KERALA TECHNOLOGICAL UNIVERSITY

CET Campus, Thiruvananthapuram, Kerala -695 016

ORDINANCE

For

Master of Technology - M.Tech.

In exercise of the Powers conferred under Clause 44 of the Ordinance, the Executive Committee of the University hereby promulgate the Ordinance for the University for the Academic Year 2015-2016.

The Academic ordinance will come into effect from the date of publication in the Gazette.

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O-1 Admission to the M. Tech. Programme

Candidates who have been awarded or qualified for the award of the Bachelor's degree in Engineering / Technology, from an Institution approved by AICTE are eligible for admission to the M. Tech., Programme. Eligibility of candidates having MCA/MSc qualifications will be decided from time to time by following the guidelines issued by All India Council for Technical Education (AICTE) and the Government of Kerala and notified separately. Other important eligibility criteria are as listed out by the Director of Technical Education with the approval of the Government of Kerala.

O-1.1 Candidates qualified in Graduate Aptitude Test in Engineering (GATE) and admitted to the M. Tech. programme are eligible to receive Half Time Teaching Assistantship (HTTA) as per the rules of the All India Council for Technical Education (AICTE)/Ministry of Human Resource Development (MHRD).

O-1.2 Sponsored candidates from Industries, R&D organizations, National Laboratories as well as Educational Institutions, with a bachelor's degree in engineering are eligible for admission to the M. Tech. programme.

O-1.3 Foreign nationals whose applications are received through Indian Council of Cultural Relations, Government of India are also eligible for admission to the M. Tech. programme.

O-1.4 Announcements for M. Tech. Programmes will be made by the DTE, Government of Kerala.

O-1.5 Selection of candidates for the M. Tech programme will be done centrally or monitored by the Directorate of Technical Education as per the guidelines given on this by the Government of Kerala

O-1.6 The number of candidates to be admitted to each M. Tech stream will be as per the approval of the University which shall be based on decision on this given by the All India Council for Technical Education.

O-1.7 Admission will be complete only on meeting all the other requirements mentioned in the letter of admission and on payment of the fees.

O-1.8 Candidates who have the Associate Membership of Professional Bodies that are approved by the University and have qualified in GATE shall also be eligible for admission to the M. Tech. programme.

O-1.9 The reservation policy of the Government of Kerala and the Government of India shall be followed in admission to the M. Tech. programme.

O-1.10 All admission will be governed by the procedure laid down for this by the Director of Technical Education, Kerala and the Government of Kerala.

O-1.11 Notwithstanding all that is stated above, the admission policy may be modified from time to time by the University, particularly to confirm to directions from the Government of Kerala and the Government of India.

O-2 Duration of the Programme

The normal duration of the M. Tech programme, including the project work, shall be four semesters.

O-3 Post Graduate Programme Clusters

The University shall identify clusters of colleges offering M. Tech programmes in different streams and allow them to formulate procedures for the smooth conduct of all academic activities associated with the M. Tech programme, in line with the ordinances/regulations of the University. These clusters shall have academic autonomy, regulated by a Cluster level Graduate Committee [CGPC] consisting of all the principals of the colleges in the cluster. The Chairman of CGPC shall be an eminent academician nominated by the Vice Chancellor. The CGPC will be responsible for all academic matters including the curriculum, syllabi, course plans, internal evaluations, end semester examinations, and grading for all streams of M. Tech. programme offered by the colleges in the cluster.
The CGPC can formulate additional rules for other academic aspects that are not covered by this Ordinance.

O-4 Specialization Streams in M. Tech., Programme

The M. Tech. programme streams offered by each cluster as well as the eligibility of candidates of different B. Tech. branches or having other qualifications, for each of them shall be approved by the CGPC.

O-5 M. Tech. Programme Structure

i) The M. Tech programme in all streams of specialization will be structured on a credit based system following the semester pattern with continuous evaluation.

ii) The University permits regular as well as external registration (part time) for those in employment.

iii) The duration for the M. Tech. programme in all streams of specialization will normally be 4 semesters. The maximum duration is 6 semesters.

iv) For students admitted on external registration, the normal duration will be 6 semesters. Here the maximum duration is 7 semesters.

v) The University permits a regular student to change over to external registration during
the programme, under specific circumstances like initiating a start up venture or to take up a job.

vi) Each semester shall have a minimum of 72 instruction days followed by the end semester examination.

vii) A common course structure for the M. Tech programmes in all streams of specialization is to be followed and consists of the following.
Core Courses
Elective Courses
Laboratory Courses
Seminar
Project

viii) Every stream of specialisation in the M. Tech. programme will have a curriculum and syllabi for the courses. The curriculum should be so drawn up that the minimum number of credits for successful completion of the M. Tech. programme in any stream of specialization is not less than 64 and not more than 68.

Ix) Credits are assigned as follows, for one semester

1 credit for each lecture hour per week
1 credit for each tutorial hour per week
1 credit for each laboratory/ practical of 2 or 3 hours per week
2 credits for the seminar
2 credits for Mini Project
6 credits for Project in the 3rd Semester
12 credits for Project in the 4th Semester

x) A pass is mandatory in all core courses. In case of failure in an elective course, there is the provision to choose another elective listed in the curriculum.

xi) On their request, CGPC shall examine the academic records and permit candidates with B. Tech (Honours) who have earned credits for any relevant graduate level courses to transfer credits towards the M. Tech. programme. Candidates who received B. Tech (Honours) degree just prior to their M. Tech admission are permitted to transfer up to 9 credits. For those who received the B. Tech (Honours) degree within three years prior to their M. Tech. admission are permitted to transfer up to 6 credits.

Xii) The maximum number of lecture based courses and laboratory courses in any semester shall not exceed 5 and 2 respectively. The maximum credits in a semester shall be 23.

Xiii) Extension of Programme duration

The normal duration of the programme shall be four semesters.

In case of prolonged illness or other personal exigencies, the university may allow a student who has earned credits for at least one semester, to extend the programme up to the maximum duration of six semesters.

Students who have earned credits for the courses listed in the first two semesters are permitted to transfer their registration as external candidates if they take up a job. However, they have to complete the programme within six semesters.

O-6. Course Registration and Enrolment

All students have to register for the courses they desire to attend in a semester. Students admitted to the first semester are advised to register for all courses offered in the first semester. They do not have to enrol for the semester. All other students are required to register at the end of the semester for the courses they desire to take in the next semester. Later they have to enrol for these courses in the new semester based on the results in the previous semester. This allows them to make minor changes in the list of courses already registered for. Before enrolment, students should clear all dues including any fees to be paid and should not have any disciplinary proceedings pending. The dates for registration and enrolment will be given in the academic calendar. Any late registration or enrolment, allowed only up to 7 working days from the commencement of the semester, will attract a late fee.

A student can drop a course or substitute one already registered for by another, for valid reasons with the approval of the faculty advisor. However this has to be done within 7 working days from the commencement of the semester.

The maximum number of credits a student can register for in a semester is limited to 24.

O-7 Recommended Credit distribution over the semesters

First Semester : 20 to 23 credits
Second Semester : 18 to 19 credits
Third Semester : 14 credits

Fourth Semester : 12 credits [Project]

O-8. Academic Assessment/Evaluation

The University follows a continuous academic evaluation procedure.

The Assessment procedure and corresponding weights recommended are as follows:-

For theory courses

i) Two internal tests, each having 15%

ii) Tutorials/Assignments/ Mini projects having 10%

iii) End Semester examination having 60%

All the above are mandatory requirements to earn credits.

Students who have missed either the first or the second test can register with the consent of the faculty member and the Head of the Department concerned for a re-test which shall be conducted soon after the completion of the second test and before the end semester examination. The re-test will cover both the first and the second test course plans. If a student misses both the scheduled tests, there is no provision for any retests and zero marks will be given for each test. In case of serious illness and where the attendance is above 70% the Principal may permit the conduct of the tests for a student based on his application and other relevant medical reports. Such cases are to be reported to CGPC.

For Laboratory /Practical courses

i) Practical Records /outputs 40%

ii) Regular Class Viva-Voce 20%

iii) Final Test (Objective) 40%

O-9. Course Completion and earning of credits

Students registered and later enrolled for a course have to attend the course regularly and meet the attendance rules of the University and appear for all internal evaluation procedures for the completion of the course. However, earning of credits is only on completion of the end semester/supplementary examination and on getting a pass grade. Students, who had completed a course but could not write the end semester/supplementary examination for genuine health reasons or personal exigencies, if otherwise eligible are permitted to write the semester examination, at the next opportunity and earn credits without undergoing the course again. Failed candidates having more than 45% marks in their internals can also avail of this option. However, those who are not eligible to appear for the end semester examination have to register and undergo the course again, whenever it is offered, to earn the credits.

O-10. End Semester and Supplementary Examinations

At the end of the semester, the end semester examination will be conducted in all courses offered in the semester and will be of three hours duration unless otherwise specified. Supplementary examinations are to be conducted for eligible candidates registered for them, before the commencement of the next semester.

O-10.1 Eligibility to write the End Semester Examination and Grading

Eligibility criteria to appear for the semester examination are the attendance requirements in the course, 45% or more marks in the internal evaluation and having no pending disciplinary action. The minimum attendance for appearing for the semester examination is 85% in the course. In case of serious illness there is a relaxation for attendance [O-14.xvi]. Those who do not meet the eligibility criteria shall be awarded an FE Grade and have to register again for the course.

A student should have a minimum of 45% marks in the end semester examination to be eligible for grading in a course. Otherwise he/she will be considered to have failed in the course and an F grade will be awarded.

O-10.2 Eligibility to write the Supplementary Examination

Only failed students and those who could not write the semester examination due to health reasons or other personal exigencies that are approved by the Principal can register for the supplementary examination provided they meet the eligibility requirements given in O-10.1. Grades awarded in the supplementary examination will be taken as the semester grades in these courses.

O-11. Conduct of End Semester Examination

The Clusters will prepare the question papers, conduct the end semester examinations, organize the valuation of the answer scripts, finalise the results and submit it to the University, as per the academic calendar.

O-12. Award of M. Tech., Degree

The award of the M. Tech. Degree shall be in accordance with the Ordinances and Procedures given by the University.

A student will be eligible for the award of M. Tech. Degree of the University on meeting the following requirements;

i) Registered and earned the minimum credits, as prescribed in the curriculum, for the stream of specialization.
ii) No pending disciplinary action.

O-13. Amendments to Ordinance:

Notwithstanding all that has been stated above, the University has the right to modify any of the above provisions of the ordinance from time to time.

O- 14. Miscellaneous provisions:

i) Stream of Specialization:

The streams of specializations are to be in line with the approval given on this by the All India Council for Technical Education.

ii) Language of Instruction

Unless otherwise stated, the language of instruction shall be English.

iii) Academic Calendar

The University shall publish in its website the academic calendar for every academic semester indicating the date of commencement of the semester as well as instruction. It will specify the course registration and enrolment dates, the schedule for mandatory internal tests for theory courses, dates by which laboratory/practical evaluations are to be completed, date for finalization of internal marks, last instruction day in the semester, planned schedule of end semester examinations and result declaration as well as approved holidays falling within the semester. Schedules for the supplementary examinations and result declaration dates are to be included in the calendar. Additionally colleges may publish their academic calendar, in line with the University academic calendar, indicating other schedules and events they plan to conduct during the semester.

Iv) Eligibility to continue with the programme

A student has to earn a minimum number of credits in a semester to register for higher semester courses. This should be at least 2/3rd of the credits for the courses listed in for the semester. CGPC shall formulate the rules based on this and spell out the procedure to proceed with the programme.

Failed students who have more than 45% marks in the internal course evaluation are permitted to write the semester examination without registering and undergoing the course. Those with less than 45% in internal course evaluation have to register again for the course, attend the classes and earn the credits.

v) Seminar

Students have to register for the seminar and select a topic in consultation with any faculty member offering courses for the programme. A detailed write-up on the topic of the seminar is to be prepared in the prescribed format given by the Department. The seminar shall be of 30 minutes duration and a committee with the Head of the department as the chairman and two faculty members from the department as members shall evaluate the seminar based on the report and coverage of the topic, presentation and ability to answer the questions put forward by the committee.

Suggested evaluation procedure:-

Faculty member in charge of the seminar and another faculty member in the department nominated by the Head of the Department are the evaluators for the seminar. Distribution of marks for the seminar is as follows.

Marks for the report: 30%
Presentation: 40%
Ability to answer questions on the topic: 30%

vi) Project work

Project work is spread over the third and fourth semesters. Project work is to be evaluated both in the third and the fourth semesters. Based on these evaluations the grade is finalised only in the fourth semester.

Project evaluation weights shall be as follows:-
For convenience the marks are allotted as follows.

Total marks for the Project: 150

In the 3rd Semester:- Marks:50
Project Progress evaluation details:

Progress evaluation by the Project Supervisor	: 20 Marks
Presentation and evaluation by the committee	: 30 Marks

In the 4th Semester:- Mraks:100

Project evaluation by the supervisor/s	: 30 Marks
Presentation & evaluation by the Committee	: 40 Marks
Evaluation by the External expert	: 30 Marks

vii) Faculty Advisor, Class Committee

a) Faculty Advisor

The Head of the Department offering the M. Tech. programme shall nominate senior faculty members as faculty advisors who shall advise the students in academic matters and support them in their studies. Their role is to help the students in academics and personal difficulties related to studies. A faculty advisor may support a group of students in a semester.

b) Class Committees are to be in place for all M. Tech. programs in the college.

Class Committee

All M. Tech streams of specialization will have class committees for each semester, constituted by the respective Heads of Departments.

The Chairman of the committee shall be a senior faculty member who does not offer any course for that stream in that semester.

Members:-

i) All faculty members teaching courses for the stream in that semester.
ii) Two student representatives nominated by the Head of the Department, from the stream.

Class committees shall meet at least thrice in a semester - one in the beginning and one around the middle of the semester and one at least two weeks before the semester examinations. These committees should monitor the conduct of the courses, adherence to the course plan and time schedule, completion of the

syllabus, standards of internal tests and evaluation process and address the difficulties faced by the students and take suitable remedial actions at the appropriate time. Before the end semester examination, the committee should meet without the student representatives and finalise the internal marks. A report on the student performance in each course should be prepared and submitted to the CGPC by the colleges.

viii) Award of Grades

Grading is based on the marks obtained by the student in a course. [O-14 ix]

The grade card will only show the grades against the courses the student has registered.

The semester grade card will show the grade for each registered course, Semester Grade Point Average (SGPA) for the semester as well as Cumulative Grade Point Average (CGPA).

ix) Grades and Grade Points

Grades and Grade Points as per UGC guidelines are to be followed by the University

Grades	Grade Point	% of Total Marks obtained in the course
O	10	90% and above
A^+	9	85% and above but less than 90%
A	8	80% and above but less than 85%
B^+	7	70% and above but less than 80%
B	6	60% and above but less than 70%
C	5	50% and above but less than 60%
P	4	45% and above but less than 50%
F	0	Less than 45%
FE	0	Failed due to eligibility criteria [O.10.1]
I		Course Incomplete

Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA) are calculated based on the above grading norms and are explained at the end of this document.

x) Academic Auditing

The University shall have a detailed academic auditing procedure in place comprising of an internal academic auditing cell within the college and an external academic auditing for each college. The internal academic auditing cell in each college shall oversee and monitor all academic activities including all internal evaluations and semester examinations. This cell is to prepare academic audit statements for each semester at regular intervals of four weeks of instruction. These reports are to be presented to the external academic auditor appointed by

the University, who will use it as a reference for his independent auditing and for the final report to the University.

Academic auditing will cover:-

i) Course delivery covering syllabus, adherence to course plan, quality of question papers for internal examinations, internal evaluation, laboratory experiments, practical assignments, mini projects, conduct of practical classes and their evaluation. Semester examination and academic performance of the students.

ii) Co-curricular and Extra-curricular activities available for students, and their organization.

iii) Academic functioning of the college encompassing students, faculty and college administration covering punctuality, attendance, discipline, academic environment, academic accountability, academic achievements and benchmarking.

xi) Revaluation and Grade improvement

There is no provision for revaluation of the semester answer books or for improving the grade.

` Students are permitted to check the answer books of the semester examination, after the results are declared. Any discrepancies in evaluation could be brought to the notice of the teacher concerned who will initiate appropriate action on this and report to the CGPC for a final decision on this.

xii) Grade Cards

Students who have written the semester examination will be given the grade cards for the registered courses, in every semester by the respective colleges. On earning the required credits for the degree, a consolidated grade sheet for the M. Tech programme will be issued by the University on the recommendation of the respective CGPC.
The M. Tech. degree will not have any classification like distinction or first class.

xiii) Academic Discipline and Malpractices in Examinations

Every student is required to observe discipline and decorous behaviour.
Any act of indiscipline, misbehaviour and unfair practice in examinations will be referred to the **Disciplinary Action Committee** (**DAC**). Malpractices in examinations shall be viewed seriously and any such incident observed or reported by a faculty member or an invigilator associated with the examinations shall be reported to the Principle who in turn shall refer it to DAC. On the basis of the report and evidence available or gathered, DAC shall immediately initiate an enquiry giving the concerned student a chance to explain his/her case. Based on this the committee shall recommend the course of action in line with the guidelines formulated for this by the Controller of Examination of the University and forward it to the Principal for action.

