representative also may attend the department council meeting where agenda related to academic matters / research activities of students are discussed

13. CURRICULUM COMMITTEE

13.1 There shall be a Curriculum Committee constituted by the Vice Chancellor to monitor and co-ordinate the working of the Choice based Credit Semester System.

13.2 A senior professor nominated by the Vice Chancellor shall be the convener of the Curriculum Committee.

13.3 The Committee shall consist of:

a) Vice-Chancellor or person nominated by VC (Chairperson)
b) The Convener of the Curriculum Committee (A professor of the University nominated by the Vice-Chancellor)
c) The Registrar -Secretary
d) The Controller of Examinations
e) Deans
f) The Heads of the Departments

13.4 The term of office of the Committee shall be two years, but the Committee once constituted shall continue in office until a reconstituted committee assumes office.

14. ACADEMIC GRIEVANCE REDRESSAL MECHANISM

14.1 Committees will be constituted at the Department and University levels to look into the written complaints regarding Continuous Evaluation (CE). Department Level Committee (DLC) will consist of the Department Council, and elected student representatives who is currently a student of that Programme of study. There will be one student representative for the post graduate programmes and one student representative for the doctoral programme.

14.2 University Level Committee (ULC) will consist of the Convenor of the Curriculum Committee, the concerned Dean, the concerned Head of the Department and a nominee of the Students' Union

14.3 Department Level Committee will be presided over by the HoD. Complaints should be submitted to the Department concerned within two weeks of publication of results of Continuous Evaluation (CE) and disposed of within two weeks of receipt of complaint. Appeals to University Level Committee should be made within two weeks of the decisions taken by Department Level Committee and disposed of within two weeks of the receipt of the complaint.

14.4 Complaints unsolved by the University Level Grievance Committee shall be placed before the Vice Chancellor.

15. TRANSITORY PROVISION

15.1 Not withstanding anything contained in these regulations, the shall for a period of one year (may be revised) from the date of coming into force of these regulations,

the Vice Chancellor have the power to provide by order that these regulations shall be applied to any Programme with such modifications as may be necessary.

16. REPEAL

16.1 The Regulations now in force so far as they are applicable to programmes offered in the University Departments and to the extent they are inconsistent with these regulations are hereby repealed. In the case of any inconsistency between the implemented regulations of Choice based Credit Semester System and its application to any independent programme offered in a University Department, the former shall prevail.

M.Sc. DEGREE COURSE in Nano science and Nano technology
under Choice Based Credit Semester System)

(Effective from 2020 Admission)

About the Department

The School of Chemical Sciences and school of Pure and Applied Physics was established in 2002 and is housed at the Payyanur Campus of the University located at Edat, Payyanur. The School is offering M.Sc Chemistry (Material Science) and M .Sc. Physics (Advanced Materials) course and Ph.D. in Chemistry, Physics and Biochemistry. The M.Sc. course pattern is of Credit and Semester System consisting of four semesters including one semester project work. The School of Chemical Sciences and Physics are having an excellent Library with latest editions of textbooks, reference books and relevant journals in chemistry, Physics. Nano Science and material science. Library also providing internet facility to students. Fourth semester M.Sc. students carry out their project works in reputed national Institutes.

1 The course shall be offered in four semesters during a period of two academic years. Each semester will have 17-18 weeks duration. The minimum duration for completion of the course is four semesters. The maximum period for the completion of the course is eight semesters.
2 The course is offered at the School of Chemical Sciences, Swami Anantha Theertha Campus of Kannur University situated at Edat, Payyanur.
3 The course is based on Choice based Credit System. The total credit required to complete the course is fixed as 80 out of which 54 credit core courses and 26 credit electives.
4 The number of periods allotted per week for a topic is considered as its credit. For practical, three hours is considered as one credit. Elective courses will be offered depending on the availability of the teaching staff/resource person at that time. At least 6 students have to register for an offered elective course.
5 No student shall register for more than 28 credits and less than 10 credits per semester. The duration of the course shall extend to more than two years (maximum four years) for the students securing less than 12 credits in a semester.

Course details:

1. In first and second semester, there will be 4 core courses and one elective course. In Third semester there will be 4 core courses and 2 elective courses each. In Fourth semester, there will be 4 core courses and 2 elective course.
2. During the fourth semester, the students will have to visit a Research Institute of National repute to have an idea about the current research activities. The report of the same may be submitted to the head of the department for valuation.
3. During the fourth semester, each student shall carry out project work in any branches of Nano Science for a period of not more than six months under the supervision of a teaching staff of the department nominated by the head of the department. The project can be carried out in a research institute/industry of national repute with co-guidance from experts there. The departmental council shall make decisions regarding the project details.
4. A student will have to present one seminar (one credit) in the fourth semester. The topics of the seminar will be chosen by the student in concern with his/her tutor.
5. Attendance is compulsory for each course and the minimum requirement for appearing for the end semester examination shall be as per general regulations of M.Sc. programme of the University.
6. Open elective means an elective course which is available for students of all programmes, including students of the same department. Students of other Department will opt these courses subject to fulfilling the eligibility of criteria as laid down by the Department offering the course.
7. One hour per week is allotted for tutorial classes. Each student will be assigned to a teaching staff of the department as his/her advisor.

Programme Specific Outcomes

1. To develop trained manpower in the field of nano science and nanotechnology with specific emphasis for exploitation of Nano Science and nanotechnology looking at the demand/need of changing trends of modern Industries.
2. Amalgamate traditional research for nano science with advanced cutting-edge technologies for product development and manufacturing such as solar cells, semiconductors, catalyst etc.
3. Introduce the powerful tools of nano science and nanotechnology for R&D with a rigorous attention to device fabrication.

4 Exposure to National & International research in the field of nano science and nanotechnology.

SEMESTER I

No	Course Code	Topic	Contact Hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
CORE COURSES									
1	MSNST01C01	Quantum and Statistical mechanics	4	-	-	60	40	100	4
2	MSNST01C02	Structure and bonding in solids	4	-	-	60	40	100	4
3	MSNST01C03	Introduction to Nanotechnology	4	-	-	60	40	100	4
4	MSNST01C04	Nano Lab – I	-	-	12	60	40	100	4
Total for core courses			24					**400**	16
ELECTIVE COURSES									
5	MSNST01E01	Environmental impacts of Nanotechnology	1x4	-	-	-	-	100	4
Total			28					**500**	**20**

SEMESTER II

No	Course Code	Topic	Contact Hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
CORE COURSES									

1	MSNST02C01	Elements of Physical Chemistry	4	-	-	60	40	100	4
2	MSNST02C02	Design and synthesis of Nanomaterials	4	-	-	60	40	100	4
3	MSNST02C03	Characterization Techniques for Nanomaterials	4	-	-	60	40	100	4
4	MSNST02C04	Nano Lab – II	-	-	12	60	40	100	4
Total for core courses			24					400	16
ELECTIVE COURSES									
5	MSNST02E01	Nanoscale Magnetic materials and Devices	1x4	-	-	60	40	100	4
6	MSNST02E02	Nanomaterials for energy and environment							
Total			28					**500**	**20**

SEMESTER III

No	Course Code	Topic	Contact Hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
CORE COURSES									
1	MSNST03C01	Semiconductor Nanomaterials and NanoLithography	4	-	-	60	40	100	4

2	MSNST03C02	Carbon Nanostructures	4	-	-	60	40	100	4
3	MSNST03C03	Nanobiotechnology	4	-	-	60	40	100	4
4	MSNST03C04	Nano Lab - III	-	-	12	60	40	100	4
Total for core courses			24					**400**	16
ELECTIVE COURSES									
5	MSNST03E01	Nano medicine and Drug delivery systems	2x4	-	-	60	40	200	8
6	MSNST03E02	Micro and Nanodevices							
Total			32					**600**	**24**

