K.S. Rangasamy College of Technology

(Autonomous Institution affiliated to Anna University, Chennai)

CURRICULUM AND SYLLABI

FOR

M.Tech. Nanoscience and Technology
(For the batch admitted in 2023– 2024)

R2022

Accredited by NAAC A++,
Approved by AICTE, Affiliated to Anna University, Chennai.

KSR Kalvi Nagar, Tiruchengode – 637 215.
Namakkal District, Tamil Nadu, India.

Department of Nano Science and Technology

VISION

- To excel as a world class teaching and research hub in Nanoscience and Technology.

MISSION

- To facilitate students and researchers to engage in need-based research in multidisciplinary domains.
- To engage in transformative technology based education that builds industry and society.

Program Educational Objectives (PEOs) for M.Tech. (NST) Programme

PEO1: Our graduates will demonstrate their competence in the processing of nanostructured materials and use them for effective industrial applications.

PEO2: Our graduates will demonstrate interdisciplinary proficiency both in theory and practice in Nanoscience and Technology research.

PEO3: Our graduates will apply the scientific concepts and mathematical analysis to bring out need based nano-products with ethical responsibility.

PROGRAMME OUTCOMES (POs) Engineering Graduates will be able to:

Engineering Graduates will be able to:

PO1: Ability to understand the importance of Nanoscience and Technology and bring out scientific solution for unsolved problems

PO2: Ability to implement multidisciplinary concepts and ideas for the development of innovative Technologies.

PO3: Capability to demonstrate leadership, quality and entrepreneurship.

PO4: Demonstrate technical skills in operation and maintenance of sophisticated instrumentations.

PO5: Ability to protect their innovative research through IPR.

PO6: Ability to bring out good quality research proposal as well as research publications.

Program Specific Outcomes (PSOs) for M.Tech. (NANO) Programme

Engineering Graduates will be able to:

PSO1: Analyse and synthesize new nano materials for multiple applications.

PSO2: Design processing conditions to engineer functional nanomaterials.

PSO3: Apply and transfer interdisciplinary systems and Engineering approaches to the field of Nanotechnology.

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MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) WITH PROGRAMME OUTCOMES (POs)

The M.Tech. Nanoscience and Technology Programme out comes leading to the achievement of the objectives are summarized in the following Table.

Program Specific Outcomes	PROGRA MME OUTCOMES (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
PSO1	2	3	3	2	2	2
PSO2	3	2	2	2	3	2
PSO3	2	2	3	2	2	3

Contributions:1-low,2- medium,3-high

Credit Distribution for M.Tech. (NST) Progrmme–2022 –2023 Batch

S. No.	Category	Credits Per Semester				Total Credits	Percentage %
		I	II	III	IV		
1.	BS	04				**04**	**5.47**
2.	PC	17	19	06	-	**42**	**57.53**
3.	PE	-	03	06	-	**09**	**12.32**
4.	OE	-	-	-	-	**-**	**-**
5.	EEC	-	-	06	12	**18**	**24.65**
6.	AC	AC I	AC II	-	-	**-**	**-**
7.	MC	-	-	-	-	**-**	**-**
Total		**21**	**22**	**18**	**12**	**73**	**100**

HS – HUMANITIESANDSOCIALSCIENCES
BS - BASICSCIENCE
ES - ENGINEERINGSCIENCES
PC - PROFESSIONALCORE
PE - PROFESSIONALELECTIVES
MC - MANDATORYCOURSES
OE - OPENELECTIVES
EEC - EMPLOYABILITYENHANCEMENTCOURSES
GE - GENERALELECTIVECOURSES

Open Electives are courses offered by different departments that do not have any prerequisites and could be of interest to students of any branch

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BASIC SCIENCE (BS)

S. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C	Prerequisite
1.	60 PNT 101	Mathematical Modelling and Simulation	BS	4	3	1	0	4	Nil

PROFESSIONAL CORE (PC)

S. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C	Prerequisite
1.	60 PNT 101	Mathematical Modelling and Simulation	BS	4	3	1	0	4	Nil
2.	60 PNT 102	Quantum Mechanics	PC	4	3	1	0	4	Basics of quantum mechanics
3.	60 PNT 103	Synthesis of Nanostructured Materials	PC	3	3	0	0	3	Basics of Nanomaterial and chemistry
4.	60 PNT 104	Nanoelectronics	PC	3	3	0	0	3	Fundamental of electronics
5.	60 PNT 105	Nano Biotechnology	PC	3	3	0	0	3	Fundamental of biology
6.	60 PNT 1P1	Advanced Nanomaterials Synthesis Laboratory	PC	4	0	0	4	2	Nil
7.	60 PNT 1P2	Nano Biotechnology Laboratory	PC	4	0	0	4	2	Nil
8.	60 PNT 201	Advanced Characterisation Techniques	PC	3	3	0	0	3	Nil
9.	60 PNT 202	Nano Photonics and its Applications	PC	3	3	0	0	3	Nil
10.	60 PNT 203	Nanolithography and Nanofabrication	PC	3	3	0	0	3	Nil
11.	60 PNT 204	Advanced Carbon Nanotubes and Applications	PC	3	3	0	0	3	Basics of Carbon Nanotubes
12.	60 PED 001 / 60 PDB E26	Research Methodology and IPR	PC	3	3	0	0	3	Nil
13.	60 PNT 2P1	Advanced Characterisation Laboratory	PC	4	0	0	4	2	Nil
14.	60 PNT 2P2	Nanomaterials Device Fabrication and Analysis Laboratory	PC	4	0	0	4	2	Nil
15.	60 PNT 301	Applications of Nanocomposites	PC	3	3	0	0	3	Nil
16.	60 PNT 302	Nanotechnology in Energy Storage Devices	PC	3	3	0	0	3	Basics of Electronics