Actions are to be based on the severity of the offence and are to be dealt with, on a course basis. Guidelines on this shall be given by the Controller of Examination which is to be followed by the Disciplinary Action Committee of the college.

DAC shall be headed by a department head and shall have three other faculty members drawn from different departments as members. In case of malpractices in end semester examinations, the report given by the college DAC and the action taken by the Principal shall be intimated to the Controller of Examination of the University

xiv) Student's Welfare Committee

Every college shall have a Student's Welfare Committee, constituted by the Principal of the college. This committee shall have at least three faculty members as members and the chairman shall be a senior faculty member in the rank of a Professor. This committee is entrusted with the task of looking after the welfare of the students by taking appropriate steps with the concurrence of the principal.

xv) Grievances and Appeals Committee

Each college should have a Grievances Redress Committee constituted by the Principal to address the grievances of the students and to consider their appeals on any decisions made by the college. This committee consisting of at least three faculty members and chaired by a senior professor shall look into student's grievances and appeals and give its recommendations to the Principal for action.

xvi) Attendance

Attendance is marked for each course. 85% attendance is mandatory for writing the semester examination in a course. Students who get Part Time Teaching Assistantship (PTTA) or Scholarships from the Central or State Governments or any other agencies are expected to have 100 % attendance. However, under unavoidable circumstances students are permitted to take leave. Leave is normally sanctioned for any approved activity taken up by students outside the college covering sports and other extra-curricular activities. Leave is also permitted on medical grounds or on personal exigencies. Leave of absence for all these is limited to 15 % of the academic contact hours for the course.

In case of long illness or major personal tragedies/exigencies the Principal can relax the minimum attendance requirement to 70%, to write the semester examination. This is permitted for one or more courses registered in the semester. The Principal shall keep all records which led to his decision on attendance, for verification by the Academic Auditor. However this concession is applicable only to any one semester during the entire programme. In case of prolonged illness, break of study is permitted up to two semesters which could extend the programme up to six semesters, the maximum permitted by the regulations.

xvii) Leave of Absence

Students who desire to take leave have to apply for it to the teacher conducting the course. This application together with any supporting documents like doctor's certificate or other relevant information is to be forwarded to the Head of the Department with the recommendation of the teacher indicating the total leave of absence the student has so far availed. Approval for leave is to be given by the head of the department. After any prolonged medical leave, normally exceeding five instruction days, on rejoining, the student has to produce the fitness certificate given by the doctor.

xviii) Project Evaluation

Normally students are expected to do the project within the college. However they are permitted to do the project in an industry or in a government research institute under a qualified supervisor from that organization. Progress of the project work is to be evaluated at the end of the third semester. For this a committee headed by the head of the department with two other faculty members in the area of the project and the project supervisor/s. If the project is done outside the college, the external supervisor associated with the student shall also be a member of the committee.

Final evaluation of the project will be taken up only if the student has earned all course credits listed in the first three semesters. Project evaluation shall be done by the same committee mentioned above with an external expert, either from an academic/R&D organization or from Industry, as an additional member. Final project grading shall take into account the progress evaluation done in the third semester and the project evaluation in the fourth semester. If the quantum of work done by the candidate is found to be unsatisfactory, the committee may extend the duration of the project up to one more semester, giving reasons for this in writing to the student. Normally further extension will not be granted and there shall be no provision to register again for the project.

Xix) Project work outside the College

While students are expected to do their projects in their colleges, provision is available for them to do it outside the college either in an industry or in an institute of repute. This is only possible in the fourth semester and the topic of investigation should be in line with the project part planned in the 3rd semester. Student should apply for this through the project supervisor indicating the reason for this well in advance, preferably at the beginning of the 3rd semester. The application for this shall include the following:-

Topic of the Project:
Project work plan in the 3rd Semester:
Reason for doing the project outside:
Institution/Organization where the project is to be done:

External Supervisor – Name:
Designation:
Qualifications:
Experience:

Letter of consent of the External Supervisor as well as from the organization is to be obtained.

This application is to be vetted by the head of the department and based on the decision taken the student is permitted to do the project outside the college.

Ragging

Ragging of any nature is a criminal and non-bailable offence. Involvement in ragging shall lead to stringent punishment, including imprisonment as per the law of the land. A student, whose involvement in ragging is established, shall be summarily dismissed from the college. Each student of the Institute, along with his/her parent, is required to give an undertaking in this regard and the same is to be submitted at the time of registration.

Calculation of SGPA/CGPA

Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) are calculated as follows.

SGPA = $\Sigma(C_i \times GP_i)/\Sigma C_i$ where C_i is the credit assigned for a course and GP_i is the grade point for that course. Summation is done for all courses registered by the student in the semester. Here the failed courses are also accounted.

CGPA = $\Sigma(C_i \times GP_i)/\Sigma C_i$ where C_i is the credit assigned for a course and GP_i is the grade point for that course. Summation is done for all courses registered by the student during all the semesters for which the CGPA is needed. Here the failed courses are also accounted. CGPA of all courses passed may also be given.

Thiruvanthapuram **Registrar**
26-6-2015

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Engineering College Campus, Thiruvananthapuram

AMENDMENTS

OF THE

ORDINANCE

For

Master of Technology (M.Tech).

In exercise of the Powers conferred under Section 44 and Section 45 of Act 17 of 2015, the following Ordinance are made amending certain provisions of the Ordinance for M.Tech dated 26-6-2015

Object of the Amendments:

The ordinance for B.Tech/B.Tech (Hons.) and M.Tech degree programmes were framed considering the examinations and valuation system would be fully web based and assuming that the results could be published before the commencement of next semester classes. But as the examination system has been changed to the conventional system, it is impossible to publish the results before the commencement of next semester classes. Also, the Controller of Examinations has suggested certain amendments in the ordinances regarding conduct of examination and malpractices. The Academic Committee also suggested some modification and additions and the same also to be incorporated in the amendment.

AMENDMENT ORDINANCE No. 2

1. **Short Title and commencement: This Ordinance is called Amendment to Ordinance for M.Tech dated 26-6-2015 as Amendment Ordinance No.2 of 2016. This shall come into force with retrospective effect from 26-6-2015.**

(i) Amendment to Clause O-6. Course Registration and Enrolment is as follows:

Clause O-6 :. Course Registration and Enrolment All students have to register for the courses they desire to attend in a semester. Students admitted to the first semester are advised to register for all courses offered in the first semester. They do not have to enroll for the semester. All other students are required to register at the end of the semester for the courses they desire to take in the next semester. Later they have to enroll for these courses in the new semester. This allows them to make minor changes in the list of courses already registered for. Before enrolment, students should clear all dues including any fees to be paid and should not have any disciplinary proceedings pending. The dates for registration and enrolment will be given in the academic calendar. Any late registration or enrolment, allowed only up to 7 working days from the registration or enrolment date, will attract a late fee. A student can drop a course or substitute one already registered for by another, for valid reasons with the approval of the faculty advisor. However this has to be done within 7 working days from the commencement of the semester. The maximum number of credits a student can register for in a semester is limited to 24.

(ii) Amendment to Clause O-10. End Semester and Supplementary Examinations is as follows:-

Clause No. O-10. End Semester and Supplementary Examinations The end semester examination will be conducted in all theory courses offered in the semester and will be of three hours duration unless otherwise specified. Supplementary examinations are to be conducted for eligible candidates registered for them, after the declaration of results.

(iii) Amendment to Clause O-14 iv) Eligibility to continue with the programme is as follows :

Clause O-14 iv) Eligibility to continue with the programme

A student shall be allowed to register for the second semester only if he/she is eligible to appear for end semester examination in 2/3 of the courses in the first semester.

(iv) Amendment to Clause O-14(ix) Grades and Grade Points

Grades and Grade Points followed by the University is as follows instead of the UGC grade points.

Clause O-14(ix) Grades and Grade Points

Grades	and	Grade Point (GP)	% of Total Marks obtained in the course
O	(Outstanding)	10	90% and above
A^+	(Excellent)	9	85% and above but less than 90%
A	(Very Good)	8.5	80% and above but less than 85%
B^+	(Good)	8	70% and above but less than 80%
B	(Above Average)	7	60% and above but less than 70%
C	(Average)	6	50% and above but less than 60%
P	(Pass)	5	45% and above but less than 50%
F	(Fail)	0	Less than 45%
FE		0	Failed due to eligibility criteria
I			Course Incomplete

(v) **Amendment to Clause O-14 xiii) Academic Discipline and Malpractices in Examinations**. (last paragraph) **is as follows:**

Clause. O-14 xiii) **Academic Discipline and Malpractices in Examinations (last paragraph)**

In case of malpractices in end semester examinations, the report on malpractice shall be handed over to the Controller of Examinations, who will hand over it to the Examination Monitoring Committee. The Controller of Examinations will consider the same as a review

Thiruvananthapuram Executive Committee

21-4-2016 By Order . Registrar.

APJ Abdul Kalam Technological University

Cluster 4: Kottayam

M. Tech Program in Nanotechnology

Scheme of Instruction & Syllabus : 2015 Admissions

Compiled By

Rajiv Gandhi Institute of Technology, Kottayam

July 2015

APJ Abdul Kalam Technological University

(Kottayam Cluster)

M.Tech Program in Nanotechnology

Scheme of Instruction

Credit requirements **:** 67 credits (22+19+14+12)
Normal Duration : Regular: 4 semesters; External Registration: 6 semesters;
Maximum duration : Regular: 6 semesters; External Registration: 7 semesters.

Allotment of credits and examination scheme:-

Semester 1 (Credits: 22)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	04 CH 6101	MATHEMATICAL METHODS FOR NANOTECHNOLOGY	3-1-0	40	60	3	4
B	04 CH 6103	INTRODUCTION TO NANOTECHNOLOGY	3-1-0	40	60	3	4
C	04 CH 6105	PHYSICS OF MATERIALS	3-0-0	40	60	3	3
D	04 CH 6107	ENGINEERING PRINCIPLES FOR NANOTECHNOLOGY	3-0-0	40	60	3	3
E	04 CH 61XX*	ELECTIVE I	3-0-0	40	60	3	3
	04 GN 6001	RESEARCH METHODOLOGY	0-2-0	100	0	0	2
	04 CH 6191	SEMINAR	0-0-2	100	0	0	2
	04 CH 6193	LAB I	0-0-2	100	0	0	1
		Total	23				22

**See List of Electives-I for slot E*

List of Elective - I Courses

Exam Slot	Course No.	Course Name
E	04 CH 6109	Nano Chemistry
E	04 CH 6111	Carbon Nanomaterial Science and Technology
E	04 CH 6113	Nanocomposites
E	04 CH 6115	Semiconductor Nanostructures& Nano-particles

M. Tech Program in Nanotechnology

Semester 2 (Credits: 19)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	04 CH 6102	INDUSTRIAL NANOTECHNOLOGY	3-1-0	40	60	3	4
B	04 CH 6104	ADVANCED NANOMATERIALS	3-0-0	40	60	3	3
C	04 CH 6106	EXPERIMENTAL AND CHARACTERIZATION TECHNIQUES FOR NANOTECHNOLOGY	3-0-0	40	60	3	3
D	04 CH 61XX*	ELECTIVE II	3-0-0	40	60	3	3
E	04 CH 61XX^	ELECTIVE III	3-0-0	40	60	3	3
	04 CH 6192	MINI PROJECT	0-0-4	100	0	0	2
	04 CH 6194	LAB II	0-0-2	100	0	0	1
		Total	22				19

**See List of Electives -II for slot D* *^See List of Electives -III for slot E*

List of Elective - II Courses

Exam Slot	Course Code	Course Name
D	04 CH 6108	Nanoelectronics
D	04 CH 6112	Nanotechnology in Energy Conversion and Storage
D	04 CH 6114	Nano biotechnology
D	04 CH 6116	Nano Toxicology

List of Elective - III Courses

Exam Slot	Course Code	Course Name
E	04 CH 6118	Polymer Nanocomposites
E	04 CH 6122	Nanosensors and Transducers
E	04 CH 6124	Nanomedicine
E	04 CH 6126	Environmental Nanotechnology

M. Tech Program in Nanotechnology

Summer Break

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
NA	04 CH 7190	Industrial Training	0-0-4	NA	NA	NA	Pass /Fail
		Total	4				0

Semester 3 (Credits: 14)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	04 CH 71XX*	ELECTIVE IV	3-0-0	40	60	3	3
B	04 CH 71XX^	ELECTIVE V	3-0-0	40	60	3	3
	04 CH 7191	SEMINAR	0-0-2	100	0	0	2
	04 CH 7193	PROJECT (PHASE I)	0-0-12	50	0	0	6
		Total	20				14

**See List of Electives-IV for slot A* *^See List of Electives-V for slot B*

List of Elective - IV Courses

Exam Slot	Course Code	Course Name
A	04 CH 7101	Self Assembling nanostructured molecular materials and devices
A	04 CH 7103	Societal Implications of Nanotechnology
A	04 CH 7105	Computational Nanosciences
A	04 CH 7107	Photonics and Plasmonics

List of Elective - V Courses

Exam Slot	Course Code	Course Name
B	04 CH 7109	Nanodevice Technology
B	04 CH 7111	Green Manufacturing Technology
B	04 CH 7113	Nanotechnology in Business Applications and Intellectual Property Rights
B	04 CH 7115	Drug delivery Systems

M. Tech Program in Nanotechnology
Semester 4 (Credits: 12)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	External Evaluation Marks		Credits
NA	04 CH 7194	Project (Phase -II)	0-0-21	70	30	NA	12
		Total	21				12

Total: 67

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6101	MATHEMATICAL METHODS FOR NANOTECHNOLOGY	3-1-0: 4	2015

Pre-requisites: Nil

Course Objectives:

1. To provide students with a good understanding of the concepts and methods of linear algebra.
2. To understand the classification, formulation and solution of partial differential equations.
3. To understand the method of series solution of ordinary differential equations.
4. To introduce the tensor representations for vector algebra.

Syllabus

Vector spaces, Linear Transformations, Inner product spaces, Power series solutions about ordinary point, Legendre polynomials, Solutions about singular points, Bessel Functions. Linear partial differential equations of second order, one dimensional wave equation, one dimensional heat equation Laplace equation. Finite difference method for numerical solution of partial differential equations, Basic Tensor analysis

Course Outcome:

The student will demonstrate the ability to understand the Mathematical tools required for nanotechnology

Text Books:

1. B.S.Grewal, Higher Engineering Mathematics, Khanna Publishers, 2000

References:

1. Bell, W. W., Special Functions for Scientists and Engineers, Dover Publications, 2004.
2. Ross, S. L., Differential Equations, Third Edition, John Wiley & Sons, 2004.

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6101	MATHEMATICAL METHODS FOR NANOTECHNOLOGY	3-1-0: 4	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: Vector spaces, sub spaces, Basis, Dimension, Linear Transformations, Range and Kernel, Isomorphism		5 5	15
MODULE 2: Matrix of transformations and Change of Basis, Inner product spaces		5 3	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE 3: Power series solutions about ordinary point, Legendre equation and Legendre polynomials, Solutions about singular points- The method of Frobenius, Bessel equation and Bessel Functions.		4 3 3	15
MODULE 4: Linear partial differential equations of second order, Classifications, Formulation and method of solutions of one dimensional wave equation Formulation and method of solutions of one dimensional heat equation Formulation and method of solutions of Laplace equation.		4 3 3	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE 5: Finite difference method – solution of Laplace equation -solution of one-dimensional heat equation – Crank Nicholson method – solution of one-dimensional wave equation		5 3	20
MODULE 6: Spaces of n-dimensions, coordinate transformations, contravariant, covariant and mixed tensors fundamental operation with tensors, metric tensor, Conjugate tensor, Christoffel symbols		5 5	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6103	INTRODUCTION TO NANOTECHNOLOGY	3-1-0:4	2015

Pre-requisites: Nil

Course Objectives:

1. To inspire the students with interest, excitement, and urge to learn the subject of nanotechnology.
2. To understand the fundamental concepts, theories and methods in nanotechnology
3. To introduce the purpose of learning important subjects in nanotechnology for meeting the requirement of various professional field applications.

Syllabus

Introduction to Nanotechnology -History of nanotechnology —top-down and bottom-up approaches. Nano scale Phenomena-Density of States, Tunnelling, Chemical bonds, Hierarchical structures and functionality, Self-assembly and surface reconstruction. Miniaturization & Nano structuring process-Moore's laws , Processing methods: - Etching –Chemical vapour deposition - Diffusion – Ion implantation – Metallization –Electro deposition, Lithography, Photolithography, Overview – Critical dimension – Overall resolution – Line-width – Lithographic sensitivity and intrinsic resist sensitivity– Nano imprint — Key consequences of adopted techniques. Nanomaterial Synthesis - Chemical methods-Sol – gel technique – Co-precipitation hydrolysis – Sono-chemical method – Combustion technique – Colloidal precipitation – Template process. Physical methods Solid-state sintering – Grain growth – Arc method – Ion-beam induced nanostructures – Grinding – High energy ball milling – Material-ball ratio – Control of grain size in the above methods, Laser ablation methods.