SEMESTER IV

No	Course Code	Topic	Contact Hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
CORE COURSES									
1	MSNST04C01	Research Project Including internal project		-	26	100	-	100	4
2	MSNST04C02	Comprehensive Viva	-	-	-	100	-	100	2
5	MSNST04C03	Seminar	-	1	-	-	-	50	1
6.	MSNST04C04	Study Tour Report	-	-	-	-	-	50	1
Total for core courses			27j					**200**	8

ELECTIVE COURSES									
3	MSNST04E01	Industrial Significance and applications of Nanotechnology	2x4	-	-	60	40	200	8
4	MSNST04E02	Nanoelectronics							
		Total	35					**500**	16

Grant Total		
Marks: 2100	**Core Credits: 56**	**Elective Credits: 24**

Course code- MSNST: Master of Science Nano science and Nano Technology; C: Core; E: Elective

FIRST SEMESTER

MSNST01C01: Quantum and Statistical mechanics

Module 1 Classical Mechanics 18 hrs

Basic Principles of Classical Dynamics – Conservation laws, Conservation of Angular Momentum and Energy - Generalized and Cyclic Co-ordinates – Limitations of Newton's Law - Hamiltonians Variation Principle - D' Alemberts Principle - Derivation of Lagrangian Equation of Motion from D' Alemberts Principle and Hamilton's Principle - Simple Application of Lagrangian Equation - Hamiltonian's Canonical Equations of Motion - Compound Pendulum, Simple Pendulum, Particle in a Central Field of Force.

Module 2 Statistical Mechanics 18 hrs

Fundamentals of Statistical Mechanics and Thermodynamics: Phase Space – Ensembles: Types of Ensembles – Microcanonical, Canonical, Grand Canonical Ensembles - Uses of Ensembles – Classical Distribution Law: Microstates and Macro states – Stirling's Approximation – Maxwell Boltzman Distribution Law - Bose-Einstein Distribution Law - Fermi-Dirac Distribution Law – Comparison of the Three Distribution Laws.

Module 3 Quantum Mechanics-I 18 hrs

Basis of Quantum Physics – De Broglie's Concept – Operators – Bra and Ket Notation, Normalized and Orthogonal Wave Function - Heisenberg's Uncertainty Principle – Linear

Harmonic Oscillator – Hydrogen Atom - Energy Eigen value - Angular Momentum – Total Angular Momentum Operators – Commutation Relationship with Components.

Module 4 Quantum Mechanics-II 18 hrs

WKB Approximation – Variational Method – Scattering – Differential Scattering – Scattering Cross-Section - Scattering Amplitude - Stationery Perturbation Theory- Non Degenerate Case – First Order Perturbation – Evaluation of First Order Energy and Wave Function – Degenerate Case – Removal of Degeneracy in the First Order.

References /compulsory readings

1. Classical Mechanics, L.S. Gupta, V. Kumar, and H.V. Sharma, Pragati Prakashan Publication (2007).
2. Statistical Mechanics, by Gupta and Kumar, Pragati Prakashan Publication and Modern Physics, by R. Murugeshan, Ninth Edition.
3. Quantum Mechanics – Satya Prakash and C. K Singh Kedar Nath and Ram Nath Co
4. Quantum Mechanics – G. Aruldhas – Princitan Hall of India, New Delhi.

Supplementary and suggested reading:

1. Classical Mechanics, H. Goldstein, Charless Poole and John Safco, Addison Wesley (2000)
2. Modern Physics and Quantum Physics – E.E Anderson, Macmillan Co., India

MSNST01C02: Structure and bonding in solids

Module 1 Chemical Bonding 22hrs

Types of chemical bonds. The octet rule. Wave Mechanical picture of chemical bonding. Ionic solids lattice energy, Born-Lande equation Typical structures, bonding considerations, radius-ratio concept, electrical neutrality, bond types- ionic,covalent and vander Waals interactions, structural distortions, consequence of *d*-electron configuration on structure, MO description of select ML_6,(Octahedral); ML_4(Tetrahedral, square-planar) –based structures, band structure defects non-stoichiometry,

Pauling rule-application to actual structures, variations in atomic packing-polymorphism, isomorphism, solid solutions, derivative structures. Characteristic properties of metals, crystalline and amorphous solids. Theories of bonding in solids. The free electron theory, Band and Zone Theories, the Kronig-Penny model, Classification of solids into insulators,

semiconductors, conductors and super conductors. Alloys, ceramics, composite materials and conducting polymers.

Module 2 Crystallography 16hr

Periodicity in crystals, translational periodicity, representation of a lattice, notations of planes in a lattice, relationship between planes. Crystal types, two and three-dimensional crystal lattices. Symmetry elements – proper and improper rotation axes, screw axes, glide planes. Symmetry groups- point groups categories of crystal, plane groups, space lattices, space groups, super groups and subgroups.

Module 3 Imperfections in solids 20hr

Types of Imperfections - classification. Point defects - Schottky defects, Frenkel defect, Disordered Crystal. Line defects - Dislocation types, Dislocation theory. Plane defect - Large- angle boundaries, Small – angle boundaries, stacking faults. Colour centers in alkali halides Crystal growth - Velocity, Theories and Mechanism of crystal growth. Twinning - Growth, Deformation and transformation twins. Transformations in Crystals - Equilibrium transformations, Kinetics of transformations Elastic deformation and plastic deformation in crystals.

Module 4 Design of New Materials 14hr

Design of new materials – Chemical bonding considerations- chemical nature of substituents and dopants, ns^2 lone pair influence, local structural rearrangements, structural distortions, mixed valence, defect-chemistry tailoring.

References /compulsory readings

1. Atomic structure and chemical Bond, Manas Chanta **Publisher:** McGraw-Hill Inc.,US (1 December 1974) **ISBN-10:** 0070965110
2. Concise Inorganic chemistry, J.D.Lee **Publisher:** Wiley; 5th edition edition (18 December 1998) **ISBN-10:** 0632052937
3. Inorganic Chemistry, G. Wwfsberg Unit IV **Publisher:** Pearson; 4 edition (31 May 2012) **ISBN-10:** 0273742752
4. Introduction to solids – L.V. Azaroff, **Publisher:** McGraw Hill Education; New edition edition (14 June 2001) **ISBN-10:** 0070992193
5. Inorganic Solids, D.M. Adams, John Wiley&Sons, NewYork, 1974
6. Materials Science and Engineering, V.Raghavan, PHI L Pvt.Ltd.,N.Delhi,2015

Supplementary and suggested reading:

1. Introduction to solid state Physics – C. Kittel, **Publisher:** John Wiley & Sons Inc (23 July 1996), **ISBN-10:** 0471142867
2. Elements of solids state physics, J.P. Srivastava, **Publisher:** Prentice Hall India Learning Private Limited; 4th Revised edition edition (17 December 2014) **ISBN-10:** 8120350669

MSNST01C03: Introduction to Nanotechnology

Module 1 Fundamentals of Nanomaterials 12 hrs

History of Nanotechnology, Feynmann's vision on Nano Science & technology, bulk vs nanomaterials. Central importance of nanoscale morphology - small things making big differences, nanotechnology as nature's technology, clusters and magic numbers, nanoscale architecture. Recent developments, challenges and future prospects of nanomaterials.