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PROFESSIONAL ELECTIVES (PE)
SEMESTER II, ELECTIVE I

S. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C	Prerequisite
1.	60 PNT E11	Polymers in Nanotechnology	PE	3	3	0	0	3	Nil
2.	60 PNT E12	Nanotechnology in Biomedical Instrumentation	PE	3	3	0	0	3	Nil
3.	60 PNT E13	Nanosensors and Applications	PE	3	3	0	0	3	Nil
4.	60 PNT E14	Nanodevices	PE	3	3	0	0	3	Nil
5.	60 PNT E15	Advanced Solid State Materials	PE	3	3	0	0	3	Nil
6.	60 PNT E16	Thin Film Science and Technology	PE	3	3	0	0	3	Nil

SEMESTER III, ELECTIVE II

S. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C	Prerequisite
1.	60 PNT E21	Nanotribology	PE	3	3	0	0	3	Nil
2.	60 PNT E22	Nanotechnology in Automobiles	PE	3	3	0	0	3	Nil
3.	60 PNT E23	Corrosion Engineering	PE	3	3	0	0	3	Nil
4.	60 PNT E24	Nano Safety and Environmental Issues	PE	3	3	0	0	3	Nil
5.	60 PNT E25	Micro and Nano Electro Mechanical Systems	PE	3	3	0	0	3	Nil
6.	60 PNT E26	Nanotechnology In Industries	PE	3	3	0	0	3	Nil

SEMESTER III, ELECTIVE III

S. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C	Prerequisite
1.	60 PNT E31	Social Impact of Nanotechnology	PE	3	3	0	0	3	Nil
2.	60 PNT E32	Computer Modeling and Simulation	PE	3	3	0	0	3	Nil
3.	60 PNT E33	Nanotechnology in Defense and Security	PE	3	3	0	0	3	Nil
4.	60 PNT E34	Nanotechnology in Food Preservation and Safety Management	PE	3	3	0	0	3	Nil
5.	60 PNT E35	Nanotechnology in Textile and Agriculture Industry	PE	3	3	0	0	3	Nil
6.	60 PNT E36	Self Assembly of Nanostructures	PE	3	3	0	0	3	Nil

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AUDITCOURSES (AC)
Semester I &II

S. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C	Prerequisite
1.	60 PAC 001	English for Research Paper Writing	AC	2	2	0	0	0	Nil
2.	60 PAC 002	Disaster Management	AC	2	2	0	0	0	Nil
3.	60 PAC 003	Constitution of India	AC	2	2	0	0	0	Nil

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C	Prerequisite
1.	60 PNT 3P1	Project Work - Phase I	EEC	12	0	0	12	6	Nil
2.	60 PNT 4P1	Project Work - Phase II	EEC	24	0	0	24	12	Nil

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COURSES OF STUDY

(For the candidates admitted from 2022-2023 onwards)

SEMESTER - I

S. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C
THEORY								
1.	60 PNT 101	Mathematical Modelling and Simulation	BS	4	3	1	0	4
2.	60 PNT 102	Quantum Mechanics	PC	4	3	1	0	4
3.	60 PNT 103	Synthesis of Nanostructured Materials	PC	3	3	0	0	3
4.	60 PNT 104	Nanoelectronics	PC	3	3	0	0	3
	60 PNT 105	Nano Biotechnology	PC	3	3	0	0	3
6	60 PAC 001	English for Research Paper Writing	AC	2	2	0	0	0
PRACTICALS								
7.	60 PNT 1P1	Advanced Nanomaterials Synthesis Laboratory	PC	4	0	0	4	2
8.	60 PNT 1P2	Nano Biotechnology Laboratory	PC	4	0	0	4	2
			Total	**27**	**17**	**2**	**8**	**21**