Course Outcome:

The student will demonstrate the ability to understand the basic concepts of nanotechnology.

Text Books:

Pradeep, T., Nano: The Essentials, McGraw Hill Publishers, Mumbai, 2007.

References:

1.Pignataro, B., Tomorrow's Chemistry Today–Concepts in Nano science, Organic Materials, and Environmental Chemistry, Wiley-VCH, Royal chemical society, 2008

2.Howard, H., Into The Nano Era: Moore's Law Beyond Planar Silicon CMOS (Vol. 106), Springer Series in Materials Science, Springer-Verlag Berlin, 2004 .

COURSE PLAN

COURSE CODE:	COURSE TITLE:	CREDITS	
04 **CH6103**	**INTRODUCTION TO NANOTECHNOLOGY**	**3-1-0:4**	
MODULES		**Contact hours**	**Sem. Exam Marks (%)**
MODULE : 1 History of nanotechnology, Conceptual origins, Experimental advances, Role of Richard Feynman, Eric Drexler and Maxwell, Size & scales: spatial and temporal scales. Concept of confinement: strong and weak confinements with suitable examples. Prefixing nano before disciplines, brief explanation on top, down and bottom-up approaches.		4 4 4	15
MODULE : 2 Density of States, Tunnelling, Chemical bonds (types and strength), Intermolecular force. Molecular and crystalline structures, Hierarchical structures and functionality. Surfaces and interfaces, Casmir force, Bulk to surface transition, Self - assembly and surface reconstruction.		4 4 4	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE : 3 Moore's laws (1, 2 &3), Processing methods: Cleaning, Oxidation, Etching, Chemical vapour deposition, Diffusion, Ion implantation. Metallization, Electro deposition, Lithography, Photolithography, Critical dimension , Overall resolution , Line-width, Lithographic sensitivity and intrinsic resist sensitivity.		4 4	15

MODULE : 4 Phase-shifting photolithography, X-ray lithography, Electron beam direct writing system, Focused ion beam (FIB) lithography, Neutral atomic beam lithography, Plasma-aided nanofabrication. Soft lithography, Nano-sphere lithography, Nano-imprint, Dip-pen nanolithography, Key consequences of adopted techniques	4 4	15
INTERNAL TEST 2 (MODULE 3 & 4)		
MODULE : 5 Chemical methods: Sol-gel technique, Co-precipitation hydrolysis, Sono-chemical method , Combustion technique, Colloidal precipitation, Template process	4 4	20
MODULE : 6 Physical methods: Solid-state sintering, Grain growth, Arc method, Ion-beam induced nanostructures, Grinding. High energy ball milling, Material-ball ratio, Control of grain size in the above methods, Laser ablation methods.	4 4	20
END SEMESTER EXAM		

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6105	PHYSICS OF MATERIALS	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

1. To introduce the quantum mechanical aspects of nanotechnology.

2. To expose on structure and applications of different types of nanomaterial

Syllabus

Schrodinger's Equation and its mathematical implication-Development of time dependent Schrödinger's equation - wave function -– Conservation of total probability, Dynamical variables and Hermitian operators – Commutation relations - Ehrenfest theorem- Heisenberg Uncertainty principle, Time independent Schrodinger equation –eigen functions. Bound states & Quantum tunnelling----- Energy levels of a particle – Infinite square well in one, two, and three dimensions - Density of states – Confined carriers - Electron wave propagation in devices - Quantum confinement - Tunnel effect - Basic principles of a few effective devices – Resonant tunnel diode, Super lattice , Quantum well, Quantum wire and Dot, Optical properties of Quantum dots.Bound states & Quantum tunnelling-Synthesis, properties and applications, Inorganic nanomaterials: Organic nanomaterials: Bio-nanomaterials: Biomimetric Systems, Bioceramics&nanotherapeutics. Nanomaterials for molecular electronics and optoelectronics: Thin film transistor, Single electron transistor, Light emitting devices, Photovoltaic nanomagnetic materials and nanosuperconductors.Structures and Applications of Nanomaterials Localized Particle, Donors, Acceptors, and Deep Traps, Mobility, Excitons.,Geometric Structure, Electronic Structure, Reactivity, Fluctuations, Mechanical properties, electronic, thermal conductivity and optical absorption.Applications of nanomaterials

Course Outcome:

The student will demonstrate the ability to understand the basic concepts of i) quantum principles of nanotechnology and ii) nanomaterials

Text Books:

1. Vladimir V. Mitin,Dmitry I. Sementsov, Nizami Z. Vagidov, Quantom Mechanics for Nanostructures, Cambridge University Prss 2010

2. Hans-Eckhardt Schaefer , Nanoscience: The Science of small in Physics, Engineering, Chemistry,

Biology and Medicine – Springer-Verlag, 2010

3. G. Cao and Y. Wang Nanostructures and nanomaterials,World Scientific, 2011

References:

1. B.H. Bransden and C.J. Joachain, Quantum Mechanics, Pearson, Second Edition (2007).

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6105	PHYSICS OF MATERIALS	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: Development of time dependent Schrödinger's equation, Statistical interpretation of wave function - Normalization of wave function Conservation of total probability, Dynamical variables and Hermitian operators, Position, Linear and angular momentum operators		4 3	15
MODULE 2: Commutation relations - Ehrenfest theorem- Heisenberg Uncertainty principle, Time independent Schrodinger equation – Properties of energy eigen functions. Free particle - Momentum eigen functions, Energy levels of a particle, Infinite square well in one, two, and three dimensions - Density of states		4 3	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE 3: : Confined carriers - Electron wave propagation in devices - Quantum confinement - Penetration of a barrier – Tunnel effect Basic principles of a few effective devices – Resonant tunnel diode, Super lattice, Quantum well, Quantum wire and Dot, Optical properties of Quantum dots.		4 3	15
MODULE 4: Synthesis, properties and applications (phenomenological description only no detailed derivations) Inorganic nanomaterials, Nanoporous Materials – Silicon - Zeolites, Transparent conducting oxides – Molecular sieves – Nanosponges, Nanoceramics, Nanoporous inorganic materials		4 3	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE 5: Organic nanomaterials: Dendrimers, Micelles, Liposomes, Block copolymers. Bionanomaterials: Biomimetric Systems, Bioceramics&nanotherapeutics Nanomaterials for molecular electronics and optoelectronics: Thin film transistor, Single electron transistor, Light emitting devices, Photovoltaic nanomagnetic materials and nanosuperconductors		4 3	20
MODULE 6: Localized Particle, Donors, Acceptors, and Deep Traps, Mobility, Excitons. Geometric Structure, Electronic Structure, Reactivity, Fluctuations, Mechanical properties, electronic, thermal conductivity and optical absorption.		4 3	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH **6107**	**ENGINEERING PRINCIPLES FOR NANOTECHNOLOGY**	**3-0-0:3**	**2015**

Pre-requisites: Nil

Course Objectives:

1. To understand and assimilate about the different developmental stages of Nanotechnology
2. To make acquaintance with fundamental aspects of vacuum technology, silicon technology and thin film technology.
3. To familiarise with fabrication of MEMS and NEMS and understand its significance in Nano electronics

Syllabus

Vacuum Technology -Pump selection and exhaust handling, Types of pumps- Pressure measurements, Thermodynamics of evaporation, Alloys, Compounds, Transport and Deposition monitoring. Silicon Technology-Semiconductor as base material- Band diagram of semiconductor- Band diagram of inhomogeneous semiconductor- Different types of components in semiconductor, Different types of transistor integration- Technological processes for micro miniaturization- Methods and limits of microminiaturization in silicon.Thin Film Technology - Electroplating, Electroless plating, Langmuir-Blodget films, Self assembled monolayers Thermal growth, Chemical vapour deposition, Sputtering deposition, Molecular beam epitaxy, Atomistic nucleation process, Cluster coalescence and deposition, Grain structure of films and coatings, Amorphous thin films, Mechanical, Electrical, Magnetic and Optical properties of Thin films.MEMS and Microsystems – Evolution of Micro Fabrication –NEMS – Working principles, Application– Substrate and Wafer, Silicon as a substrate material, MEMS packaging, MEMS and NEMS Technology for micro fluidic devices.

Course Outcome:

The student will demonstrate the knowledge of contemporary techniques of fabrication of microelectronics and nanoelectronics.

Text Books:

1.Peter M. Martin, “Hand book of Deposition Technologies for thin films and coatings” by Sciene, Technology and Applications, Noyes Publications

2.Milton Ohring, *Materials Science of Thin films* Published by Academic Press Limited(1991)

3. Tai-Ran Hsu, “MEMS & Microsystems – Design and Manufacture,” Tata McGraw Hill, 2002

References

1.Karl glosekotter, “Nanoelectronics and Nanosystems”, Springer, 2004

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 **CH6107**	**ENGINEERING PRINCIPLES FOR NANOTECHNOLOGY**	**3-0-0:3**	
MODULES		**Contact hours**	**Sem. Exam Marks(%)**
MODULE : 1 Pump selection and exhaust handling , Rotary oil pumps, Roots pump. Diffusion pumps, Turbo molecular pump, Cryo-pump, Sputter-ion pump, Pressure measurements.		3 3	15
MODULE : 2 Thermodynamics of evaporation, Evaporation rate, Alloys, Compounds, Sources, Transport and Deposition monitoring. Technological processes for micro miniaturization- Methods and limits of microminiaturization in silicon.		3 3	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE : 3 Semiconductor as base material- Band diagram of semiconductor- Band diagram of in homogeneous semiconductor. Different types of components in semiconductor, Different types of transistor integration.		3 3	15
MODULE : 4 Electroplating, Electroless plating, Langmuir-Blodget films, Self assembled monolayers ,Thermal growth. Chemical vapour deposition, Sputtering deposition, Molecular beam epitaxy, Atomistic nucleation process, Cluster coalescence and deposition		4 4	15

INTERNAL TEST 2 (MODULE 3 & 4)		
MODULE : 5 Grain structure of films and coatings, Amorphous thin films, Mechanical, Electrical, Magnetic and Optical properties of Thin films. MEMS and Microsystems – Evolution of Micro Fabrication – Micro Systems and Microelectronics	4 4	20
MODULE : 6 NEMS – Working principles, Application of MEMS and NEMS in Various Fields. Introduction – Substrate and Wafer, Active Substrate Material. Silicon as a substrate material, MEMS packaging, MEMS and NEMS Technology for micro fluidic devices.	4 4	20
END SEMESTER EXAM		

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH6109	NANO CHEMISTRY	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

1. To understand the structure and properties of different types of Nanoparticles
2. To make acquaintance with fundamental aspects of nanocatalysis
3. To familiarise with various aspects of nanoscale growth

Syllabus

Size effects on structure and morphology of Nanoparticles-Fundamental Properties - Size Effects Confinement Effects - Fraction of Surface Atoms - Specific Surface Energy and Surface Stress - Effect on Lattice Parameter – and Phonon Density of States - Morphology. Super plasticity and reactivity of metal Nanoparticles- Introduction – Mechanism – Superplastic Nanostructured Materials - Applications, Reactivity - Size Effects - Structural and - Electronic Properties - Reactivity in Chemisorption and Catalysis of Monometallic Nanoparticles - Support Effects - Alloying Effects - Effect of Surface Segregation - Geometric Effects -Electronic Effects. Nanocatalysis-— Formation of assemblies of biomolecules on the surface of inorganic materials– Operation of electronic switches. Supramolecular chemistry- Applications and Prospects -— Molecular Recognition - Anionic Coordination Chemistry and Recognition of Anionic Substrates - Multiple Recognition. Supercritical fluids-— Physicochemical Properties - Purification and Extraction - Synthesis. Features of nanoscale growth-—- Thermodynamics of Phase Transitions -Dynamics of Phase Transitions - Thermodynamics of Spinodal Decomposition - Thermodynamics of Nucleation - Triggering the Phase Transition- Application to Solid Nanoparticles.

Course Outcome:

To describe, explain, and illustrate the chemical and physical processes involved in the synthesis and properties of nanoparticles

Text Books:

1. Brechignac, P. Houdy, M. Lahmani, —Nanomaterials and Nanochemistry, Springer publication (2007).

References:

1. C. N. Rao, A. Muller, A. K. Cheetham, —Nanomaterials chemistry, Wiley-VCH (2007).

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6109	NANO CHEMISTRY	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: Fundamental Properties - Size Effects on Structure and Morphology of Free or Supported Nanoparticles Size and Confinement Effects - Fraction of Surface Atoms - Specific Surface Energy and Surface Stress		3 3	15
MODULE 2: Effect on the Lattice Parameter - Effect on the Phonon Density of States - Nanoparticles Morphology Super plasticity – Introduction – Mechanism – Superplastic Nanostructured Materials - Industrial Applications		3 3	15
FIRST INTERNAL TEST			
MODULE 3: Reactivity of Metal Nanoparticles - Size Effects-Structural Properties - Electronic Properties Reactivity in Chemisorption and Catalysis of Monometallic Nanoparticles - Support Effects - Alloying Effects - Effect of Surface Segregation - Geometric Effects -Electronic Effects		3 3	15
MODULE 4: Catalysis on nanoparticles – Oxide reactions – Semiconducting nanoparticles in heterogeneous nanocatalysis —– Formation of assemblies of biomolecules on the surface of inorganic materials– Operation of electronic switches		3 3	15
SECOND INTERNAL TEST			
MODULE 5: Supramolecular Chemistry: Applications and Prospects - From Molecular to Supramolecular Chemistry – Molecular Recognition - Anionic Coordination Chemistry and Recognition of Anionic Substrates - Multiple Recognition Supercritical Fluids – Introduction – Physicochemical Properties - Solubility - Viscosity - Diffusion –Thermal Conductivity - Applications - Purification and Extraction – Synthesis		4 4	20
MODULE 6: Specific Features of Nanoscale Growth – Introduction - Thermodynamics of Phase Transitions -Dynamics of Phase Transitions Thermodynamics of Spinodal Decomposition - Thermodynamics of Nucleation – Growth - Size Control - Triggering the Phase Transition- Application to Solid Nanoparticles.		5 5	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6111	Carbon Nanomaterial Science and Technology	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

1. To understand the structure and properties of Carbon-Nanotubes

2. To familiarise with extraordinary properties of nanotubes

3. To understand the recent advancements in the field of modified nanotubes, fullerenes, graphene and their applications in various fields.

Syllabus

Introduction to Carbon-Nanotube Science and Technology-Classification- Synthesis- - Purification s – Dry and wet spinning, Defect Control - Properties - Applications– Electronics, Energy, Mechanical, Sensors, Field emission and lighting, Biological – Environmental and health effects of carbon nanotubes - Mechanical Properties and thermal stability of Carbon Nanotubes -Ballistic heat transport – Phonon transport – Thermal conductance- Influence of defects on thermal conductivity –Heat transport in SWNTs and MWNTS, Optical response of Carbon Nanotubes – Excitonic effects – Optical spectra of SWNTs – Overview of Raman Spectroscopy– Photoluminescence spectroscopy of nanotubes – Photoluminescence imaging -Ultrafast spectroscopy of carbon nanotubes -Magnetic phenomena in Carbon Nanotubes-Band structure – Magnetization – Magneto transport – Magneto optics –Carbon nanotube optolectronics- Overview of CNT electronics – Photoconductivity - Nanotube Photodetectors– CNT photoconductor- Photo voltage in CNT diodes- Photovoltage imaging– Electroluminescence- Electrical transport in Carbon Nanotubes– Quantum transport – Quantum dots- Doped carbon nanotubes, Inorganic Nanotubes and fullerene like structures, Fabrication of fullerene (C60) . Graphite, Expanded graphite, Graphene.

Course Outcome:

To demonstrate an understanding of synthesis, characterisation and properties of different types of carbon based nanoparticles

Text Books:

1. Peter J. F. Harris, Carbon Nanotubes and Related Structures, Cambridge University Press;1st edition, 2009.
2. Michael J. O'Connell, Carbon Nanotubes: Properties and Applications, CRC; 2006.