Module 2 Size and shape dependent properties of nanomaterials 20 hrs

Size and shape dependent properties, Melting points and lattice constants, Surface Tension, density of states, Wettability - Specific Surface Area and Pore – Composite Structure - Mechanical properties, Optical properties: Surface plasmon resonance in metal nanoparticles and quantum size effect in in Semiconductors, Electrical conductivity: Surface scattering, change of electronic structure, quantum transport, effect of microstructure, Magnetic properties: Ferroelectrics, dielectrics and superparamagnetism,

Module 3 Classification of nanomaterials 20 hrs

Classification based on the dimensionality, Zero-dimensional nanostructures: metal, semiconductor and oxide nanoparticles. One-dimensional nanostructures: nanowires and nanorods, Two-dimensional nanostructures: Thin films, Three-dimensional nanomaterials, Special Nanomaterials: Carbon fullerenes and carbon nanotubes, micro and mesoporous materials, core-shell structures, organic-inorganic hybrids

Module 4 Stabilization of nanomaterials 20 hrs

Surface science for nanomaterials, surface energy, stabilization mechanisms, electrostatic - Nernst Equation, electric double layer, Debye-Huckel Screening strength. Interaction between nanoparticles – DLVO Theory, steric stabilization and electrosteric stabilization, nucleation and growth of nuclei, critical radius, homogenous and heterogeneous nucleation.

References/compulsory reading

1. G. Cao and Y.Wang, Nanostructures and Nanomaterials, 2nd Ed., Imperial College Press, 2004.
2. R. Kelsall , I.Hamley and M. Geoghegan, Nanoscale Science and Technology, Wiley, 2005.
3. K. J Klabunde, R. M. Richards, Nanoscale Materials in Chemistry, 2nd Ed., Wiley, 2009.
4. T. Pradeep, A text book of Nano Science and Technology, Tata McGraw-Hill Education, 2012.
5. G. Schmidt, Nanoparticles: from Theory to applications, Wiley-VCH, 2004

Supplementary/ Suggested reading

1. Murty, B. S., P. Shankar, Baldev Raj, B. B. Rath, and James Murday. Textbook of Nano Science and nanotechnology. Springer Science & Business Media, 2013
2. Robert K, Ian H, Mark G, Nanoscale Science and Technology, John Wiley & sons Ltd.,2005.

MSNST01C04: Nano Lab 1

Module 1 **68 hrs**

- Synthesis of different sized Ag nanoparticles by aqueous method and their optical microscopy studies
- Synthesis of different sized Au nanoparticles by aqueous method and their optical microscopy studies

Module 2 **40 hrs**

- Chemical synthesis of CdSe Quantum dots with different sizes.
- Band gap estimation of CdSe quantum dots by using optical spectroscopy
- Exciton and plasmon interaction studies of Au-CdSe system by using optical spectroscopy.

Module 3 **54 hrs**

- Sol-gel synthesis of ZnO nanoparticles.
- Analysis of optical properties of ZnO nanoparticles

Module 4 **54 hrs**

- Coprecipitation synthesis of magnetic (iron oxide) nanoparticles.
- Steric and electrostatic stabilization of iron oxide nanoparticles

- Stability studies of iron oxide nanoparticle dispersions using optical microscopy

References /compulsory readings

1. Nanostructures and Nanomaterials- Synthesis, Properties & applications by Guozhong Cao , Imperial college Press, (2006). Publisher: World Scientific Publishing Company; 2 edition (4 January 2011) ISBN-13: 978-9814324557
2. Nanoparticles and Nanostructured Films- Preparation Characterization and Applications by Janos H. Fendler, WILEY-VCH Verlag GmbH. D-69469 Weinheim (Federal Republic of Germany), 1998. Publisher: Wiley VCH (28 May 1998) ISBN-13: 978-3527294435
3. Nanomaterials and Nanochemistry by C. Brechignac.P. Houdy M. Lahmani, Springer-Verlag (2007). (For Unit III-Part I Chapter I)

Supplementary/ Suggested reading

1. NANO: The Essentials- Understanding Nano Science and Nanotechnology, by T Pradeep, Tata McGraw Hill Education Pvt. Ltd. New Delhi) ISBN-13: 978-0-07-061788-9
2. Introduction to Nano Science & Nanotechnology by Gabor L. Hornyak, Harry F. Tibbals, Joydeep Dutta, John J. Moore, CRC Press, Tylor & Francis Group New York, 2009. Publisher: CRC Press (15 December 2008) ISBN-13: 978-1420047790

MSNST01E01: Environmental Impacts of Nanotechnology

Module 1. Possible Health Impact of Nanomaterials 18 hrs

Sources of Nanoparticles; Epidemiological Evidence; Entry Routes into the Human Body – Lung, Intestinal Tract, Skin; Nano particle Size - Surface and Body Distribution; Effect of Size and Surface Charges; Nanoparticles, Thrombosis and Lung Inflammation ;Nanoparticles and Cellular Uptake; Nanoparticles and the Blood-Brain Barrier.

Module 2. Nanomaterials for environmental remediation 18 hrs

Introduction- Nanoparticle-based Remediation Materials - Acid-Base Chemistry - Redox Chemistry- Field Deployments of ZVI - Absorption Chemistry - Hybrid Nanostructured Remediation Materials- Self-assembled Monolayers on Mesoporous Supports (SAMMS) - Functional CNTs .

Module 3. - Biotoxicity of Nanoparticles in Environmental Pollution 18 hrs

Introduction; Nanoparticles in the Environment; Nanoparticles in Mammalian Systems; Health Threats; Nanomaterials and Biotoxicity; Toxicological Studies and Toxicity of CNTs-case study; Toxicity of CNTs and metal oxides and Occupational Exposure Risk; Toxicity of MWCNTs/SWCNTs and Impact on Environmental Health. Air Pollution; Introduction to Air Pollution Particles;

Module 4. - Nanotoxicity on human organs 18 hrs

Effects of Nanoparticles on the Cardiovascular System; Nanopartide Translocation and Direct Vascular Effects; Endothelial Dysfunction and Endogenous Fibrinolysis; Coagulation and Thrombosis; Cardiac Autonomie Dysfunction; Effects of Nanoparticles on the Liver and Gastrointestinal Tract; Effects of NP on the Nervous System.

References /compulsory readings

1. Challa. S. S. R, Kumar, "Nanomaterials - Toxicity, Health and Environmental Issues", Wiley-VCH publisher, 2006.
2. Nancy. A, Monteiro-Riviere, Lang Tran. C, "Nanotoxicology: Characterization, Dosing and Health Effects", Informa healthcare, 2007.
3. Drobne. D, "Nanotoxicology for safe and Sustainable Nanotechnology", Dominant publisher, 2007.
4. Zafar Nyamadzi. M, "A Reference handbook of nanotoxicology", Dominant publisher, 2008.

Supplementary/ Suggested reading

1. NANO: The Essentials- Understanding Nano Science and Nanotechnology, by T Pradeep, Tata McGraw Hill Education Pvt. Ltd. New Delhi) ISBN-13: 978-0-07-061788-
2. Introduction to Nano Science & Nanotechnology by Gabor L. Hornyak, Harry F. Tibbals, Joydeep Dutta, John J. Moore, CRC Press, Tylor & Francis Group New York, 2009. Publisher: CRC Press (15 December 2008) ISBN-13: 978-1420047790

SECOND SEMESTER

MSNST02C01: Elements of Physical Chemistry

Module 1 Thermodynamics 22 hrs

First Law of Thermodynamics, heat, work, heat capacity, enthalpy and internal energy, Second Law of Thermodynamics – Entropy and Criterion for Equilibrium – Statistical interpretation of entropy – Boltzmann equation. Auxiliary Functions – Thermodynamic Relations – Maxwell's Equations – Gibbs - Helmholtz Equation – Examples – Heat capacity, enthalpy, entropy and the third law of Thermodynamics- First, second, and third laws of thermodynamics as applied to nanoscale systems

Module 2 Phase Equilibria 22 hrs

Phase equilibrium in a one – component system – Composition and Phase diagrams of binary Systems – Criteria for Phase stability – Thermodynamics and kinetics of phase transformations- Homogeneous nucleation- Heterogeneous nucleation. Physical phenomena of small systems - nano-crystals, macromolecules, thermodynamics and physical properties of long chain molecules and molecular structures

Module 3 Surface chemistry 14 hrs

Surface Chemistry: Adsorption and absorption, Adsorption isotherms, Freundlich adsorption isotherm, Langmuir adsorption isotherm, B.E.T. theory of multilayer adsorption, Gibbs adsorption isotherm, Application of adsorption.