References:

1. Jorio, A., Dresselhaus, G., and Dresselhaus, M.S. (Eds.), “Carbon Nanotubes – Advanced Topics in the Synthesis, Structure, Properties and Applications,” Springer Verlag, New York,

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6111	CARBON NANOMATERIAL SCIENCE AND TECHNOLOGY	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: : Classification- Single and Double-Wall Carbon Nanotubes, Synthesis- Bulk production methods such as Arc discharge and laser vaporization, Chemical vapor deposition- Purification by dry and wet methods Dry and wet spinning of carbon nanotubes from liquid suspensions, Defect Control - Mechanical and Thermal Properties - Electronic Structure and Atomic Arrangement – Transport Properties – Chemical Reactivity		3 3	15
MODULE 2: : Applications of Carbon Nanotubes – Electronics, Energy, Mechanical, Sensors, Field emission and lighting, Biological – Environmental and health effects of carbon nanotubes Ballistic heat transport – Phonon transport – Thermal conductance- Length effect on thermal conductivity – Influence of defects on thermal conductivity –Heat transport in SWNTs and MWNTS		3 4	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE 3: Introduction to optical response of Carbon Nanotubes – Excitonic effects – Optical spectra of SWNTs – Pressure, temperature and strain effects Overview of Raman Spectroscopy– Photoluminescence spectroscopy of nanotubes– Photoluminescence imaging - Introduction to ultrafast spectroscopy of carbon nanotubes		3 3	15
MODULE 4: Band structure – Magnetization – Magneto transport – Magneto optics Introduction to Carbon nanotube optoelectronics- Overview of CNT electronics, Photoconductivity - Nanotube Photodetectors–CNT photoconductor-		3 4	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE 5: Photo voltage in CNT diodes, Photovoltage imaging– Electroluminescence- Electrical transport in Carbon Nanotubes– Quantum transport – Quantum dots Doped carbon nanotubes, Properties and Applications.		4 4	20
MODULE 6: Introduction to inorganic Nanotubes and fullerene like structures, Fabrication of fullerene (C60)–Properties and Applications. Graphite, Expanded graphite, Graphene- Synthesis, Properties, Chemical, Mechanical and Thermal modifications of Graphene and its Applications		4 4	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6113	Nanocomposites	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

1. To impart a knowledge about the features of nanocomposites
2. To understand the processing and characterisation techniques of nanocomposites
3. To divulge the applications of nanocomposites in various fields.

Syllabus

Properties and features of Nanocomposites-— Physics of modulus – Continuum measurements – Yield – Fracture – Rubbery elasticity and viscoelasticity – Composites and Nanocomposites –Mechanical properties – Diffusion and permeability –Features of nanocomposites – Basics of polymer nanocomposites – Nano-reinforcements – Matrix materials-Metal matrix, Polymeric and Inorganic composite matrix – Hazards of particles-Processing of Nanocomposites-Viscosity - Types of flow– Non-newtonian Flow - Low-viscosity processing - Solvent processing - Particle behavior - In situ polymerization - Post-Forming - Hazards of solvent Processing - Melt, High -shear, and Direct processing - Melting and Softening - Melt processes with small shears or Low-shear rates flow - Melt processes with large deformations or high-shear rates - Thermo-Kinetic processes-Characterization of Nanocomposites-Introduction to characterization – Experiment design – Sample preparation – Imaging – Structural characterization – Scales in nanocomposites – Texture – Electromagnetic energy – Visualization – Physicochemical analysis – Characterization of physical properties – Identification – Mechanical – Surface mechanical – Exposure – Barrier properties – Recipes and standards- Optical, Structural applications – Nanoparticulate systems with organic matrices —- Biodegradable protein nanocomposites -– Application as exterior automatic components – Hybrid nanocomposite materials – Application for corrosion protection.

Course Outcome:

To demonstrate an understanding of synthesis, characterisation, properties and applications of nanocomposites

Text Books:

1. Thomas E. Twardowski, Introduction to Nanocomposite Materials – Properties, Processing, Characterization, DesTech Publications, April 2007

References:

2. Nanocomposite Science and Technology Pulickel M. Ajayan , Linda S. Schadler , Paul V. Braun, 2006, Wiley

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6113	NANOCOMPOSITES	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: Nanocomposites – Definition –Physics of modulus – Continuum measurements – Yield – Fracture – Rubbery elasticity and viscoelasticity Composites and Nanocomposites –Mechanical properties – Diffusion and permeability –Features of nanocomposites		3 4	15
MODULE 2: Basics of polymer nanocomposites – Nano-reinforcements – Matrix materials-Metal matrix, Polymeric and Inorganic composite matrix – Hazards of particles Viscosity - Types of flow– Viscosity - Experimental viscosity - Non-newtonian Flow - Low-viscosity processing - Solvent processing		3 4	15
FIRST INTERNAL TEST			
MODULE 3: Particle behavior - In situ polymerization - Post-Forming - Hazards of solvent Processing - Melt, High -shear, and Direct processing Melting and Softening - Melt processes with small shears or Low-shear rates flow - Melt processes with large deformations or high-shear rates - Thermo-Kinetic processes		3 4	15
MODULE 4: Introduction to characterization – Experiment design – Sample preparation – Imaging – Structural characterization Scales in nanocomposites – Texture – Electromagnetic energy – Visualization – Physicochemical analysis – Characterization of physical properties – Identification		3 4	15
SECOND INTERNAL TEST			
MODULE 5: Hybrid nanocomposite materials – Application for corrosion protection Nanocomposites – Optical, Structural applications – Nanoparticulate systems with organic matrices – Applications		3 4	20
MODULE 6: Biodegradable protein nanocomposites - Applications of nanocomposites – Application as exterior automatic components Graphite, Expanded graphite, Graphene- Synthesis, Properties, Chemical, Mechanical and Thermal modifications of Graphene and its Applications.		3 4	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6115	SEMICONDUCTOR NANOSTRUCTURES& NANO-PARTICLES	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

1. To instruct about the features of semiconductor nanoparticles.

2. To expose to the applications of semiconductor nanoparticles

Syllabus

Semiconductor nanoparticles- Synthesis, Cluster compounds, Quantum-dots from MBE and CVD, Wet chemical methods, Reverse micelles, Electro-Deposition, Pyrolytic synthesis, Self-assembly Strategies. Size–dependant physical properties, Melting point, Solid-State Phase transformations, Excitons, Band-gap variations-Quantum confinement, Effect of strain on band-gap in epitaxial Quantum dots, Single particle conductance. Optical luminescence and Fluorescence from direct band gap semiconductor nanoparticles, Surface-trap passivation in core-shell nanoparticles, Carrier injection, Polymer-nanoparticle, LED and solar cells, Electroluminescence, Barriers to nanoparticle lasers, Doping nanoparticles, Mn-Zn-Se phosphors, Light emission from indirect semiconductors, Light emission form Si nanodots. Semiconductor nanowires, Fabrication strategies, Quantum conductance effects in semiconductor nanowires, Porous Silicon, Nanobelts, Nanoribbons, Nanosprings.

Course Outcome:

To demonstrate an understanding of synthesis, characterisation, properties and applications of semiconductor nanoparticles.

Text Books:

1. Handbook of Semiconductor Nanostructures and Nanodevices Vol 1-5- A. A. Balandin, K. L. Wang

References:

2. Nanostructures and Nanomaterials - Synthesis, Properties and Applications - Cao, Guozhong.

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6115	SEMICONDUCTOR NANOSTRUCTURES& NANO-PARTICLES	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: Semiconductor nanoparticles Synthesis, Cluster compounds, Quantum-dots from MBE and CVD, Wet chemical methods,		3 3	15
MODULE 2: : Reverse micelles, Electro-Deposition, Pyrolytic synthesis, Self-assembly Strategies. Semiconductor nanoparticles: Size–dependant physical properties, Melting point, Solid-State Phase transformation		4 4	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE 3: Excitons, Band-gap variations-Quantum confinement Effect of strain on band-gap in epitaxial Quantum dots, Single particle conductance.		3 3	15
MODULE 4: Introduction to characterization – Experiment design – Sample preparation – Imaging – Structural characterization Scales in nanocomposites – Texture – Electromagnetic energy – Visualization – Physicochemical analysis – Characterization of physical properties – Identification		3 3	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE 5: Hybrid nanocomposite materials – Application for corrosion protection Semiconductor nanoparticles – Applications, Optical luminescence and Fluorescence from direct band gap semiconductor nanoparticles,		4 4	20
MODULE 6: : Surface-trap passivation in core-shell nanoparticles, Carrier injection, Polymer-nanoparticle, LED and solar cells, Electroluminescence, Barriers to nanoparticle lasers, Doping nanoparticles, Mn-Zn-Se phosphors, Light emission from indirect semiconductors, Light emission form Si nanodots.		4 4	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P-C	YEAR
04 GN 6001	RESEARCH METHODOLOGY	0-2-0:2	2015

Pre-requisites:

Course Objectives:

To enable the students:

- To get introduced to research philosophy and processes in general.
- To formulate the research problem and prepare research plan
- To apply various numerical /quantitative techniques for data analysis
- To communicate the research findings effectively

Syllabus

Introduction to the Concepts of Research Methodology, Research Proposals, Research Design, Data Collection and Analysis, Quantitative Techniques and Mathematical Modeling, Report Writing.

Course Outcome:

Students who successfully complete this course would learn the fundamental concepts of Research Methodology, apply the basic aspects of the Research methodology to formulate a research problem and its plan. They would also be able to deploy numerical/quantitative techniques for data analysis. They would be equipped with good technical writing and presentation skills.

Text Books:

1. Research Methodology: Methods and Techniques', by Dr. C. R. Kothari, New Age International Publisher, 2004
2. Research Methodology: A Step by Step Guide for Beginners' by Ranjit Kumar, SAGE Publications Ltd; Third Edition

References:

1. Research Methodology: An Introduction for Science & Engineering Students', by Stuart Melville and Wayne Goddard, Juta and Company Ltd, 2004
2. Research Methodology: An Introduction' by Wayne Goddard and Stuart Melville, Juta and Company Ltd, 2004
3. Research Methodology, G.C. Ramamurthy, Dream Tech Press, New Delhi
4. Management Research Methodology' by K. N. Krishnaswamy et al, Pearson Education

COURSE CODE:	COURSE TITLE	CREDITS	
04 GN 6001	RESEARCH METHODOLOGY	0-2-0: 2	
MODULES		Contact Hours	
MODULE : 1 Introduction to Research Methodology: Concepts of Research, Meaning and 2 Objectives of Research, Research Process, Types of Research, Type of research: Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, and Conceptual vs. Empirical		5	
MODULE :2 Criteria of Good Research, Research Problem, Selection of a problem, Techniques involved in definition of a problem, Research Proposals – Types, contents, Ethical aspects, IPR issues like patenting, copyrights.		4	
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE: 3 **Research Design :** Meaning, Need and Types of research design, Literature Survey and Review, Identifying gap areas from literature review, Research Design Process, Sampling fundamentals, Measurement and scaling techniques, Data Collection – concept, types and methods, Design of Experiments.		5	
MODULE 4: **Quantitative Techniques:** Probability distributions, Fundamentals of Statistical analysis, Data Analysis with Statistical Packages, Multivariate methods, Concepts of correlation and regression - Fundamentals of time series analysis and spectral analysis.		5	
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE: 5 **Report Writing:** Principles of Thesis Writing, Guidelines for writing reports & papers, Methods of giving references and appendices, Reproduction of published material, Plagiarism, Citation and acknowledgement.		5	
MODULE: 6 Documentation and presentation tools – LaTeX, Office with basic presentations skills, Use of Internet and advanced search techniques.		4	

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6191	SEMINAR - I	0-0-2:2	2015

Pre-requisites: NIL

Course Objectives:

- To train the students to do literature survey.
- To train the students to do critical review of technical papers.
- To train the students to do presentations and technical reports.

Each student shall prepare a paper on any topic of interest in the field of specialization– Nanotechnology. He/she shall get the paper approved by the Programme Coordinator/ Faculty in-charge and present it in the class in the presence of Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6193	NANOSCIENCE AND TECHNOLOGY LAB -I	0-0-2:1	2015

Syllabus

1. Preparation of Nanoparticle suspensions and sedimentation study
2. Emission studies in Nano fuel additives
3. Distillation characteristics of Nanofluids
4. Molecular Modeling of Boiling in Nanofluids
5. Preparation of Nanoparticles – Chemical reduction method
6. Preparation of Nanoparticles – sol-gel method
7. Preparation of Nanoparticles - Sonochemical Reactor
8. Preparation of Nanoparticles – Ball milling
9. Chemical bath deposition- Dip Coating
10. Effect of particle size on Physical / Chemical properties
11. Probing DNA structure with Nanoparticles

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6102	INDUSTRIAL NANOTECHNOLOGY	3-1-0:4	2015

Pre-requisites: Nil

Course Objectives:

1. To impart a knowledge of scope and applications of nanotechnology in electrical and electronics industry
2. To understand the scope and applications of Nanotechnology in agriculture and food technology
3. To reveal the applications of scope and applications of Nanotechnology in textiles and cosmetics

Syllabus

Nanotechnology in electrical and electronics industry-–Electronic circuit chips – Lasers - Micro and Nano- Electromechanical systems – Sensors, Actuators, Optical switches, Bio-MEMS –Diodes and Nano-wire Transistors - Data memory –Lighting and Displays – Filters (IR blocking) –– Batteries - Fuel cells and Photo-voltaic cells – Electric double layer capacitors – Lead-free solder –Nanotechnology in biomedical and chemical industry-Nanoparticles in bone substitutes and dentistry – Implants and Prosthesis - Reconstructive Intervention and Surgery– Nanorobotics in Surgery – Photodynamic Therapy - Nanosensors in Diagnosis– Neuro-electronic Interfaces –Protein Engineering – Drug delivery – Therapeutic applications. Nanocatalyts

Nanotechnology in agriculture and food technology-Nanotechnology in Agriculture -Precision farming, Smart delivery system – Insecticides using nanotechnology – Potential of nano-fertilizers - Nanotechnology in food industry - Packaging, Food processing - Food safety and bio- security – Contaminant detection – Smart packaging-Nanotechnology in textiles and cosmetics-Nanofibre production - Electrospinning – Controlling morphologies of nanofibers – Tissue engineering application– Polymer nano particles and Polymer nanofibers - Nylon-6 Nanocomposites from polymerization - Nano-filled polypropylene fibers - Bionics– Swim-suits with shark-skin-effect, Soil repellence, Lotus effect - Nano finishing in Modern textiles Cosmetics – Formulation of Gels, Shampoos, Hair-conditioners– Sun-screen dispersions for UV protection using Titanium oxide – Color cosmetics

Course Outcome:

To demonstrate an understanding of various applications of nanotechnology in an industrial point of view.

Text Books:

1. Mark A. Ratner and Daniel Ratner, Nanotechnology: A Gentle Introduction to theNext Big Idea, Pearson(2003).
2. Bharat Bhushan, Springer Handbook of Nanotechnology, Barnes & Noble (2004).

References:

1. Neelina H. Malsch (Ed.),*Biomedical Nanotechnology*, CRC Press (2005)
2. P. J. Brown and K. Stevens, *Nanofibers and Nanotechnology in Textiles*, Woodhead Publishing Limited, Cambridge, (2007).
3. Y-W. Mai,*Polymer Nano composites*, Woodhead publishing, (2006).

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6102	INDUSTRIAL NANOTECHNOLOGY	3-1-0:4	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: Advantages of nanoelectrical and electronic devices –Electronic circuit chips – Lasers - Micro and Nano- Electromechanical systems Sensors, Actuators, Optical switches, Bio-MEMS –Diodes and Nano-wire Transistors - Data memory –Lighting and Displays – Filters (IR blocking) – Quantum optical devices		4 4	15
MODULE 2: Batteries - Fuel cells and Photo-voltaic cells – Electric double layer capacitors – Lead-free solder – Nanoparticle coatings for electrical products. Nanoparticles in bone substitutes and dentistry – Implants and Prosthesis - Reconstructive Intervention and Surgery– Nanorobotics in Surgery – Photodynamic Therapy - Nanosensors in Diagnosis– Neuro-electronic Interfaces –Protein Engineering – Drug delivery – Therapeutic applications		4 4	15
FIRST INTERNAL TEST			
MODULE 3: Nanocatalyts – Smart materials – Heterogenous nanostructures and composites – Nanostructures for Molecular recognition (Quantum dots, Nanorods, Nanotubes) Molecular Encapsulation and its applications – Nanoporous zeolites – Self-assembled Nanoreactors - Organic electroluminescent displays.		4 4	15
MODULE 4: Nanotechnology in Agriculture -Precision farming, Smart delivery system – Insecticides using nanotechnology Potential of nano-fertilizers - Nanotechnology in food industry – Packaging		4 5	15
SECOND INTERNAL TEST			
MODULE 5: Food processing - Food safety and bio- security – Contaminant detection – Smart packaging. Nanofibre production - Electrospinning – Controlling morphologies of nanofibers – Tissue engineering application– Polymer nano particles and Polymer nanofibers - Nylon-6 Nanocomposites from polymerization - Nano-filled polypropylene fibers		5 6	20
MODULE 6: Bionics– Swim-suits with shark-skin-effect, Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes) – Modern textiles (Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear) Cosmetics – Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) – Sun-screen dispersions for UV protection using Titanium oxide – Color cosmetics.		6 6	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6104	ADVANCED NANOMATERIALS	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

1. To impart a knowledge of scope and applications of Magnetic Nano materials.
2. To understand the scope and applications of Carbon Nano Structures &Dendrimers.
3. To acquaint with Thermo Electric Materials.