Module 4 Colloids 14 hrs

Colloids: Classification of Colloids, Preparation of colloidal solutions, Purification of colloidal solution, Properties of colloidal solution, Emulsion, Gels, uses of colloids, Micelle formation, The critical micellization concentration, Factors affecting the MC.

References /compulsory readings

1. David V. Ragone, Thermodynamics of Materials, Volume I, J. W. Wiley 1995.
2. Thermodynamics in Materials Science, By Robert T. De Hoff, McGraw-Hill, 1993.
3. Thermodynamics and Statistical Mechanics by A N Tikhonov, Peter Theodore Landsberg
4. Physical Chemistry by P. W. Atkins, Oxford Press
5. Introduction to Modern Colloid Science by Robert J. Hunter, Oxford University Press.
6. Nanoscale Materials in Chemistry by Kenneth J. Khabhunde (ed.) Wiley Interscience

Supplementary and suggested reading:

1. Robert K, Ian H, Mark G, Nanoscale Science and Technology, John Wiley & sons Ltd.,2005.
2. Daniel V. Schroeder: An Introduction to Thermal Physics, Addison-Wesley, 2000
3. Thermodynamics and Statistical Mechanics by John M. Seddon, J. D. Gal

MSNST02C02: Design and synthesis of Nanomaterials

Module 1 Physical Methods for synthesis of nanomaterials 20 hrs

Inert gas condensation, arc discharge, RF plasma, ion sputtering, laser ablation, laser pyrolysis, layer deposition ball milling, Spray pyrolysis, Microwave irradiation Gamma radiation, ion implantation, molecular beam epitaxy, Physical Vapour deposition, chemical vapour deposition method and Electrospinning

Module 2 Chemical Methods for synthesis of nanomaterials 20 hrs

Chemical methodologies, their advantages, nanoparticles, 1D-nanostructures-Nanowires, nanotubes and nanorods; 2D-nanostructures-thin films-Nanoparticles through homogeneous & heterogenous nucleation in solution, co-precipitation, chemical reduction, hydrothermal and solvothermal synthesis, template based synthesis, electrochemical synthesis, sonochemical synthesis, polyol method, sol-gel synthesis, micelles and microemulsion assisted synthesis, thermal decomposition, self-assembly methods and Langmuir Blodgett (LB) method.

Module 3 Biological Methods for synthesis of nanomaterials 20 hrs

Use of bacteria, fungi, actinomycetes and algae for nanoparticle synthesis, natural synthesis of magnetic nanoparticles using magnetotactic bacteria, viruses as components for the formation of nanostructured materials, role of plant derivatives in nanoparticle synthesis. Nanoparticle synthesis with the help of enzymes and biomolecules, nanomaterial synthesis from industrial or agricultural wastes

Module 4 Lithographic Techniques for fabrication of nanomaterials 12 hrs

Electron beam lithography, SEM based nanolithography, X-ray lithography, focused ion beam lithography, near field scanning optical microscopy, AFM lithography, dip pen lithography.

References/compulsory reading

1. Nanostructures and Nanomaterials- Synthesis, Properties & applications by Guozhong Cao , Imperial college Press, (2006). Publisher: World Scientific Publishing Company; 2 edition (4 January 2011) ISBN-13: 978-9814324557

2. An introduction to Electrospinning and Nanofibers by Seeram Ramakrishna, Kazutoshi Fujihara, Wee Eong Tee, Teck Cheng Lim, Zaveri Ma, World Sci. Pub. Ltd. Singapore, 2005. Publisher: World Scientific Publishing Co Pte Ltd (8 May 2005) ISBN-13: 978-9812564542
3. Springer Handbook of Nanotechnology - Bharat Bhusan Publisher: Springer-Verlag (15 May 2006) ISBN-13: 978-3540343660
4. Introduction to Nano Science & Nanotechnology by Gabor L. Hornyak, Harry F. Tibbals, Joydeep Dutta, John J. Moore, CRC Press, Tylor & Francis Group New York, 2009. Publisher: CRC Press (15 December 2008) ISBN-13: 978-1420047790
5. Introduction to Nanoscale Science & Technology, Di Ventra, Evoy, Heflin, Springer Science, NY, 2004. Publisher: Springer; 1 edition (30 June 2004)
6. Nanofabrication- Fundamentals and Applications, By Ampere A Tseng, Singapore 2008. Publisher: World Scientific Publishing Co Pte Ltd (18 March 2008) ISBN-13: 978-9812705426

Supplementary/Suggested reading

1. Nanoparticles and Nanostructured Films- Preparation Characterization and Applications by Janos H. Fendler, WILEY-VCH Verlag GmbH. D-69469 Weinheim (Federal Republic of Germany), 1998. Publisher: Wiley VCH (28 May 1998) ISBN-13: 978-3527294435
2. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens Publisher: Wiley-Interscience; 1 edition (30 May 2003) Sold by: Amazon Asia-Pacific Holdings

MSNST02C03: Characterization Techniques for Nanomaterials

Module 1 Spectroscopic Techniques 18 hrs

X-ray Spectroscopy techniques: powder XRD, small angle X-ray diffraction, grazing incidence X-ray diffraction and single crystalline X-ray diffraction, X-ray fluorescence spectroscopy, X-ray photoelectron spectroscopy, UV-visible spectroscopy, FT-IR spectroscopy, Raman spectroscopy, absorption and emission Spectroscopy.

Module Microscopic Techniques 18 hrs

Optical microscopy, scanning electron microscopy, transmission electron microscopy, scanning probe microscopy, atomic force microscopy, scanning tunnelling microscopy, near field scanning optical microscopy, confocal laser scanning microscopy.

Module 3 Thermal & Mechanical methods 18 hrs

Thermal methods: thermogravimetric analysis, derivative thermogravimetry, differential thermal analysis, differential scanning calorimetry, combustion calorimetry, thermal diffusivity by the laser flash technique- simultaneous techniques including analysis for gaseous products. Mechanical testing- Introduction, tension testing, high strain rate testing of materials, fracture toughness testing methods, hardness testing.