Syllabus

Magnetic Materials**,** Fundamentals of magnetic materials, Dia, Para, Ferro, Anti-Ferro, Ferri, Super Para magnetic Materials and Giant and Colossal Magneto-Resistance. Important properties in relation to Nano-magnetic materials. Magnetism in nanostructures-Nanostructure Magnetism; Effect Bulk Nano structuring of Magnetic property; Gaint and Colossal Magnetic resistance; Super Para Magnetism in metallic nanoparticle; Super para magnetism/ FM in Semi- conduction Quantum Dots, Carbon Nano Structures &Dendrimers-Carbon Nano Structures: Introduction; Fullerenes, C60, C80 and C240 Nanostructures; Properties & Applications (Mechanical, Optical and Electrical)
Dendrimers**–** The Dendritic State, Unique Dendrimer Properties, Dendrimers as Nano-pharmaceuticals and Nano-medical Devices, Dendrimers as Reactive Units for the Synthesis of More Complex Nano-scale Architectures. Thermo Electric Materials-

Thermo Electric Materials (TEM): Concept of phonon, Thermal conductivity, Specific heat, Exothermic & Endothermic processes. Different types of TEM; Bulk TEM Properties. One dimensional TEM;Composite TEM; Applications.

Course Outcome:

To demonstrate an understanding of various engineering Nano-materials..

Text Books:

1**.** Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
2.Nanoscale materials -Liz Marzan and Kamat.
3. Applied Physics Of Carbon Nanotubes : Fundamentals Of Theory, Optics And Transport Devices - S. Subramony & S.V. Rotkins.
4. CRC Handbook of Thermoelectrics, Ed. CR Rowe

References

1. Physics of Magnetism - S. Chikazumi and S.H. Charap.
2. Magnetostriction and Magnetomechanical Effects - E.W. Lee.
3. Physical properties of Carbon Nanotube-R Satio.

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COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH **6104**	**ADVANCED NANOMATERIALS**	**3-0-0:3**	
MODULES		**Contact hours**	**Sem. Exam Marks (%)**
MODULE : 1 Fundamentals of magnetic materials Dia, Para, Ferro, Anti-Ferro, Ferri, Super-Para magnetic Materials and Giant and Colossal Magneto-Resistance. Important properties in relation to Nano magnetic materials.		3 3 2	15
MODULE : 2 Nanostructure Magnetism; Effect Bulk Nano structuring of Magnetic property; Gaint and Colossal Magnetic resistance. Super Para Magnetism in metallic nanoparticle;		4 3	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE : 3 Molecular Encapsulation and its applications – Nano porous zeolites – Self-assembled Nano reactors - Organic electroluminescent displays . Nanotechnology in Agriculture -Precision farming, Smart delivery system – Insecticides using nanotechnology		3 4	15
MODULE : 4 Potential of nano-fertilizers - Nanotechnology in food industry – Packaging. Food processing - Food safety and bio- security – Contaminant detection – Smart packaging.		3 3	15

INTERNAL TEST 2 (MODULE 3 & 4)		
MODULE : 5 Nano fiber production - Electro spinning – Controlling morphologies of Nano fibers – Tissue engineering application– Polymer Nano particles and Polymer Nano fibers - Nylon-6 Nano composites from polymerization - Nano-filled polypropylene fibers. Cosmetics – Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) – Sun-screen dispersions for UV protection using Titanium oxide – Color cosmetics.	3 3	20
MODULE : 6 Bionics– Swim-suits with shark-skin-effect, Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes) – Modern textiles (Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear)	4 4	20
END SEMESTER EXAM		

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6106	**EXPERIMENTAL AND CHARACTERIZATION TECHNIQUES FOR NANOTECHNOLOGY**	**3-0-0:3**	**2015**

Prerequisites: Nil

Course Objectives:

1. To describe the various Statistical principles for analyzing nanomaterial
2. To explain the fundamental concepts, theories and methods of spectroscopy applicable to nanotechnology
3. To instruct the microscopic methods of characterizing nanomaterial

Syllabus

Statistical principles**,** Design-of-Experiment methods as applied to Nano materials, Self-assembly, Processing, and Associated development of analytical protocols. Elementary ideas of blocking, general principles of linear model analysis. Introduction to replication, Covariance, Experimental treatment structures, and Full- and partial-factorial designs, Error analysis. Experimental Techniques**,** Experimental techniques for temperature measurement – Thermo reflectance thermometry– Measurement of thermal phenomena in Nano-fluids – Thermal conductivity measurement in Nano-fluids using steady state and transient methods, Spectroscopy and Microscopy**,** Spectroscopy of Semiconductors – Excitons – Infrared surface spectroscopy – Raman Spectroscopy–Brillouin spectroscopy –Dynamic Light Scattering (DLS)–NMR Spectroscopy–ESR Spectroscopy–Photoelectron Spectroscopy (XPS), Microscopic methods, SEM, TEM, STM, SPM, Atomic force Microscopy (AFM), Neutron and X- ray Diffraction**,** Debye Scherrer formula – Dislocation density – Micro strain macromolecular crystallography using synchrotron radiation – Role for neutron scattering in Nano science. Optical absorption and emission spectroscopy – Photoluminescence – Thermo luminescence – X – ray absorption Fine Structure (XAFS) – Extended X- ray absorption fine structure (EXAFS) – Electron scattering for chemical Analysis (ESCA)

Course Outcome:

The student will demonstrate the ability to understand the basic concepts of characterizing Nano materials.

Text Books:

1**.** Pradeep, T., Nano: The Essentials, McGraw Hill Publishers, Mumbai, 2007

2.T. Tsakalakos, I. Ovid'ko and A.K. Vasudevan (eds.), "Synthesis, Functional Properties and Applications of Nanostructures", Kluwer Academic Publishers, Dordrecht, 2003

References:

1.Weilie Zhou & Zhong Lin Wang, Scanning Microscopy for Nanotechnology, Springer 2006

1. 2. H.A. Willard a n d L . L . Merrit, J.A. Dean, " Instrumental methods of Analysis", Van Nonstrand, New York, 1986

COURSE PLAN

COURSE NO:	COURSE TITLE:	CREDITS	
04 **CH6106**	**EXPERIMENTAL AND CHARACTERIZATION TECHNIQUES FOR NANOTECHNOLOGY**	**3-0-0:3**	
MODULES		**Contact hours**	**Sem. Exam Marks;%**
MODULE : 1 Experimental methods as applied to nanomaterials, Self assembly, Processing, and Associated development of analytical protocols. Elementary ideas of blocking, General principles of linear model analysis. Introduction to replication, Covariance,		4 3	15
MODULE : 2 Experimental treatment structures, and Full- and partial-factorial designs, Error analysis. Experimental techniques for temperature measurement – Thermo reflectance thermometry.		3 3	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE : 3 Thermal conductivity measurement in nanofluids using steady state and transient methods. Measurement of thermal phenomena in nanofluids		3 3	15
MODULE : 4 Spectroscopy of Semiconductors – Excitons – Infrared surface spectroscopy – Raman Spectroscopy.		4	15

Brillouin spectroscopy –Dynamic Light Scattering (DLS)–NMR Spectroscopy–ESR Spectroscopy–Photoelectron Spectroscopy (XPS)	4	
INTERNAL TEST 2 (MODULE 3 & 4)		
MODULE : 5 Microscopic methods, SEM, TEM, STM, SPM, Atomic force Microscopy (AFM). Debye Scherrer formula – Dislocation density – Microstrain macromolecular crystallography using synchrotron radiation.	 4 3	20
MODULE : 6 Role for neutron scattering in nanoscience. Optical absorption and emission spectroscopy – Photoluminescence – Thermoluminescence. X – ray absorption Fine Structure (XAFS) – Extended X- ray absorption fine structure (EXAFS) – Electron scattering for chemical Analysis (ESCA).	 4 4	20
END SEMESTER EXAM		

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6108	NANOELECTRONICS	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

1. To understand the fundamental concepts of nanoelectronics
2. To introduce nanodevices and nanosystems with applications.

Syllabus

Basics of Nanoelectronics- Capabilities of nano electronics – Physical fundamentals of nano electronics – Basics of information theory – The tools for micro and nano fabrication – Basics of lithographic techniques for nanoelectronics.Quantum electron devices-Classical to quantum physics: Upcoming electronic devices– 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 circuit design – Comparison between FET and SET circuit design Nanoelectronics with tunnelling devices and Superconducting devices- Tunnelling element technology - RTD: Circuit design based RTD – Defect tolerant circuits. Molecular electronics – Elementary circuits – Flux quantum devices – Application of superconducting devices – Nanotube based sensors, Fluid flow , Gas temperature; Strain – Oxide nanowire, Gas sensing, LPG Sensor-Nano designs and Nanocontacts – Metallic Nanostructures.-Replacement Technologies, Energy and Heat dissipation – Parameter spread as Limiting Effect – Limits due to thermal particle motion – Reliability as limiting factor – Physical limits – Final objectives of integrated chip and systems, Memory devices and sensors – Nano ferroelectrics – Ferroelectric random access memory – Fe-RAM Circuit design – Ferroelectric thin film properties and integration – Calorimetric sensors – Electrochemical cells – Surface and bulk acoustic devices – Gas sensitive FETs – Resistive semiconductor gas sensors –Electronic noses – Identification of hazardous solvents and gases – Semiconductor sensor array.

Course Outcome:

The student will demonstrate the ability to understand the basic concepts of nanoelectronics

Text Books:

1. Nanoelectronics and Nanosystems, Karl Goser, Peter Glosekotter, Jan Dienstuhl., Springer, 2004

References:

1. Nanoelectronics and information technology : Advanced electronic materials and novel devices (2^{nd} edition) Rainer Waser (ed.) Wiley VCH VerlagWeiheim (2005)
2. Nanotechnology: Basic science and emerging technologies – Mick Wilson, KamaliKannangara, Geoff Smith, Michelle Simmons, BurkhardRaguse, Overseas Press (2005)

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6108	NANOELECTRONICS	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE 1: Capabilities of nanoelectronics – Physical fundamentals of nanoelectronics Basics of information theory – The tools for micro and nano fabrication Basics of lithographic techniques for nanoelectronics.		3 3 4	15
MODULE 2: : Classical to quantum physics: Upcoming electronic devices– Electrons in mesoscopic structure Short channel MOS transistor – Split gate transistor – Electron wave transistor – Electron spin transistor – quantum cellular automate		3 3	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE 3: Quantum dot array – Principles of Single Electron Transistor (SET) – SET circuit design – Comparison between FET and SET circuit design. Tunneling element technology - RTD: Circuit design based RTD – Defect tolerant circuits. Molecular electronics – Elementary circuits – Flux quantum devices		4 4	15
MODULE 4: Application of superconducting devices – Nanotube based sensors, Fluid flow , Gas temperature; Strain – Oxide nanowire, Gas sensing (ZnO,TiO2,SnO2,WO3), LPG Sensor (SnO2 powder)- Nano designs and Nano contacts – Metallic Nanostructures.		3 3	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE 5: Energy and Heat dissipation –Parameter spread as Limiting Effect –Limits due to thermal particle motion –Reliability as limiting factor –Physical limits –Final objectives of integrated chip and systems Memory devices and sensors –Nano ferroelectrics –Ferroelectric random access memory –Fe-RAM Circuit design –Ferroelectric thin film properties and integration –Calorimetric sensors –		3 3	20
MODULE 6: Electrochemical cells –Surface and bulk acoustic devices –Gas sensitive FETs –Resistive semiconductor gas sensors –Electronic noses – Identification of hazardous solvents and gases – Semiconductor sensor array.		6	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6112	NANOTECHNOLOGY IN ENERGY CONVERSION AND STORAGE	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

1. To understand the application of nanotechnology for sustainable energy.
2. To make acquaintance with fundamental aspects of energy storage systems

Syllabus

Nanotechnology for sustainable energy- Energy conversion process, Indirect and direct energy conversion- Materials for light emitting diodes- Batteries- Advanced turbines- Catalytic reactors- Capacitors- Fuel cells.Renewable energy technology-Energy challenges, Development and Implementation of renewable energy technologies - Nanotechnology enabled renewable energy technologies -Energy transport, Conversion and Storage- Nano, Micro, and Poly crystalline and Amorphous Si for Solar cells, Nano-micro Si-Composite structure, Various techniques of Si deposition.Micro fuel cell technologyMicro-fuel cell technologies, Integration and Performance for Micro-Fuel cell Systems-Thin film and micro fabrication methods - Design methodologies - Micro-fuel cell power sources. Micro fluidic systems-Nano-electromechanical systems and novel micro fluidic devices - Nano engines – Driving mechanisms – Power generation - Micro channel battery - Micro heat engine fabrication - Thermocapillary forces -Thermocapillary pumping - Piezoelectric membrane.Hydrogen storage methods - Metal hydrides - Size effects - Hydrogen storage capacity - Hydrogen reaction kinetics -Carbon-free cycle- Gravimetric and volumetric storage capacities - Hydriding/dehydriding kinetics -High enthalpy of formation - and Thermal management during the Hydriding reaction.

Course Outcome:

The student will demonstrate the knowledge of nanotechnology based energy storage systems

Text Books:

1. J. Twidell and T. Weir, *Renewable Energy Resources*, E & F N Spon Ltd, London, (1986).
2. Martin A Green, *Solar cells: Operating principles, technology and system applications*, Prentice Hall Inc, Englewood Cliffs, NJ, USA, (1981).

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6112	NANOTECHNOLOGY IN ENERGY CONVERSION AND STORAGE	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: Nanotechnology for sustainable energy- Energy conversion process Indirect and direct energy conversion- Materials for light emitting diodes		3 4	15
MODULE 2: Batteries- Advanced turbines- Catalytic reactors-Capacitors- Fuel cells. Energy challenges, Development and Implementation of renewable energy technologies - Nanotechnology enabled renewable energy technologies		3 4	15
FIRST INTERNAL TEST			
MODULE 3: Energy transport, Conversion and Storage- Nano, Micro, and Poly crystalline and Amorphous Si for Solar cells, Nano-micro Si-Composite structure, Various techniques of Si deposition.		3 4	15
MODULE 4: Micro-fuel cell technologies, Integration and Performance for Micro-Fuel cell Systems Thin film and micro fabrication methods		4 3	15
SECOND INTERNAL TEST			
MODULE 5: Design methodologies - Micro-fuel cell power sources Nano-electromechanical systems and novel micro fluidic devices - Nano engines – Driving mechanisms –Power generation -Micro channel battery -Micro heat engine (MHE) fabrication -Thermocapillary forces -Thermocapillary pumping (TCP) - Piezoelectric membrane		3 4	20
MODULE 6: Hydrogen storage methods -Metal hydrides -Size effects -Hydrogen storage capacity -Hydrogen reaction kinetics Carbon-free cycle- Gravimetric and volumetric storage capacities - Hydriding/dehydriding kinetics -High enthalpy of formation and Thermal management during the Hydriding reaction.		3 4	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6114	NANO BIOTECHNOLOGY	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

1. To explain the fundamental principles of bionanotechnology.
2. To introduce DNA based nanostructures.
3. To reveal various applications of bionanotechnology Syllabus

Syllabus

Introduction to Nanobiotechnology-Negligible gravity and inertia, Atomic granularity, Thermal motion, Water environment and their importance in bionanomachines. The role of proteins- Amino acids- Nucleic acids- Lipids and Polysaccharides in modern biomaterials. Overview of natural Bionanomachines: Thymidylate Sythetase, ATP synthetase, Actin and Myosin, Opsin, Antibodies and Collagen. Principles of Nanobiotechnology-Construction of Nanomachines, Structure and functional properties of Biomaterials, Protein Folding, Self-Assembly, Self-Organization, Molecular Recognition, Information driven nanoassembly, Role of enzymes in chemical transformation, Allosteric motion and covalent modification in protein activity regulation. Protein and DNA based Nanostructures-Protein based nanostructures, Building blocks and templates – Proteins as transducers and amplifiers of biomolecular recognition events – Nanobioelectronic devices and polymer nanocontainers – Microbial production of inorganic nanoparticles – Magnetosomes .DNA based nanostructures – Topographic and Electrostatic properties of DNA and proteins – DNA oligomers-Applications of Nanobiotechnology-Applications of nanobiotechnologyin early medical diagnostics, Drug targeting, Drug delivery, Nanosurgery and other Biomedical field.– Application in optical detection methods – Nanoparticles as carrier for genetic material – Nanotechnology in agriculture – Fertilizer and Pesticides. Designer proteins, Peptides, Nucleic acids, DNA computing, DNA as a semiconductor, Biosensors.

Course Outcome:

The student will demonstrate the understanding of the impact ofbionanotechnology in a biomedical context.