Module 4 Magnetic & Electrochemical methods 18 hrs

Vibrating sample magnetometer, Mossbauer spectroscopy, electron paramagnetic resonance and nuclear magnetic resonance methods. Magneto-optic Kerr effect. Electrochemical Techniques: Cyclic voltammetry, electrochemical impedance, scanning electrochemical microscopy, quartz crystal micro balance

References /compulsory readings

1. Introduction to Nano Science and Nanotechnology, by K K Chattopadhyay, PHI Learning Pvt. Ltd. New Delhi 2019, ISBN-13: 978-81-203-3608-7.
2. Characterization of Materials Vol 1 &2, by Elton N. Kaufmann, John Wiley and Sons Publication, 2003. New Jersey.
3. Principles of instrumental analysis, Douglas A Skoog, Donald M West, Saunders College, Philadelphia. Publisher: Cengage; 6 edition (1 November 2014) ISBN-13: 978-81-315- 25579.
4. NANO: The Essentials- Understanding Nano Science and Nanotechnology, by T Pradeep, Tata McGraw Hill Education Pvt. Ltd. New Delhi) ISBN-13: 978-0-07-061788-9
5. X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials, 2nd Edition - Harold P. Klug, Leroy E. Alexander, Publisher: Wiley-Blackwell; 2nd Revised edition edition (1 January 1974) ISBN-13: 978-0471493693
6. Transmission Electron Microscopy: A Textbook for Materials Science (4-Vol Set)- David B. Williams and C. Barry Carter, Publisher: Springer; 1st ed. 1996. Corr. 6th printing edition (15 April 2005) ISBN-13: 978-0306453243

Suggested and Supplementary readings:

1. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton, Publisher: Springer; Softcover reprint of hardcover 1st ed. 2005 edition (12 October 2010) ISBN-13: 978-1441938374

2. Springer handbook of Nanotechnology ed. Bharat Bhushan (Springer), Publisher: Springer-Verlag (15 May 2006) ISBN-13: 978-3540343660

MSNST02C04: NanoLab II

Module 1

- Thin film Preparation of Metal Oxide (Spin Coating)
- Cyclic Voltammetry studies of Metal oxide as thin film electrodes
- Synthesis of metal oxide nanotubes
- Photocatalytic studies of semiconductors

Module 2

- Synthesis of nanocomposite materials
- Effect of particle size on conductivity of a nanocomposites
- Hydro/Solvothermal synthesis of metal oxide nanostructures of different morphology by varying parameters
- Chemical bath deposition of thin films based on metal oxides.

Module 3

- Solvothermal method for ZnO – band edge in UV - Vis spectroscopy – size
- of the particle
- Synthesis of SnO_2 nanostructures
- Fabrication of gas sensor using SnO_2 nanostructure
- TGA-DTA studies of metal oxide nanoparticles

Module 4

- Co-precipitation synthesis of iron oxide nanoparticles
- Synthesis of ferrofluids and their characterizations using the iron oxide nanoparticles
- Hydrothermal synthesis of TiO_2 nanoparticles
- Construction of Solar cell with TiO_2 nanoparticles

References /compulsory readings

1. Nanostructures and Nanomaterials- Synthesis, Properties & applications by Guozhong Cao , Imperial college Press, (2006). Publisher: World Scientific Publishing Company; 2 edition (4 January 2011) ISBN-13: 978-9814324557

2. Nanoparticles and Nanostructured Films- Preparation Characterization and Applications by Janos H. Fendler, WILEY-VCH Verlag GmbH. D-69469 Weinheim (Federal Republic of Germany), 1998. Publisher: Wiley VCH (28 May 1998) ISBN-13: 978-3527294435
3. Nanomaterials and Nanochemistry by C. Brechignac.P. Houdy M. Lahmani, Springer-Verlag (2007). (For Unit III-Part I Chapter I)

Supplementary/ Suggested reading

1. NANO: The Essentials- Understanding Nano Science and Nanotechnology, by T Pradeep, Tata McGraw Hill Education Pvt. Ltd. New Delhi) ISBN-13: 978-0-07-061788-9
2. Introduction to Nano Science & Nanotechnology by Gabor L. Hornyak, Harry F. Tibbals, Joydeep Dutta, John J. Moore, CRC Press, Tylor & Francis Group New York, 2009. Publisher: CRC Press (15 December 2008) ISBN-13: 978-1420047790

MSNST02E01: Nanoscale Magnetic materials and Devices

Module 1 Overview of Magnetism in Solids 16 hrs

Introduction – Magnetic fundamentals – Spontaneous Magnetization and Curie Temperature – Magnetic Parameters – Stoner-Wohlfarth threshold – Antiferromagnetic materials – .ferroelectric domains, phase transitions, deviations from ideal ferroelectric behavior, diffuse-phase transitions, electrostriction, and electro-optic effects in ferroelectrics, Complex perovskites, polar nano regions, ferroelectric relaxors, order-disorder ferroelectrics, Antiferroelectrics, Memory Fundamentals – Magnetic Storage Fundamentals

Module 2 Fundamentals of Nanomagnetism 14hrs

Electron Transport in Magnetic Multi-layers – Spintronics - Spin Polarized Electron Tunneling – Interlayer Exchange Coupling – Spin Relaxation in Magnetic Metallic layers and Multi-layers - Non-Equilibrium Spin Dynamics in Laterally Defined Magnetic Structures

Module 3 Fabrication and Characterization of Nanomagnetic materials 20 hrs

Particulate Nanomagnets – Geometrical Nanomagnets – Fabrication Techniques Scaling – Characterization using Various Techniques – Imaging Magnetic Microspectroscopy – Study of Ferromagnetic & and Antiferromagnetic Interfaces – Optical Imaging – Lorentz

Microscopy – Electron Holography of Magnetic Nanostructures –Magnetic Force Microscopy

Module 4 Applications and Devices 22 hrs

Magnetic Data Storage – Introduction – Magnetic Media – Properties – Materials Used – Write Heads – Read Heads – Magnetoresistance – General – in Normal Metals and in Ferromagnetic Materials – Future of Magnetic Data Storage - Magneto-Optics and Magneto-optic recording – Kerr Effect – Faraday Effect, Magnetic Semiconductors, Spintronics devices, noise reduction.

References/compulsory readings

1. Advanced semiconductor and organic Nano-techniques - Vol I Hadis Morkoc, Academic Press, London (2003) ISBN 0125070616

2. Modern Techniques for Characterizing Magnetic Materials Edited by Yimei Zhu, Springer (2005) ISBN 1402080077

3. Magnetic Microscopy of Nanostructures Hans P.Oepen and H.Hopster, Springer (2004) ISBN 3540401865

4. Ultra thin Magnetic Structures III – Fundamentals of Nanomagnetism JAC Bland and B. Heinrich, Springer (2004) ISBN 3540219536

5. Magnetic Materials: Fundamentals and Device Applications Nicola Ann Spaldin, Cambridge University Press (2003) ISBN 0521016584

Supplementary/ Suggested reading

1. Hans .P.O, and Hopster. H, "Magnetic Microscopy of Nanostructures", Springer ,2004.

2. Bland. J.A.C, and B. Heinrich. B, "Ultra thin Magnetic Structures III – Fundamentals of Nanomagnetism", Springer ,2004.

3. Nicola. A.S, "Magnetic Materials: Fundamentals and Device Applications", Cambridge University Press ,2003.

MSNST02E02: Nanomaterials for energy and environment

Module 1 Nanomaterials for energy and environment 18 hrs

Energy and Environment, sustainable energy production based on renewable energy sources, Sustainability: Agriculture, Water, Energy, Materials and clean environment, Nanomaterials used in energy and environmental applications and their properties, Solar energy, solar cells, dye sensitized solar cell, organic solar cells, Hydrogen energy, hydrogen production by water

splitting, hydrogen storage.

Module 2 Nanomaterials for energy and environment 18 hrs

Alternative energy technologies, Electrochemical energy conversion and storage systems, Fuel cells, Types of fuel cells, thermodynamics of fuel cells, electrocatalysts for anode reactions, catalysts for oxygen reduction reactions, Batteries, Li-ion battery, Na-ion battery, General properties of electrochemical capacitors, Supercapacitor, Electrical double layer capacitor, pseudocapacitor, Li-ion based hybrid supercapacitors, Applications of electrochemical capacitors.