Text Books:

1. C. M. Niemeyer, C. A. Mirkin, —*Nanobiotechnology: Concepts, Applications andPerspectives* Wiley–VCH,2004

References:

2. David S Goodsell*,"Bionanotechnology*, John Wiley & Sons, (2004)

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6114	NANO BIOTECHNOLOGY	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE 1: Negligible gravity and inertia, Atomic granularity, Thermal motion, Water environment and their importance in bionanomachines. The role of proteins- Amino acids- Nucleic acids- Lipids and Polysaccharides in modern biomaterials.		4 3	15
MODULE 2: Overview of natural Bionanomachines: Thymidylate Sythetase, ATP synthetase, Actin and Myosin, Opsin, Antibodies and Collagen Construction of Nanomachines, Structure and functional properties of Biomaterials, Protein Folding		4 3	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE 3: : Self-Assembly, Self-Organization, Molecular Recognition, Information driven nanoassembly, Role of enzymes in chemical transformation Allosteric motion and covalent modification in protein activity regulation.		3 4	15
MODULE 4: Protein based nanostructures, Building blocks and templates – Proteins as transducers and amplifiers of biomolecular recognition events Nanobioelectronic devices and polymer nanocontainers – Microbial production of inorganic nanoparticles – Magnetosomes		3 3	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE 5: DNA based nanostructures – Topographic and Electrostatic properties of DNA and proteins – DNA oligomers. Applications of nanobiotechnologyin early medical diagnostics, Drug targeting, Drug delivery		4 3	20
MODULE 6:Nanosurgery and other biomedical field. Application in optical detection methods –Nanoparticles as carrier for genetic material, Nanotechnology in agriculture –Fertilizer and Pesticides. Designer proteins, Peptides, Nucleic acids, DNA computing, DNA as a semiconductor, Biosensors.		4 4	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6116	NANO TOXICOLOGY	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

1. To acquaint with get toxic effects of nanotechnolgy
2. To understand the current status of rules and regulations related to nanotechnology research

Syllabus

Introduction-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; Nano particles and Cellular Uptake; Nanoparticles and the Blood- Brain barrier, Concept of Nanotoxicology- Laboratory rodent studies- Ecotoxicologic studies- Methodology for Nanotoxicology- Toxicity testing. Mechanism-

Mechanism of Nanosize particle toxicity- Reactive oxygen species mechanisms of NSP toxicity- Interactions between Nanoparticles with Cells and their Cellular nanotoxicology- Cytotoxicology of ultrafine particles- Cytotoxicology and potential Mechanism of Nanomaterials. Toxicology of Nanoparticles in environmental Pollution-Nanopopulation- Nanomaterials in Environment- Toxicology of Airborne- Manufactured Nanomaterials in the Environment.-Human Exposure to Nanosized Materials- Biological Activities of Nanomaterials and Nanoparticles- Respiratory tract- Efficient deposition of inhaled NSPs- Disposition of NSPs in the respiratory- Epithelial translocation- Translocation to the circulatory system- Neuronal uptake and translocation- translocation of NSPs in the blood circulation to bone marrow in mice- Studies of neuronal translocation of UFPs from respiratory tract- Exposure via GI Tract and Skin- Risk Assessment and Excecution, Portals of entry and target issue- Risk assessment- Ethical- Legal and social implications- Nanoparticle Toxicology and Ecotoxicology, The Role of Oxidative Stress- Development of Test Protocols for Nanomaterials- Regulation of Engineered Nanomaterials in Europe, USA and India.

Course Outcome:

To demonstrate a knowledge of toxic and ethical issues

Text Books:

1. Yuliang Zhao and Hari Singh Nalwa, ,,Nanotoxicology: Interactions of Nanomaterials with Biological Systems, American Scientific Publishers,2007

References:

2. M. Zafar Nyamadzi, -A reference handbook of nanotoxicology, Dominant publisher (2008).

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6116	NANO TOXICOLOGY	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE 1: 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; Nano particles and Cellular Uptake; Nanoparticles and the Blood- Brain barrier		3 3	15
MODULE 2: Concept of Nanotoxicology- Laboratory rodent studies- Ecotoxicologic studies- Methodology for Nanotoxicology- Toxicity testing. Mechanism of Nanosize particle toxicity- Reactive oxygen species mechanisms of NSP toxicity-		4 3	15
FIRST INTERNAL TEST			
MODULE 3: Interactions between Nanoparticles with Cells and their Cellular nanotoxicology Cytotoxicology of ultrafine particles- Cytotoxicology and potential Mechanism of Nanomaterials.		3 4	15
MODULE 4: Nanopopulation- Nanomaterials in Environment- Toxicology of Airborne- Manufactured Nanomaterials in the Environment. Biological Activities of Nanomaterials and Nanoparticles- Respiratory tract- Efficient deposition of inhaled NSPs- Disposition of NSPs in the respiratory- Epithelial translocation- Translocation to the circulatory system		3 3	15
SECOND INTERNAL TEST			
MODULE 5: Neuronal uptake and translocation- translocation of NSPs in the blood circulation to bone marrow in mice- Studies of neuronal translocation of UFPs from respiratory tract- Exposure via GI Tract and Skin. Portals of entry and target issue- Risk assessment- Ethical- Legal and social implications.		4 4	20
MODULE 6: Toxicology and Ecotoxicology, The Role of Oxidative Stress- Development of Test Protocols for Nanomaterials- Regulation of Engineered Nanomaterials in Europe, USA and India.		4 4	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6118	POLYMER NANOCOMPOSITES	3-0-0:3	2015

Prerequisites : Nil

Course Objectives:

1. To describe the fundamental aspects of polymeric nanocomposites
2. To impart a knowledge of developing polymer nanocomposites.
3.To expose to the various applications of polymer nanocomposites

Syllabus

Nanofillers and Matrices- Definition of nanocomposite, Nanofillers, Classification of Nanofillers, Carbon and Noncarbon based nanofillers- Properties of various polymer Nanocomposites: Nanotube/Polymer Composites, Layered Filler Polymer Composite Processing- Polyamide Matrices, Polyimide Matrices, Polypropylene and Polyethylene Matrices, Liquid-Crystal Matrices, Epoxy and Polyurethane Matrices, Rubber Matrices. -Processing of Nanocomposites-Synthesis of Nanocomposite: Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing Ceramic/Polymer Composites, Metal/Polymer Nanocomposites, Modification of Interfaces, Modification of Nanotubes, of Nanoparticles, Properties of Nanocomposites-Mechanical Properties, Modulus and the Load-Carrying Capability of Nanofillers, Failure Stress and Strain Toughness, Glass Transition and Relaxation Behavior, Abrasion and Wear Resistance, Permeability, Dimensional Stability Contents, Thermal Stability and Flammability, Electrical and Optical Properties, Resistivity, Permittivity, and Breakdown Strength, Refractive Index, Light-Emitting Devices. biodegradable polymer Nanocomposites, Properties, Biodegradability, Foam processing of biodegradable nanocomposites. Nanocomposites based on water soluble polymers, Crystallization behavior, Overview of nanocomposite structure and crystallization behavior, Nanocomposites containing functionalized nanoparticles: Organic and polymer materials for light-emitting diodes, Luminescent polymer for device applications.

Course Outcome:

To demonstrate an understanding of processing and applications of polymer nanocomposites

Text Books:

1.Polymer nanocomposites: Edited by Yiu-Wing Mai and Zhong-Zhen Yu, First published 2006, Woodhead Publishing Limited and CRC Press LLC, USA.

References:

1.Nanocomposite Science and Technology: Edited by P.M. Ajayan, L.S. Schadler, P.V.Braun, 2003 WILEY-VCH Verlag GmbH Co. KGaA, Weinheim.

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS
04 **CH6118**	**POLYMER NANOCOMPOSITES**	**3-0-0:3**

MODULES	Contact hours	Sem. Exam Marks(%)
MODULE : 1 Definition of nanocomposite, Nanofillers, Classification of Nanofillers, Carbon and Noncarbon based nanofillers. Properties of various polymer Nanocomposites: Nanotube/Polymer Composites, Layered Filler Polymer Composite Processing	3 3	15
MODULE : 2 Polyamide Matrices, Polyimide Matrices, Polypropylene and Polyethylene Matrices, Liquid-Crystal Matrices, Epoxy and Polyurethane Matrices, Rubber Matrices. Synthesis of Nanocomposite: Direct Mixing, Solution Mixing, In-Situ Polymerization.	4 3	15
INTERNAL TEST 1 (MODULE 1 & 2)		
MODULE : 3 In-Situ Particle Processing Ceramic/Polymer Composites Metal/Polymer Nano-composites, Modification of Interfaces, Modification of Nanotubes and Nanoparticles	3 4	15
MODULE : 4 Mechanical Properties, Modulus and the Load-Carrying Capability of Nanofillers, Failure Stress and Strain Toughness. Glass Transition and Relaxation Behavior, Abrasion and Wear Resistance, Permeability, Dimensional Stability Contents, Thermal	3 3	15

Stability and Flammability		
INTERNAL TEST 2 (MODULE 3 & 4)		
MODULE : 5 Electrical and Optical Properties, Resistivity, Permittivity, and Breakdown Strength, Refractive Index, Light-Emitting Devices. Biodegradable polymer nanocomposites, Properties, Biodegradability, Foam processing of biodegradable nanocomposites.	4 4	20
MODULE : 6 Nanocomposites based on water soluble polymers, Crystallization behavior, Overview of nanocomposite structure and crystallization behavior. Nanocomposites containing functionalized nanoparticles: Organic and polymer materials for light-emitting diodes, Luminescent polymer for device applications.	4 4	20
END SEMESTER EXAM		

COURSE CODE	COURSE NAME	Credits	YEAR
04 CH 6122	NANOSENSORS AND TRANSDUCERS	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

1. To impart a knowledge about the fundamental aspects of nanosensors and transducers.
2. To expose to the applications of nanosensors and transducers.

Syllabus

Transduces-Conductometric and capacitive transducers – Optical waveguide based transducers – Optical fiber based transducers – Interferometric optical transducers – Surface Plasmon resonance transducers – Electrochemical transducers – Soild state transducers transducers – p-n diodes or bipolar junction based transducers – Schottky diode based transducers – MOS capacitor based transducers – FET based transducers– Acoustic wave transducers –Quartz crystal microbalance– Film Bulk acoustic wave resonator (BAW transducer)– Interdigitally launched surface acoustic wave transducer (SAW transducer) – Cantilever based transducers. Sensor Characteristics and Physical Effects-Active and Passive sensors – Static characteristic:- Accuracy, offset and linearity – Dynamic characteristic:- First and second order sensors – Physical effects involved in signal transduction:- Photoelectric effect – photodielectric effect – Photoluminescence effect – Electro luminescence effect – Chemiluminescence effect – Doppler effect – Barkhausen effect– Hal effect – nernst / Ettinshausen effect – Thermoelectric effect –Peizoresistive effect–Piezoelectric effect– Pyroelectric effect– Magneto-Mechanical effect (magnetostriction) –Magnetoresistive effect – Faraday-HenryLaw – Magneto optice Kerr effect – KerrandPockelseffect.Nano based Inorganic Sensors-Density of States (DOS) – DOS of 3D, 2D, 1D and 0D materials – One dimensional gas sensors:- Gas sensing with nano structured thin films – Absorption on surfaces – Metal oxide modifications by additives – Surface modifications – Nano optical sensors – Nano mechanical sensors – Plasmon resonance sensors with nano particles – AMR, Giant and colossal Magnetoresistors – Magnetic tunnelingjunctions.Organic / Biosensors-Structure of Protein – Role of protein in nanotechnology – Using protein in nanodevices – Antibodies in sensing – Antibody in nano particle conjugates – Enzymes in sensing – Enzyme nanoparticle hybrid sensors – Motor proteins in sensing – Transmembrane sensors – Nanosensors based on Nucleotides and DNA – Structure of DNA – DNA decoders and microarrays – DNA protein conjugate based sensors – Bioelectronic sensors – DNA Sequencing with nanopores – Sensors based on molecules with Dendritic architectures – Biomagnetic sensors.

Course Outcome:

The student will demonstrate the ability to develop sensors and transducers using nanosystems.

Text Books:

1. Nanotechnology enabled sensors by KouroushKalantar – Zadeh, Benjamin Fry, Springer Verlag New York, (2007) ISBN-13: 9780387324739.

References: Sensors and signal conditioning, II edition Ramon Pallas-Areny, John G. Webster John Wiley & Sons (2001).

COURSE PLAN

COURSE NO:	COURSE TITLE:	CREDITS	
04 CH 6122	NANOSENSORS AND TRANSDUCERS	3-0-0:3	
MODULES		Contact hours	Sem. Exam Marks; %
MODULE : 1 Conductometric and capacitive transducers –Optical waveguide based transducers –Optical fiber based transducers –Interferometric optical transducers –Surface Plasmon resonance transducers –Electrochemical transducers –Soild state transducers p-n diodes or bipolar junction based transducers –Schottky diode based transducers –MOS capacitor based transducers –FET based transducers –Acoustic wave transducers		6	15
MODULE : 2 Quartz crystal microbalance– Film Bulk acoustic wave resonator (BAW transducer)– Interdigitally launched surface acoustic wave transducer (SAW transducer) –Cantilever based transducers– Active and Passive sensors –Static characteristic:- Accuracy, offset and linearity – Dynamic characteristic:- First and second order sensors.		6	15
FIRST INTERNAL TEST			
MODULE : 3 Physical effects involved in signal transduction:- Photoelectric effect –photodielectric effect –Photoluminescence effect –Electro luminescence effect –Chemiluminescence effect –Doppler effect –Barkhausen effect– Hal effect – Nernst/ Ettinshausen effect –Thermoelectric effect –Peizoresistive effect –Piezoelectric effect–Pyroelectric effect– Magneto- Mechanical effect (magnetostriction) –Magnetoresistive effect – Faraday-Henry Law – Magneto optice Kerr effect – KerrandPockels effect.		6	15
MODULE : 4 Density of States(DOS) –DOS of 3D, 2D, 1D and 0D materials –One dimensional gas sensors:- Gas sensing with nano structured thin films –Absorption on surfaces –Metal oxide modifications by additives –Surface modifications –Nano optical sensors –Nano mechanical sensors.		8	15
SECOND INTERNAL TEST			
MODULE : 5 Plasmon resonance sensors with nano particles –AMR, Giant and colossal Magnetoresistors –Magnetic tunneling junctions. Structure of Protein –Role of protein in nanotechnology –Using protein in nanodevices –Antibodies in sensing –Antibody in nano particle conjugates –Enzymes in sensing –Enzyme nanoparticle hybrid sensors.		4 4	20
MODULE : 6 Motor proteins in sensing –Transmembrane sensors –		4	20

Nanosensorsbased on Nucleotides and DNA – Structure of DNA – DNA decoders and microarrays – DNA protein conjugate based sensors, Bioelectronic sensors –DNA Sequencing with nanopores –Sensors based on molecules with Dendritic architectures – Biomagnetic sensors.	4	
END SEMESTER EXAM		

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6124	NANOMEDICINE	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

1. To describe fundamental aspects of bionanosystems.
2. To introduce different nanosystems used in nanomedcine
3. To explain the nanodrug delivery

Syllabus

Basic of nanobiomolecules, Structure property relationship of Biological Materials: Nano Structure of proteins and Polysaccharides – Structure property relationship of tissues, Bones and Teeth -Collagen rich tissues -Elastic tissues Preparation of nanobiomaterials –Polymeric scaffolds collagen –Elastins – Mucopolysaccharides – Proteoglycans -Cellulose and derivates –Dextrans –Alginates –Pectins -Chitin. Types of Nanobiomolecules- Introduction - Development of nanomedicines –NanoShells –Nanopores – Tectodendrimers –Nano particle drug system for oral administration –Drug system for nasal administration –Drug system for ocular administration –Nanotechnology in diagnostic application. DNA- Nanobiotechnology- Introduction –Antibody Conjugated Nanoparticles –Conjugated Nanoparticles interaction with biological surfaces –Biomedical nanoparticles –Liposome's –Dentrimers – Different types of drug loading –Drug release –Biodegradable polymers –Applications.Nanostructured Materials in medicine- Gold and Silver nanoparticles in cancer targeting and treatment –Nanoparticles in treatment of breast cancer –Chemotherapy –Active and Passive cancer tissue targeting –Micro fluidics –Chemotherapeutic agents – Immunotherapy –Vaccine immunotherapy –Radiotherapy – Thermotherapy – Photo dynamic therapy –Nano particulate targeting.

Course Outcome:

The student will demonstrate the ability to understand and develop nanomedicines based on nanomaterials.

Text Books:

1. J. B Park, "Biomaterials Science and Engineering", Plenum Press, New York, 1984.
2. Kewal K. Jain, The Handbook of Nanomedicine, Humana Press, (2008).