Module 3 Nanomaterials for energy and environment 18 hrs

Green nanotechnology and its principles, Nanomaterials for environmental Remediation, Photocatalysis, Water purification using nanomaterials, desalination of water, Solid waste removal, Porous materials to store clear energy gases, Metal organic frame works(MOFs), Storage of carbon dioxide, methane and hydrogen in MOFs.

Module 4 Nanomaterials for energy and environment 18 hrs

Introduction to commercial plastics and elastomers -Natural Rubber (NR), modified NR and blends-Polyesters from microbial and plant biofactories (polylactic acid and poly hyroxyalkanoates)- Plastics from vegetable oils -Cellulose and starch based materials - Natural fillers, fibers, reinforcements and clay nanocomposites -Biodegradability

References /compulsory readings

1. Jingbio louise Liu, Sajid Bashir, Advanced Nanomaterials and their applications in Renewable energy, Elsevier, 2015.
2. Tetsuo Soga, Nanostructured Materials for Solar Energy Conversion, Elsevier , 2006.
3. G.A. Nazri and G. Pistoia, Lithium Batteries: Science and Technology, Kluwer Academic Publishers, Dordrecht, Netherlands, 2004.
4. J. Larmine and A. Dicks, Fuel Cell System Explained, John Wiley, New York , 2000.

Supplementary and suggested reading:

1. Francois B´eguin and El˙zbieta Frackowiak, Supercapacitors, Wiley-VCH, 2013.
2. Challa S.S.R. Kumar, Nanomaterials: toxicity, health and environmental issues, Wiley-VCH, 2006.

THIRD SEMESTER

MSNST03C01 Semiconductor Nanomaterials and NanoLithography

Module 1. Basics of Bulk semiconductors 14hrs

Introduction-Semiconductor-Doping-Concept of effective mass-Carrier transport, mobility and electrical conductivity-Optical properties of semiconductors- Excitons-Phonons-Types of semiconductors etc.

Module 2. Semiconductor nanostructures 20hrs

Quantum confinement in one, two and three dimensions: quantum wells, quantum wires Quantum dots- Superlattices-Band Offsets-Quantum dot lasers. Requirements for an ideal semiconductor nanostructure - Epitaxial growth of quantum wells - Lithography and etching Induced dots and wires - Electro statically induced dots and wires- Semiconductor nanocrystals - Colloidal quantum dots-Self-assembly techniques - Physical processes in semiconductor nanostructures.

Module 3. Basics of Lithography 20 hrs

Optical lithography: Contact and proximity printing - Projection Printing – Mask alignment, Reflection and catadioptric projection - Refraction projection – Enhancement – overlay accuracies. Positive and negative photoresists, UV – photolithography for systems of 100 nm – Nano designs for electronic circuits. Electron Lithography: Electron optics - Raster scan and Vector scan - Electron proximity / Projection Printing, Electron resists - Electron Beam Applications - X – ray Lithography: Proximity printing - X-ray masks - X-ray sources - Synchrotron radiation – Xray projection - X-ray resists. Ion Lithography: Focused ion beam - Point sources of Ion - Ion column - Beam writing – Focused Ion Beam Lithography - Masked Ion Beam Lithography - Ion Projection Lithography.

Module 4. Nanolithography techniques: 18hrs

High – resolution E-beam Nanolithography - Resist Exposure Metrics – High resolution resists - Proximity Effects - Direct writing. Proximal Probe Nanolithography: STM – AFM - Dip pen Nano lithography - Resists & Imaging Layers for proximal probes - Langmuir – Blodgett Film resists – Patterned synthesis of nanomaterials - Self-Assembled Monolayers Resists - Anodic Oxidation – Nanoscratching.

References /compulsory readings

1. Robert W. Kelsall, Mark. Geoghegan, Ian W. Hamley, Nanoscale Science and Technology, John Wiley and Sons, 2005 ISBN 0470850868

2. C.Y. Chang and S.M.Sze, "ULSI Technology", McGraw-Hill Companies Inc., Singapore, 1996.

3. John N. Helbert, "Hand Book of VLSI Microlithography", Noyes Publication, USA, 2001.

4. James R. Sheats and Bruce W. Amith, "Microlithography Sciences and Technology", Marcel Dekker Inc., New York, 1998.

MSNST03C02 Carbon Nanostructures

Module I: Introduction to Carbon nanostructures 14 hrs

Carbon molecules, nature of the carbon bond, new carbon structures, discovery of C60 structure of C60 and its crystal, From a Graphene Sheet to a Nanotube, Single wall and Multi walled Nanotubes, Zigzag and Armchair Nanotubes, Euler's Theorem in Cylindrical and Defective

Module 2. Synthesis and properties of Fullerenes 20 hrs

Structure of Higher Fullerenes, Growth Mechanisms; Production and Purification- Fullerene Preparation by Pyrolysis of Hydrocarbons, Partial Combustion of Hydrocarbons, Arc Discharge Methods, Production by Resistive Heating, Rational Syntheses; Physical Properties-, Spectroscopic Properties, Thermodynamic Properties; Chemical Properties- Hydrogenation and Halogenation, Nucleophilic Addition to Fullerenes.

Module 3. Carbon Nanotubes 20hrs

The Structure of Carbon Nanotubes- Nomenclature, Structure of SingleWalled Carbon Nanotubes and Structure of Multiwalled Carbon Nanotubes; Structure and Production of Further Tubular Carbon Materials- Spectroscopic Properties of Carbon Nanotubes- Raman and Infrared Spectroscopy of Carbon Nanotubes, Absorption and Emission Spectroscopy of Carbon Nanotubes, ESR-Spectroscopic Properties of Carbon Nanotubes.

Module 4. Graphene 18 hrs

Structure of graphene; Preparation of graphene – synthesis of graphene by various physical and chemical methods and Purification; Electronic Properties Band Structure of Graphene -

Mobility and Density of Carriers - Quantum Hall Effect - Spectroscopic Properties of graphene - Raman, Application of Fullerene, CNT, Graphene and other carbon nanomaterials Mechanical, Thermal Applications, Electronic Applications and biological Applications.

References /compulsory readings

1. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.
2. Carbon Nanotechnology- Liming Dai.
3. Nanotubes and Nanowires- CNR Rao and A Govindaraj RCS Publishing. 4. Physical properties of Carbon Nanotube-R Satio.

MSNST03C03 Nanobiotechnology

Module 1. Basics of biotechnology 14hrs

Biology inspired concepts - biological networks – biological Neurons – the function of neuronal cell – biological neuronal cells on silicon modeling of neuronal cells by VLSI circuits – bioelectronics – molecular Processor – DNA analyzer as biochip – molecular electronics

Module 2. Lipid and DNA Technology 18 hrs

Nano-biometrics - introduction – lipids as nano-bricks and mortar: self-assembled nanolayers – the bits that do think – proteins – three dimensional structures using a 20 amino acid – biological computing – A Protein based 3D optical memory using DNA to build nano cubes and hinges - DNA as smart glue – DNA as wire template – DNA computer.

Module 3. Bionanocomposites 20 hrs

Natural nano composites - introduction – natural nano composite materials – biologically synthesized nano structures – biologically derived synthetic nano composites – protein based nanostructure formation – biologically inspired nano composites. Nanotechnology in Agriculture (Fertilizers and pesticides).

Module 4. Characterization methods for Nanobiomaterials 20 hrs

Nanoanalytics - quantum dot biolabeling – nanoparticle molecular labels – analysis of biomolecular structure by AFM and molecular pulling-force spectroscopy– biofunctionalized nanoparticles for SERS and SPR.