References:

1.Natalie P. Praetories and Tarun K. Mandal, Recent Patents on Drug Delivery& Formulation

2. Zhang, Nanomedicine: A Systems Engineering Approach" 1st Ed. Pan Stanford Publishing, (2005).

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS
04 CH 6124	NANOMEDICINE	3-0-0:3

MODULES	Contact Hours	Sem. Exam Marks (%)
MODULE 1: : Structure property relationship of Biological Materials: Nano Structure of proteins and Polysaccharides Property relationship of tissues, Bones and Teeth -Collagen rich tissues - Elastic tissues Preparation of nanobiomaterials.	4 3	15
MODULE 2: Polymeric scaffolds collagen –Elastins –Mucopolysaccharides – Proteoglycans -Cellulose and derivates –Dextrans –Alginates –Pectins -Chitin. Introduction - Development of nanomedicines –NanoShells –Nanopores – Tectodendrimers	3 3	15
INTERNAL TEST 1 (MODULE 1 & 2)		
MODULE 3: Nano particle drug system for oral administration –Drug system for nasal administration Drug system for ocular administration –Nanotechnology in diagnostic application.	3 4	15
MODULE 4: : Introduction –Antibody Conjugated Nanoparticles –Conjugated Nanoparticles interaction with biological surfaces Biomedical nanoparticles –Liposome's –Dentrimers –Different types of drug loading.	3 3	15
INTERNAL TEST 2 (MODULE 3 & 4)		
MODULE 5: : Gold nanoparticles in cancer targeting and treatment – Nanoparticles in treatment of breast cancer. Silver nanoparticles in cancer targeting and treatment –Nanoparticles in treatment of breast cancer	4 4	20
MODULE 6: Drug release –Biodegradable polymers –Applications. Immunotherapy –Vaccine immunotherapy –Radiotherapy –Thermotherapy – Photo dynamic therapy –Nano particulate targeting	4 4	20
END SEMESTER EXAM		

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH6126	ENVIRONMENTAL NANOTECHNOLOGY	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

1. To introduce the nanoparticles derived from microorganisms.
2. To expose to nanopolluantsand its impact on environment.
3. To understand the nanoremediation method

Syllabus

Synthesis of nanomaterials-Synthesis of nanomaterials by physico- chemical approaches, Bionanocomposites: Nanoparticles and microorganisms- microbial synthesis of Nanomaterials-Biological methods for synthesis of nano emulsions using bacteria- Fungi and 5 actinomycetes- Plants based nanoparticle synthesis- Nanocomposite biomaterials- Fibres, devises and Structures- Nano Bio Systems. Nanotechnology in remediation-Nanoremediation- Identification and characterization of Hazardous waste- Nano pollution- air- Water- Soil contaminants-Identification and Characterization Organic and Inorganics-Environmental cleanup technologies.Nanomaterials-Remediation-Nanomembranes-Nanomeshes-Nanofibres-Nanoclays and Adsorbents- Zeolites- Nano catalysts- Bio polymers-Single enzyme nano particles- Bio metallic iron nanoparticles- Nano photo catalysis.Nano remediation technologies-Environmental nano remediation technology- thermal- Physico- Chemical and biological methods- Nano filtration for treatment of waste- Removal of organics & inorganics and Pathogens- nanotechnology for water remediation and purification. Treatment of hi-tech industrial waste waters using nanoparticles/ modified structures/ devices. Environmental benefits of naomaterials. Sustainable Nanotechnology-Application of industrial ecology to nanotechnology- Fate of Nano materials in environment- Environmental life cycle of nano materials- Environmental and health impacts of nanomaterials- toxicological threats- Eco-toxicology- Exposure to nanoparticles- Biological damage- Threat posed by nano materials to humans- Environmental reconnaissance and surveillance. Corporate social responsibility for nano technology- nanomaterials in future- Implications.

Course Outcome:

The student will demonstrate knowledge of environmental remedial measures related to nanomaterial.

Text Books:

1. Enviro-nanotechnology by Mao Hong Fan, Chin-Pao Huang, Alan E Bland, Z Honglin Wang, RachidSliman, Ian Wright. Elsevier, 2010.
2. Nanotechnology: Health and Environmental risk by Jo Anne Shatkin. CRC press, 2008.

References:

1. Nanotechnology: Importance and Application by M.H. Fulekar, I K International, 2010.
2. Nanotechnologies, Hazards and Resource efficiency by M. Steinfeldt, Avon Gleich, U. Petschow, R. Haum. Springer, 2007.
3. Handbook of Nanofabrication. Edited by Gary Wiederrcht. Elsevier, 2010.

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 6126	ENVIRONMENTAL NANOTECHNOLOGY	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: Synthesis of nanomaterials by physico- chemical approaches, Bionanocomposites Nanoparticles and micro organisms- microbial synthesis of Nanomaterials- Biological methods for synthesis of nano emulsions using bacteria- Fungi and actinomycetes		4 3	15
MODULE 2: Plants based nanoparticle synthesis- Nanocomposite biomaterials- Fibres, devises and Structures- Nano Bio Systems Nanoremediation- Identification and characterization of Hazardous waste- Nano pollution- air- Water- Soil contaminants-Identification and Characterization Organic and Inorganics-Environmental cleanup technologies		3 4	15
FIRST INTERNAL TEST			
MODULE 3: Nanomaterials-Remediation-Nanomembranes-Nanomeshes-Nanofibres-Nanoclays and Adsorbents- Zeolites- Nano catalysts Bio polymers-Single enzyme nano particles- Bio metallic iron nanoparticles- Nano photo catalysis.		3 3	15
MODULE 4: Environmental nano remediation technology- thermal- Physico-Chemical and biological methods Nano filtration for treatment of waste- Removal of organics & inorganics and Pathogens- nanotechnology for water remediation and purification.		3 3	15
SECOND INTERNAL TEST			
MODULE 5: Treatment of hi-tech industrial waste waters using nanoparticles/ modified structures/ devices. Environmental benefits of naomaterials Application of industrial ecology to nanotechnology- Fate of Nano materials in environment- Environmental life cycle of nano materials- Environmental and health impacts of nanomaterials- toxicological threats		4 4	20
MODULE 6: Eco-toxicology- Exposure to nanoparticles- Biological damage- Threat posed by nano materials to humans- Environmental reconnaissance and surveillance. Corporate social responsibility for nano technology- nanomaterials in future- Implications		4 4	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6192	MINI PROJECT	0-0-4:2	2015

Pre-requisites:

- Each student is allotted to a faculty of the department by the HOD
- By mutual discussions, the faculty guide will assign a topic in the general / subject area to the student.
- The students have to refer the Journals and conference proceedings and collect the published literature.
- The student is exposed to collect at least 25 such Research papers published in the last 5 years.
- Using Power point, the student has to make presentation for 20 minutes followed by 10 minutes discussion.
- The student has make two presentations, one at the middle and the other near the end of the semester.
- The student has to write a mini project report for about 30-50 pages (Title page, One page Abstract, review of research paper under various subheading, Concluding remarks and List of References). The project report has to be submitted to the HOD one week before the final presentation, after the approval of the faculty guide.

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 6194	NANOSCIENCE AND TECHNOLOGY LAB -II	0-0-2: 1	2015

Syllabus

1. MATLAB programming to plot 1-D rectangular potential well
2. Numerical solution of Schrodinger wave equation using MATLAB
3. Study of single electron transistor using MOSES 1.2 simulator
4. Electrochemical Biosensors for the Detection of Pesticides
5. Development and Characterization of Nanocomposite.
6. Synthesis of soft nanomaterials
7. Nanostructed DNA Templates
8. Particle size determination – XRD, DLS/ SLS
9. Morphological study of nano particles – SEM
10. Surface Topographic study of Nanoparticles – AFM
11. Identification of functional group of nanoparticles – FTIR

COURSE CODE	COURSE NAME	Credits	YEAR
04 CH 7101	SELF ASSEMBLING NANOSTRUCUTRED MOLECULAR MATERIALS AND DEVICES	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

3. To impart the knowledge about the self assembly and nanofabrication.
4. To impart the knowledge about nanostructure materials and devices.

Syllabus

Self-assembly and nanofabrication-Self organization of nanosized building blocks to form 2D / 3D structures. Biological molecules in Self-assembly and organization, DNA directed self assembly. Self-assembled molecular structures-Vesicles: Types, Formation and Applications; Liposomes: Formation, Applications, Dendrimers: Unique properties, Applications and use in formation of nanostructure.Supramolecular Complexes-Application as molecular devices, Detectors, Catalysts; Natural Supramolecular Structures / Complexes, Formation of Artificial Supramolecular Complexes.Self assembled Monolayers & Membrane and Mesoporous materials-Fabrication and Applications of SAMs and Langmuir Blodgett films using organic molecules. Synthesis of mesoporous materials; Applications in nanotechnology.

Course Outcome:

The student will be able to understand the concepts of nano structured materials.

Text Books:

2. Nanostructured Materials (Processing, Properties and Applications); Carl C Koch, William Andrew Inc., Published 2006.

References:

1. Nanoparticles; ed Gunter Schmid, Published 2006,Wiley-VCH.

COURSE PLAN

COURSE NO:	COURSE TITLE:	CREDITS
04 CH 7101	SELF ASSEMBLING NANOSTRUCUTRED MOLECULAR MATERIALS AND DEVICES	3-0-0:3

MODULES	Contact hours	Sem. Exam Marks; %
MODULE : 1 Self organization of nanosized building blocks to form 2D / 3D structures. Biological molecules in Self-assembly and organization, DNA directed self assembly.	5 5	15
MODULE : 2 Vesicles: Types, Formation and Applications Liposomes: Formation, Applications.	3 4	15
FIRST INTERNAL TEST		
MODULE : 3 Dendrimers: Unique properties, Applications and use in formation of nanostructure. Application as molecular devices, Detectors, Catalysts.	3 4	15
MODULE : 4 Natural Supramolecular Structures / Complexes, Formation of Artificial Supramolecular Complexes.	4 3	15
SECOND INTERNAL TEST		
MODULE : 5 Fabrication and Applications of SAMs and Langmuir Blodgett films using organic molecules.	5	20
MODULE : 6 Synthesis of mesoporous materials; Applications in nanotechnology.	6	20
END SEMESTER EXAM		

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH7103	SOCIETAL IMPLICATIONS OF NANOTECHNOLOGY	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

1. To impart the knowledge about the economic impact of nanotechnology.
2. To impart the knowledge about ethics and laws related to nanotechnology

Syllabus

Economic impact of nanotechnology **-**Socio-Economic Impact of Nanoscale Science - Managing the Nanotechnology Revolution: Consider the Malcolm Baldrige National Quality Criteria - The Emerging Nano Economy: Key Drivers, Challenges, and Opportunities - Transcending Moore's Law with Molecular Electronics and Nanotechnology -Semiconductor Scaling as a Model for Nanotechnology Commercialization - Sustaining the Impact of Nanotechnology on Productivity, Sustainability, and Equity. Social scenarios**-** Navigating Nanotechnology Through Society - Nanotechnology, Surveillance, and Society: Methodological Issues and Innovations for Social Research - Nanotechnology: Societal Implications: Individual Perspectives - Nanotechnology and Social Trends - Five Nanotech Social Scenarios -Technological Revolutions and the Limits of Ethics in an Age of Commercialization - Vision, Innovation, and Policy. Converging technology and governance**-**Nanotechnology's Implications for the Quality of Life - Management of Innovation for Convergent Technologies - The "Integration/Penetration Model:" - The Use of Analogies for Interdisciplinary Research in the Convergence of Nano-, Bio-, and Information Technology - Converging Technologies: Innovation, Legal Risks, and Society .Governance**-** Problems of Governance of Nanotechnology -Institutional Impacts of Government Science Initiatives - Nanotechnology for National Security. Ethics and lawEthics and Law **-** Ethical Issues in Nanoscience and Nanotechnology: Reflections and Suggestions - Ethics and Nano: A Survey - Law in a New Frontier - An Exploration of Patent Matters Associated with Nanotechnology - The Ethics of Ethics - Negotiations over Quality of Life in the Nanotechnology Initiative

Course Outcome:

The student will be able to

1. Analyze the economic impact of nanotechnology.
2. Understand the ethics and laws related to nanotechnology

Text Books:

1. Mihail C. Roco and William Sims Bainbridge —*Nanotechnology: Societal Implications II-Individual Perspectives*‖, Springer (2007).

References:

1. Jurgen Schulte —*Nanotechnology: Global Strategies, Industry Trends and Applications*‖, John Wiley & Sons Ltd (2005).
2. Mark. R. Weisner and Jean-Yves Bottero — *Environmental Nanotechnology applications and impact of nanomaterial*‖, The McGraw-Hill Companies (2007)

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 7103	SOCIETAL IMPLICATIONS OF NANOTECHNOLOGY	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: 1 **Economic impact of nanotechnology:** Socio-Economic Impact of Nanoscale Science - Managing the Nanotechnology Revolution: Consider the Malcolm Baldrige National Quality Criteria - The Emerging Nano Economy: Key Drivers, Challenges, and Opportunities - Transcending Moore's Law with Molecular Electronics and Nanotechnology		3 3	15
MODULE 2: 2 Semiconductor Scaling as a Model for Nanotechnology Commercialization - Sustaining the Impact of Nanotechnology on Productivity, Sustainability, and Equity.		6	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE 3: **Social scenarios:** Navigating Nanotechnology Through Society - Nanotechnology, Surveillance, and Society. Methodological Issues and Innovations for Social Research - Nanotechnology Societal Implications: Individual Perspectives - Nanotechnology and Social Trends - Five Nanotech Social Scenarios -Technological Revolutions and the Limits of Ethics in an Age of Commercialization - Vision, Innovation, and Policy.		10	15
MODULE 4: : **Converging technology and governance:** Nanotechnology's Implications for the Quality of Life - Management of Innovation for Convergent Technologies - The "Integration/Penetration Model:" – The Use of Analogies for Interdisciplinary Research in the Convergence of Nano-, Bio-, and Information Technology - Converging Technologies: Innovation, Legal Risks, and Society Governance- Problems of Governance of Nanotechnology -Institutional Impacts of Government Science Initiatives - Nanotechnology for National Security		10	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE 5: **Ethics and law:** Ethics and Law - Ethical Issues in Nanoscience and Nanotechnology: Reflections and Suggestions		5	20
MODULE 6: : Ethics and Nano: A Survey - Law in a New Frontier - An Exploration of Patent Matters Associated with Nanotechnology - The Ethics of Ethics - Negotiations over Quality of Life in the Nanotechnology Initiative.		5	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 7105	COMPUTATIONAL NANOSCIENCES	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

To impart the knowledge about the computational nanoscience

Syllabus

Introduction to Matlab and Mathematics,Monte Carlo Simulations; Computational methods and Simulations from ab initio to multiscale Modeling. Molecular dynamics, computing and simulations. Nanodesign Nano-CAD, Modeling of Nanodevices. Applications and examples, problems based on Molecular dynamics simulations.

Course Outcome:

The student will be able to understand the Nano-CAD and design it for an application.

Text Books:

1. Introduction to Computer simulation methods. Gould, Tobochnik et al (Addition weekly-2006).

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 7105	COMPUTATIONAL NANOSCIENCES	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: Introduction to Matlab and Mathematics (and their open source counterparts-Scilab and Octave);		6	15
MODULE 2: Examples from nano-optics and nano-electronics.		6	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE 3: Monte Carlo Simulations Computational methods and Simulations from abinitio to multiscale Modeling.		4 6	15
MODULE 4: Molecular dynamics, computing and simulations.		8	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE 5: Nanodesign Nano-CAD, Modeling of Nanodevices.		6	20
MODULE 6: Applications and examples, problems based on Molecular dynamics simulations.		6	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	Credits	YEAR
04 CH 7107	PHOTONICS AND PLASMONICS	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

1.To impart the knowledge about the Physics of photonics.
2.1To identify and represent various power system components.
3.To impart the knowledge about the fabrication of Technology, Materials, and Fabrication of Photonic Crystals and Applications of Photonic Crystals Devices.

Syllabus

Physics of Linear Photonic Crystals : Maxwell's Equations, Bloch's Theorem, Photonic Band Gap and Localized Defect States, Transmission Spectra, Nonlinear Optics in Linear Photonic Crystals, Guided Modes in Photonic Crystals Slab.

Technology, Materials, and Fabrication of Photonic Crystals and Applications of Photonic Crystals Devices: Choices of Materials: Semiconductors, Amorphous, and Polymers, Fabrications of Photonic Crystals Structures (1-D,2-D,3-D), Application of 1-D Photonic Crystals, Couplers, Waveguides, High-Q Cavities, etc, 2-D Photonic Crystals , Photonic Crystal Fibers, 4 Tunable Photonic Crystal Filters.

Physics of Nonlinear Photonic Crystals: 1-D Quasi Phase Matching, Nonlinear Photonic Crystal Analysis, Applications of Nonlinear Photonic Crystals Devices, Materials: LiNbO3, Chalcogenide Glasses, etc, Wavelength Converters, etc.