References /compulsory readings

1. Nanoelectronics and Nanosystems: From transistors to molecular devices. K.Goser, P. Glosekotter, J. Dienstuhl, Springer (2004)

2. Nanotechnology: basic science and emerging technologies – Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005).

3. Nanobiotechnology: Concepts, Applications and Perspectives, Christof M.Niemeyer, / Chad A.Mirkin, (eds.), Wiley-VCH, Weinheim, (2004)

4. Bionanotechnology : Lessons from Nature, by: David S. Goodsell, Wiley-Liss (2004)

Supplementary and suggested reading:

1. NanoBiotechnology Protocols, Sandra J Rosenthal, David W.Wright, Series: Methods in Molecular Biology, (2005)

2. Protein Nanotechnology, Protocols, Instrumentation, and Applications, Tuan Vo-Dinh, Series: Methods in Molecular Biology (2005).

MSNST03C04: NanoLab III

Module 1

- Synthesis of graphene
- Application of graphene as supercapacitor electrode
- Molten salt synthesis of metal oxide nanoparticles

Module 2

- Ag-assisted Electroless etching of Si wafer to form Si nanowires
- Characterisation of Si nanowires and their application as electrodes

Module 3

- Synthesis of activated carbon using KOH activation and controlling the pore size by varying parameters
- Study the electric double layer capacitance properties of activated carbon.
- Synthesis of 2-D nanosheets of MoS_2 by exfoliation technique

Module 4

- Synthesis of polymer nanowires using electrospinning and their characterizations
- Controlling the size and morphology of nanostructures by varying parameters of eletrospinning

- Synthesis of metal oxide/carbon composite nanowires using electrospinning

References /compulsory readings

1. Nanostructures and Nanomaterials- Synthesis, Properties & applications by Guozhong Cao , Imperial college Press, (2006). Publisher: World Scientific Publishing Company; 2 edition (4 January 2011) ISBN-13: 978-9814324557

2. Nanoparticles and Nanostructured Films- Preparation Characterization and Applications by Janos H. Fendler, WILEY-VCH Verlag GmbH. D-69469 Weinheim (Federal Republic of Germany), 1998. Publisher: Wiley VCH (28 May 1998) ISBN-13: 978-3527294435

3. Nanomaterials and Nanochemistry by C. Brechignac.P. Houdy M. Lahmani, Springer-Verlag (2007). (For Unit III-Part I Chapter I)

Supplementary/ Suggested reading

1. NANO: The Essentials- Understanding Nano Science and Nanotechnology, by T Pradeep, Tata McGraw Hill Education Pvt. Ltd. New Delhi) ISBN-13: 978-0-07-061788-9

2. Introduction to Nano Science & Nanotechnology by Gabor L. Hornyak, Harry F. Tibbals, Joydeep Dutta, John J. Moore, CRC Press, Tylor & Francis Group New York, 2009. Publisher: CRC Press (15 December 2008) ISBN-13: 978-1420047790

MSNST03E01 Nano medicine and Drug delivery systems

Module. 1 Prospect of Nano-Medicine 18 hrs

History of the idea – The Biological and Mechanical Traditions – Nano-medicine - Taxonomy – Bio-Pharmaceuticals – Implantable Materials – Implantable Devices – Surgical Aids – Diagnostic Tools – Genetic Testing – Imaging – Nanoparticles Probe – Case Analysis – 1) Resiprocytes – Mechanical Artificial Red Cells – 2) Using DNA as a construction medium

Module 2. Nanosensors 18 hrs

Chemical and Molecular Sensors – Displacement and Motion Sensors – Force Nanosensors – Pressure Sensing – Thermal Nanosensors – Electric and Magnetic Sensing – Cellular Bioscanning – Non-invasive Neuroelectric Monitoring – Macrosensing – Acoustic Macrosensing – Electric and Magnetic Macrosensing – Neural Macrosensing

Module 3. Drug deliver basics 16 hrs

Needs and Requirements – Nanoparticle Flow: Implications for Drug Delivery – Polymeric Nanoparticles as Drug Carriers and Controlled Release Implant Devices – Genetic Vaccines: A Role for Liposomes – Polymer Micelles as Drug Carriers – Recent Advances in Microemulsions as Drug Delivery Vehicles – Lipoproteins as Pharmaceutical Carriers – Solid Lipid Nanoparticles as Drug Carriers

Module 4. Nanocapsules 20 hrs

Nanocapsules – A New Drug Delivery System Nanocapsules preparation, Characterization and Therapeutic Applications – Dendrimers as Nanoparticulate Drug Carriers – Cells and Cell Ghost as Drug Carriers – Cochleates as Nanoparticular Drug Carriers – Aerosols as Drug Carriers – Magnetic Nanoparticles as Drug Carriers – Nanoparticulate Drug Delivery to the Reticuloendothelial System and to Associated Disorders – Delivery of Nanoparticles to the Cardiovascular System – Nanocarriers for the Vascular Delivery of Drugs to the Lungs – Nanoparticulate Carriers for Drug Delivery to the Brain – Nanoparticles for Targeting Lymphatics – Polymeric Nanoparticles for Delivery in the Gastro-Intestinal Tract – Nanoparticular Carriers for Ocular Drug Delivery – Nanoparticles and Microparticles as Vaccines Adjuvants – Pharmaceutical NanoCarriers in Treatment and Imaging of Infection.

References /compulsory readings

1. Nano Medicines Edited by Dr.Parag Diwan and Ashish Bharadwaj, Pentagon Press(2006) ISBN 81-8274-139-4

2. Nanoparticulates as Drug Carriers Edited by Vladimir P.Torchilin, Imperial College Press, North Eastern University, USA (2006) ISBN 1-86094-630-5

Supplementary/ Suggested reading

1. NanoBiotechnology Protocols, Sandra J Rosenthal, David W.Wright, Series: Methods in Molecular Biology, (2005)

2. Protein Nanotechnology, Protocols, Instrumentation, and Applications, Tuan Vo-Dinh, Series: Methods in Molecular Biology (2005).

MSNST03E02: Micro and Nanodevices

Module 1. Introduction 18 hrs

MEMS and NEMS definitions, Taxonomy of Nano-and Microsystems-Synthesis and Design. Classification and considerations, Biomimetics, Biological analogies, and design–

Biomimetics Fundamentals, Biomimetics for NEMS and MEMS, Nano-ICs and Nanocomputer architectures.

Module 2. Modelling of MEMS and NEMS 16 hrs

Introduction to modeling, analysis and simulation, basic electro-magnetic with application to MEMS and NEMS, modeling developments of micro-and nano actuators using electromagnetic-Lumped-parameter mathematical models of MEMS, energy conversion in NEMS and MEMS.

Module 3. - Sensors 20 hrs

Introduction-types of sensors-Mechanical, optical, spintronic, bioelectronic and biomagnetic sensors-surface modification-surface materials and interactions and its examples Physical effects : - Photoelectric Effect, Photoluminescence Effect, Electroluminescence Effect, Chemiluminescence Effect, Doppler Effect, Hall Effect, thermoelectric effect, magneto-optical phenomena

Module 4. - Future Nanosystems 18 hrs

Nano machines, nano robots, electronics based on CNT, molecular Electronics. Quantum Computation: Future of Meso/Nanoelectronics -Interfacing with the Brain, the solutions in NanoManufacturing technology

References /compulsory readings

1. Sergey Edward Lyshevski, Lyshevski Edward Lyshevski, "Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering "– 2nd Ed., CRC Press, 2005.
2. Edelstein. A. S, and Cammarata, "Nanomaterials: Synthesis, Properties and Applications Institute of Physics", Bristol, Philadelphia: Institute of Physics, 2002.
3. Mahalik. N. P, "Micro manufacturing and Nanotechnology", Springer Berlin Heidelberg New York 2006.
4. Mark. J Jackson, "Micro and Nanomanufacturing", 2007.
5. Principles of Electronic Ceramics, L.L. Hench and J.K. West, John Wiley & Sons, Singapore, 1990

Supplementary and suggested reading:

1. Zheng Cui, "Nanofabrication, Principles, Capabilities and Limits", 2008.
2. Kalantar–Zadeh. K, "Nanotechnology Enabled Sensors, Springer," 2008.