Elements of Plasmonics: Introduction to Plasmonics, merging photonics and electronics at nanoscale dimensions, single photon transistor using surface plasmon, nanowire surface plasmons-interaction with matter, single emitter as saturable mirror, photon correlation, and integrated systems. All optical modulation by plasmonic excitation of quantum dots, Channel plasmon- polariton guiding by subwavelength metal grooves, Near-field photonics: surface plasmonpolaritons and localized surface plasmons, slow guided surface plasmons at telecom frequencies.

Course Outcome:

The student will be able to understand the concepts of photonics and plasmonics.

Text Books:

1.By Mool Chand Gupta, John Ballato.
2.Nanoplasmonics, From fundamentals to Applications Vol. 1 & 2- S. Kawata& H. Masuhara.

COURSE PLAN

COURSE NO:	COURSE TITLE:	CREDITS	
04 CH 7107	PHOTONICS AND PLASMONICS	3-0-0:3	
MODULES		Contact hours	Sem. Exam Marks; %
MODULE : 1: Maxwell's Equations, Bloch's Theorem, Photonic Band Gap and Localized Defect States, Transmission Spectra.		3 4	15
MODULE : 2 Nonlinear Optics in Linear Photonic Crystals, Guided Modes in Photonic Crystals Slab. Choices of Materials: Semiconductors, Amorphous, and Polymers-Fabrications of Photonic Crystals Structures (1-D,2-D,3-D)		3 4	15
FIRST INTERNAL TEST			
MODULE : 3 Application of 1-D Photonic Crystals, Couplers, Waveguides, High-Q Cavities, etc, 2-D Photonic Crystals , Photonic Crystal Fibers, 4 Tunable Photonic Crystal Filters.		3 3	15
MODULE : 4 1-D Quasi Phase Matching, Nonlinear Photonic Crystal Analysis, Applications of Nonlinear Photonic Crystals Devices, Materials: LiNbO3, Chalcogenide Glasses, etc, Wavelength Converters, etc.		3 3	15
SECOND INTERNAL TEST			
MODULE : 5 Introduction to Plasmonics, merging photonics and electronics at nanoscale dimensions, single photon transistor using surface plasmon, nanowire surface plasmons-interaction with matter, single emitter as saturable mirror, photon correlation, and integrated systems.		6	20
MODULE : 6 All optical modulation by plasmonic excitation of quantum dots, Channel plasmon- polariton guiding by subwavelength metal grooves, Near-field photonics: surface plasmonpolaritons and localized surface plasmons, slow guided surface plasmons at telecom frequencies.		6	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 7109	NANO DEVICE TECHNOLOGY	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

1. To impart the knowledge about the MEMS and NEMS

Syllabus

Introduction-MEMS and NEMS definitions, Taxonomy of Nano-and Microsystems- Synthesis and Design. Classification, Biomimetics, Biological analogies, and Design, Nano-ICs and Nanocomputer architectures. Modeling of micro and nanoscale electromechanical systems -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.Sensor characteristics and physical effects-Introduction to sensors, Static Characteristics and Dynamic characteristics, Physical effects:- Photoelectric Effect, Photoluminescence Effect, Electroluminescence Effect , Chemiluminescence Effect, Doppler Effect , Hall Effect, Thermoelectric effect, Magneto-Optical Phenomena.FutureNanosystems-Nano machines, Nano robots, Electronics based on CNT, Molecular Electronics. Quantum Computation: Future of Meso/Nanoelectronics -Interfacing with the Brain, Towards molecular medicine, Lab-on-biochips-Guided evolution for challenges and the solutions in Nano manufacturing technology

Course Outcome:

The student will be able to understand the concepts of MEMS and future nanosystem

Text Books:

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. A. S. Edelstein and Cammarata, Nanomaterials: Synthesis, Properties and Applications Institute of Physics, Bristol, Philadelphia: Institute of Physics, (2002).

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 7109	NANO DEVICE TECHNOLOGY	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: MEMS and NEMS definitions, Taxonomy of Nano-and Microsystems- Synthesis and Design. Classification, Biomimetics, Biological analogies, and Design Nano-ICs and Nanocomputer architectures.		3 3	15
MODULE 2: 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		3 4	15
FIRST INTERNAL TEST			
MODULE 3: Introduction to sensors, Static Characteristics and Dynamic characteristics Physical effects:- Photoelectric Effect, Photoluminescence Effect, Electroluminescence Effect , Chemiluminescence Effect		4 3	15
MODULE 4: Doppler Effect , Hall Effect, Thermoelectric effect, Magneto-Optical Phenomena		5	15
SECOND INTERNAL TEST			
MODULE 5: Nano machines, Nano robots, Electronics based on CNT, Molecular Electronics		6	20
MODULE 6: Quantum Computation: Future of Meso/Nanoelectronics -Interfacing with the Brain, Towards molecular medicine, Lab-on-biochips- Guided evolution for challenges and the solutions in Nano manufacturing technology		3 4	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P: C	YEAR
04 CH 7111	GREEN MANUFACTURING TECHNOLOGY	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

1. To impart the knowledge about the green manufacturing technology

Syllabus:

Green manufacturing trends-Green Manufacturing: Fundamentals - Basic definitions and issues surrounding green manufacturing process, Traditional manufacturing to green manufacturing - Economic issues, Surrounding green manufacturing - Areas of automotive, semiconductor and Medical areas as well as in the supply and packaging areas. Sustainable Green manufacturing- Introduction - Sustainable green manufacturing - Green manufacturing sustainability processes, Requirements, and Risk - The sustainable lean and green audit process. International green manufacturing, standards and compliance. Green rapid prototyping and rapid manufacturing- Green flexible automation. Green collaboration processes - Alternative energy resources. Globally green manufacturing supply chains and logistic networks-Sustainable green manufacturing system design. Role of nanotechnology in green manufacturing and sustainable energy. Green plastics manufacturing. Natural Rubber -Plastics from vegetable oils -Cellulose and starch based materials - Natural fillers, Fibres, Reinforcements and clay reinforced plastic nano-composites -Biodegradability, Life cycle assessment and economics of using natural materials. Waste management

Sustainability and global conditions - Material and solid waste management - Energy management -chemical waste management and green chemistry - Climate change and air emissions management - Supply water and waste-water management - Environmental business management. Role of nanotechnology in waste management.

Course Outcome:

The student will be able to understand the green manufacturing process and waste management

Text Books:

1. T. David Allen and David R. Shonnard, *Green engineering*, Prentice Hall NJ, (2002).
2. David Dornfeld, *Green*manufacturing *fundamental and applications,* Prentice hall (2002).

References:

1. G. Sammy Shinga, *Green electronics design and manufacturing,* Prince Publications (2008).
2. James clark, *Green chemistry,* Blackwell publishing (2008).

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 7111	GREEN MANUFACTURING TECHNOLOGY	3-0-0:3	
MODULES		Contact hours	Sem. Exam Marks (%)
MODULE : 1 Green Manufacturing: Fundamentals - Basic definitions and issues surrounding green manufacturing process, Government motivations for green manufacturing. Traditional manufacturing to green manufacturing - Economic issues		3 3	15
MODULE : 2 Surrounding green manufacturing - Areas of automotive, semiconductor and Medical areas as well as in the supply and packaging areas.		4	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE : 3 Introduction - Sustainable green manufacturing - Green manufacturing sustainability processes, Requirements, and Risk - The sustainable lean and green audit process. International green manufacturing standards and compliance.		3	15
MODULE : 4 Green rapid prototyping and rapid manufacturing- Green flexible automation. Green collaboration processes - Alternative energy resources. Globally green manufacturing supply chains and logistic networks- Sustainable green manufacturing system design. Role of nanotechnology in green manufacturing and sustainable energy.		5 4	15

INTERNAL TEST 2 (MODULE 3 & 4)		
MODULE : 5 Introduction to commercial plastics and elastomers -Natural Rubber (NR), Modified NR and Blends -Polyesters from microbial and plant bio-factories (polylactic acid and poly hydroxyl-alkanoates). Plastics from vegetable oils -Cellulose and starch based materials - Natural fillers, Fibres, Reinforcements and clay reinforced plastic nanocomposites . Biodegradability, Life cycle assessment and economics of using natural materials.	4 4 2	20
MODULE : 6 Sustainability and global conditions - Material and solid waste management - Energy management -chemical waste management and green chemistry. Climate change and air emissions management - Supply water and waste-water management - Environmental business management. Role of nanotechnology in waste management.	4 6	20
END SEMESTER EXAM		

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 7113	NANOTECHNOLOGY IN BUSINESS APPLICATIONS AND INTELLECTUAL PROPERTY RIGHTS	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

1. To impart the knowledge about the Nanobusiness and intellectual property rights.

Syllabus

Overview- Introduction – Types of nanobusinesses – Ease of entry – Intellectual property – Ethics– risks/dangers –Standardization, Investors and commercialization centers – Business applications – Social aspects of nanotechnology. Market landscape Nanotechnology landscape and commercially attributable sectors - Tools to map, understand and segment the nanotechnology marketplace – Potential nanotechnology end-users and applications - Global market for nanotechnology products – Attracting venture capital –How to liaise effectively with partners - Academy-Industry relationship – University and employee's inventions.
Relationship between technology development and new business creation– The company concepts– New technology–New opportunity– Sole proprietorships– General and limited partnerships– Professional and Closed corporations. Materials processing economics Comparison and projection of yield– manufacturing output– labor and equipment expenses to calculate and estimate costs – relative performance enhancements for materials processing– alternate approaches– Identification of equipment– facilities and overheads – specific manufacturing methods– Tools to estimate the economics of process– Addressing the effect of overall system costs – its benefits. Basics of managing intellectual property in organizations
Introduction: The invisible infrastructure of innovation-Intellectual Property Dynamics in Society-The types of Intellectual Property- Patent documents-the construction of the patent, Face of the patent, conception, Body of the patents - The innovation cycle- The rise of the intellectual property system-Balancing the tension between exclusive rights and the accessible domains. The innovation forest: Intellectual property rights and how they grow- The ABCDs of intellectual property: Flow and infringement of IP rights-The patent system-Copyrights-Trademarks -Trade secrets- The global diversity of innovation communities-The role of the innovation cycles, Entrepreneurship opportunities and Policy matters related to Nanotechnology.

Course Outcome:

The student will be able to understand intellectual property right and patenting formalities and also to apply if needs.

Text Books:

1. Sherron Sparks, Nanotechnology: Business Applications and Commercialization, CRC Press, Taylor &Francis group, London (2012).

References:

1. Jeffrey H. Matsuura Nanotechnology Regulation and Policy Worldwide, Artech House; 1 Ed., (2006).

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 7113	NANOTECHNOLOGY IN BUSINESS APPLICATIONS AND INTELLECTUAL PROPERTY RIGHTS	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE 1: Introduction – Types of nanobusinesses – Ease of entry – Intellectual property – Ethics– risks/dangers –Standardization, Investors and commercialization centers – Business applications – Social aspects of nanotechnology.		3 3 2	15
MODULE 2: Nanotechnology landscape and commercially attributable sectors - Tools to map, understand and segment the nanotechnology marketplace – Potential nanotechnology end-users and applications - Global market for nanotechnology products – Attracting venture capital –How to liaise effectively with partners - Academy-Industry relationship –University and employee's inventions.		3 3	15
FIRST INTERNAL TEST			
MODULE 3: Relationship between technology development and new business creation– The company concepts– New technology–New opportunity– Sole proprietorships– General and limited partnerships–Professional and Closed corporations. Comparison and projection of yield– manufacturing output– labor and equipment expenses to calculate and estimate costs		4 4	15
MODULE 4: Relative performance enhancements for materials processing– alternate approaches–Identification of equipment– facilities and overheads – Specific manufacturing methods– Tools to estimate the economics of process– Addressing the effect of overall system costs – its benefits.		3 3	15
SECOND INTERNAL TEST			
MODULE 5: Introduction: The invisible infrastructure of innovation-Intellectual Property Dynamics in Society-The types of Intellectual Property- Patent documents-the construction of the patent, Face of the patent, conception, Body of the patents – The innovation cycle- The rise of the intellectual property system-Balancing the tension between exclusive rights and the accessible domains.		3 3	20
MODULE 6: The innovation forest: Intellectual property rights and how they grow- The ABCDs of intellectual property: Flow and infringement of IP rights-The patent system-Copyrights-Trademarks -Trade secrets- The global diversity of innovation communities-The role of the innovation cycles, Entrepreneurship opportunities and Policy matters related to Nanotechnology.		6	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 7115	DRUG DELIVERY SYSTEMS	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

1. To impart the knowledge about the Applications of nano technology in medical fields

Syllabus

Imaging techniques- Medical diagnostics – Imaging – MRI – Principle, Instrumentation, Operation and Imaging – NMR-Principle, Instrumentation, Operation and imaging - Nanotechnology based diagnostics including imaging Applications, Nano bioactive glasses- Introduction - Nano Bioactive glasses – Preparation –Methods - Nanobioactive glass powders – Properties – Mechanical- Measurement of bioactivity – In vitro studies - Coating on metallic implant – Characterization Implant applications. Cancer treatment
Gold and Silver nanoparticles in cancer targeting and treatment - Nanoparticles in treatment of breast cancer – Chemotherapy: Active and Passive cancer tissue targeting – Micro fluidics – Chemotherapeutic agents – Immunotherapy – Vaccine immunotherapy – Radiotherapy – Thermotherapy – Photo dynamic therapy –Nano particulate targeting. Targeted drug delivery -Delivery mechanism: Introduction, Antibody conjugated nanoparticles – Conjugated nanoparticles interaction with biological surfaces – Biomedical Nanoparticles – Liposomes - Dentrimers - Different types of drug loading, Drug release and Biodegradable polymers –Applications. Targeted drug delivery: Basic and special pharmacology – Strategies for Targeted delivery – In nature – Bacteria – Virus – Prion strategies for targeted delivery – By human – Oral delivery – Transdermal – Transmucosal – Invasive – Targeted delivery to brain – Macrophage targeting Total

Course Outcome:

The student will be able to understand various applications of nanotechnology in biomedical field.

Text Books:

1. Challa Kumar, Nanomaterials for medical diagnosis and therapy , Wiley VCH 2005

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 CH 7115	DRUG DELIVERY SYSTEMS	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: Medical diagnostics – Imaging – MRI – Principle, Instrumentation, Operation and Imaging – NMR-Principle, Instrumentation, Operation and imaging		3 3	15
MODULE 2: Nanotechnology based diagnostics including imaging Applications Introduction - Nano Bioactive glasses –Preparation –Methods - Nanobioactive glass powders – Properties – Mechanical- Measurement of bioactivity		2 3 3	15
FIRST INTERNAL TEST			
MODULE 3: In vitro studies - Coating on metallic implant – Characterization Implant applications. Gold and Silver nanoparticles in cancer targeting and treatment - Nanoparticles in treatment of breast cancer		4 3	15
MODULE 4: Chemotherapy: Active and Passive cancer tissue targeting – Micro fluidics – Chemotherapeutic agents Immunotherapy – Vaccine immunotherapy – Radiotherapy – Thermotherapy – Photo dynamic therapy –Nano particulate targeting.		4 3	15
SECOND INTERNAL TEST			
MODULE 5: Delivery mechanism: Introduction, Antibody conjugated nanoparticles – Conjugated nanoparticles interaction with biological surfaces – Biomedical Nanoparticles – Liposomes - Dentrimers - Different types of drug loading, Drug release and Biodegradable polymers –Applications.		3 3	20
MODULE 6: Targeted drug delivery: Basic and special pharmacology – Strategies for Targeted delivery – In nature – Bacteria – Virus – Prion strategies for targeted delivery – By human – Oral delivery – Transdermal – Transmucosal – Invasive – Targeted delivery to brain – Macrophage targeting		6	20
END SEMESTER EXAM			

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 CH 7193	PROJECT PHASE - I	0-0-12: 6	2015

Course Objectives:

The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real-life problems related to industry and current research.

The project work can be a design project/experimental project and/or computer simulation project on any of the topics related to the stream of specialisation. The project work is chosen/allotted individually on different topics. Work of each student shall be supervised by one or more faculty members of the department. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to carry out their main project outside the parent institute, subject to the conditions specified in the M. Tech regulations of the APJ Abdul Kalam Technological University. Students are encouraged to take up industry problems in consultation with the respective supervisors.

The student is required to undertake the main project phase-1 during the third semester and the same is continued in the 4th semester (Phase 2). Phase-1 consist of preliminary work, two reviews of the work and the submission of a preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4th semester.

COURSE CODE	COURSE NAME	L-T-P: C	YEAR
04 CH 7194	PROJECT PHASE - II	0-0-21: 12	2015

Main project phase II is a continuation of project phase-I started in the third semester. There would be two reviews in the fourth semester, first in the middle of the semester and the second at the end of the semester. First review is to evaluate the progress of the work, presentation and discussion. Second review would be a pre -submission presentation before the evaluation committee to assess the quality and quantum of the work done. It is encouraged to prepare at least one technical paper for possible publication in journals or conferences. The project report (and the technical paper(s)) shall be prepared without any plagiarised content and with adequate citations, in the standard format specified by the Department /Cluster/University.