3. Serge Luryi, Jimmy Xu, Alex Zaslavsky, “Future trends in MicroElectronics”, John Wiley & Sons, Inc. Hoboken, New Jersey 2007.

FOURTH SEMESTER

MSNST04E01: Industrial Significance and applications of Nanotechnology

Module 1. Biomedical Applications 18 hrs

Nanoparticles and Micro–organism- Biosensors- Bioreceptors and their properties - Biochips- Integrated nanosensor networks for detection and response- DNA based biosensors and diagnostics- Natural nanocomposite systems; spider silk, bones, shells - Nanomaterials in bone substitutes and dentistry – Implants and Prosthesis –Tissue Engineering – Neuroscience -Neuro-electronic Interfaces -Nanorobotics– Photodynamic Therapy - Protein Engineering – Nanosensors in Diagnosis–Drug delivery – Cancer therapy and other therapeutic applications.

Module 2. Agricultural and Food Sector Applications 18 hrs

Nanotechnology in Agriculture -Precision farming, Smart delivery systems – Insecticides using nanotechnology – Potential of nano-fertilizers – Potential benefits in Nanotechnology in Food industry – Global Challenges- Product innovation and Process improvement- Consumer benefits- Food processing - Packaging- - Packing materials; physical properties- Improvements of mechanical and barrier properties- Antimicrobial functionality- Active packaging materials- -Information and communication technology- Sensors- RF identification- Food safety- Nanomaterial based Food diagnostics – Contaminant detection – Intelligent packaging- Nanoengineered Food ingredients- Potential risks to Nanofood to consumers

Module 3. Applications in Textile and Cosmetics Sector 18 hrs

Nanofibre production – Electrospinning and charge injectionmethod – morphological control- yarns and polymide nanofibers- Carbon Nanotube and Nanofibre Reinforced Polymer Fibres- multifunctional polymer nanocomposites- Improvement of polymer functionality- Nylon-6 nanocomposites from polymerization- Dyeable Polypropylene - nanocoatings and surface modifications - Nano-filled polypropylene fibers - UV resistant, antibacterial, self-cleaning, flame retardant textiles – Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear textiles-

Cosmetics; Formulation of Gels, Shampoos, Hair-conditioners–Nanomaterials in Sun-screen UV protection – Color cosmetics

Module 4. - Defence and Aerospace Applications 18 hrs

Pathways to Physical protection- Detection and diagnostics of chemical and biological agents, methods- Chemical and Biological counter measures- Decontamination- Post exposure and pre exposure protection and decontamination- Nanotechnology enabled bio chemical weapons- Influence operations- Evasion of medical countermeasures- Nanotechnology based satellite communication system- Guidance, Navigation and control- Spacecraft thermal control- mini, micro, nanosatellite concepts- Fiber optic and Chemical microsensors for space craft and launch support- Micro/Nano pressure and temperature sensors for space missions.

References /compulsory readings

1. Mark. A, Ratner and Daniel Ratner, "Nanotechnology: A Gentle Introduction to the Next Big Idea", Pearson, 2003.
2. Bharat Bhushan, "Springer Handbook of Nanotechnology", Barnes & Noble 2004.
3. Neelina. H, Malsch (Ed.), "Biomedical Nanotechnology", CRC Press 2005.
4. Udo. H, Brinker, Jean-Luc Mieusset (Eds.), "Molecular Encapsulation: Organic Reactions in Constrained Systems", Wiley Publishers 2010.
5. Jennifer Kuzma and Peter Ver Hage, "Nanotechnology in agriculture and food production", Woodrow Wilson International Center, 2006.
6. Lynn. J, Frewer, Willehm Norde. R. H, Fischer and Kampers. W. H "Nanotechnology in the Agri- food sector", Wiley-VCH Verlag, 2011.
7. Brown. P. J and Stevens. K "Nanofibers and Nanotechnology in Textiles", Woodhead Publishing Limited, Cambridge, 2007.
8. Mai. Y-W "Polymer Nano composites", Woodhead publishing, 2006.
9. Chang. W.N "Nanofibres fabrication, performance and applications", Nova Science Publishers Inc, 2009.
10. Helvajian. H and. Robinson. E.Y "micro and nanotechnology for space systems" the aerospace corporation, Micrograph , 1997.
11. Margaret. E, Kosal, "Nanotechnology for Chemical and Biological defence, Springer 2009.

MSNST04E02: Nanoelectronics

Module 1. Basics of Nanoelectronics 18 hrs

Basics of nano electronics – Contribution of Nanoelectronics to Mankind – Physical fundamentals – The birth of electronics – Phase shifters**,** piezoelectric sensors and actuators, Ultrasonic transducers, optical limiters, energy harvesters, MOSFETs, The tools for micro and nano fabrication- Basics of Lithographic techniques for nano electronic devicesbasics of information theory- .

Module 2. Quantum Electronic Devices 18 hrs

Basics of Quantum electronic devices – The journey from classical physics to quantum physics: upcoming electronic devices – Fundamentals to understand the evolution of quantum electronics- electrons in mesoscopic structure – short channel MOS transistor – split gate transistor – electron wave transistor – electron spin transistor – quantum cellular automate – quantum dot array – principles of Single Electron Transistor (SET) – SET circuit design – comparison between FET and SET circuit design-Coulomb Blockade effect-.

Module 3. Molecular Electronics and Bioelectronics 18 hrs

Tunneling devices and super conducting devices – tunnelling element technology RTD – circuit design based RTD –Defect tolerant circuits, Molecular electronics – elementary circuits – flux quantum devices – applications of super conducting devices –Bioelectronics – molecular processor – DNA analyzer as biochip – DNA computer – Quantum computer.

Module 4. Memory Devices and Sensors 18 hrs

Nano ferroelectrics - ferroelectric random access memories – introduction – Fe RAM circuit design – ferroelectric thin film properties and integration –Sensors based on nanotubes and Nanowires (Metal Oxide nanostructures for Gas flow, Temperature and strain) - Nano designs and Nano contacts – Molecular nanowires-Organic LED, Organic FETs- CNT and Graphene FTE, SiNW FET etc. electronic noses – – semiconductor sensor array.

References /compulsory readings

1. Nanoelectronics and Nanosystems: From transistors to molecular devices. K.Goser, P. Glosekotter, J. Dienstuhl, Springer (2004)

2. Nanoelectronics and information technology: Advanced electronic materials and novel devices (2nd edition), Rainer Waser (Ed.), Wiley-VCH Verlag, Weiheim (2005).

3. Nanotechnology: basic science and emerging technologies – Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005).

4. Transport in Nanostructures, D. K. Ferry and S. M. Goodwick, Cambridge Univ. Press. Cambridge, UK, 2001 Reprint, Ch. 4. 2. Physics of Semiconductor devices, J. P. Colinge and C. A. Colinge, Kluwer Academic Pub, 2002, Dordrech.

5. Quantum Transport: Atom to Transistor, Supriyo Datta, Cambridge University Press, 2005