SEMESTER - II

S. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C
THEORY								
1.	60 PNT 201	Advanced Characterisation Techniques	PC	3	3	0	0	3
2.	60 PNT 202	Nano Photonics and its Applications	PC	3	3	0	0	3
3.	60 PNT 203	Nanolithography and Nanofabrication	PC	3	3	0	0	3
4.	60 PNT 204	Advanced Carbon Nanotubes and Applications	PC	3	3	0	0	3
5.	60 PNT E1*	Professional Elective I	PE	3	3	0	0	3
6.	60 PED 001 / 60 PDB E26	Research Methodology and IPR	PC	3	3	0	0	3
7.	60 PAC 002	Disaster Management	AC	2	2	0	0	0
PRACTICALS								
8.	60 PNT 2P1	Advanced Characterisation Laboratory	PC	4	0	0	4	2
9.	60 PNT 2P2	Nanomaterials Device Fabrication and Analysis Laboratory	PC	4	0	0	4	2
			Total	**28**	**20**	**0**	**8**	**22**

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SEMESTER - III

S. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C
THEORY								
1.	60 PNT 301	Applications of Nanocomposites	PC	3	3	0	0	3
2.	60 PNT 302	Nanotechnology in Energy Storage Devices	PC	3	3	0	0	3
3.	60 PNT E2*	Professional Elective II	PE	3	3	0	0	3
4.	60 PNT E3*	Professional Elective III	PE	3	3	0	0	3
PRACTICALS								
5.	60 PNT 3P1	Project Work - Phase I	EEC	12	0	0	12	6
			Total	**24**	**12**	**0**	**12**	**18**

SEMESTER - IV

S. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C
PRACTICALS								
1.	60 PNT 4P1	Project Work - Phase II	EEC	24	0	0	24	12
			Total	**24**	**0**	**0**	**24**	**12**

TOTAL NUMBER OF CREDITS TO BE EARNED FOR AWARD OF THE DEGREE =73

Note:
HS- Humanities and Social Sciences including Management Courses
BS- Basic Science Courses
ES-Engineering Science Courses
PE-Professional Core Courses
PE-Professional Elective Courses
OE- Open Elective Courses
EEC-Employability Enhancement Courses
MC-Mandatory Courses
AC-Audit Courses

L : Lecture
T : Tutorial
P : Practical

Note:
1. Hour Lecture is equivalent to 1 credit
2. Hour Tutorial is equivalent to 1credit
3. HoursPracticalisequivalentto1credit

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M.Tech. Degree Programme

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2022-2023 onwards)

FIRST SEMESTER

S. No.	Course Code	Name of the Course	Duration of Internal Exam	Weightage of Marks			Minimum Marks for Pass in End Semester Exam	
				Continuous Assessment*	End Semester Exam **	Max. Marks	End Semester Exam	Total
THEORY								
1	60 PNT 101	Mathematical Modelling and Simulation	2	40	60	100	45	100
2	60 PNT 102	Quantum Mechanics	2	40	60	100	45	100
3	60 PNT 103	Synthesis of Nanostructured Materials	2	40	60	100	45	100
4	60 PNT 104	Nanoelectronics	2	40	60	100	45	100
5	60 PNT 105	Nano Biotechnology	2	40	60	100	45	100
6	60 PAC 001	English for Research Paper Writing	2	100	00	100	00	0
PRACTICAL								
7	60 PNT 1P1	Advanced Nanomaterials Synthesis Laboratory	3	60	40	100	45	100
8	60 PNT 1P2	Nano Biotechnology Laboratory	3	60	40	100	45	100

SECOND SEMESTER

S. No.	Course Code	Name of the Course	Duration of Internal Exam	Weight age of Marks			Minimum Marks for Pass in End Semester Exam	
				Continuous Assessment*	End Semester Exam **	Max. Marks	End Semester Exam	Total
THEORY								
1	60 PNT 201	Advanced Characterisation Techniques	2	40	60	100	45	100
2	60 PNT 202	Nano Photonics and its Applications	2	40	60	100	45	100
3	60 PNT 203	Nanolithography and Nanofabrication	2	40	60	100	45	100
4	60 PNT 204	Advanced Carbon Nanotubes and Applications	2	40	60	100	45	100
5	60 PNT E1*	Professional Elective I	2	40	60	100	45	100
6	60 PED 001 /	Research Methodology and	2	40	60	100	45	100

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	60 PDB E26	IPR						
7	60 PAC 002	Disaster Management	2	100	00	100	00	0
PRACTICAL								
8	60 PNT 2P1	Advanced Characterisation Laboratory	3	60	40	100	45	100
9	60 PNT 2P2	Nanomaterials Device Fabrication and Analysis Laboratory	3	60	40	100	45	100

THIRD SEMESTER

S. No.	Course Code	Name of the Course	Duration of Internal Exam	Weight age of Marks			Minimum Marks for Pass in End Semester Exam	
				Continuous Assessment*	End Semester Exam **	Max. Marks	End Semester Exam	Total
THEORY								
1	60 PNT 301	Applications of Nanocomposites	2	40	60	100	45	60
2	60 PNT 302	Nanotechnology in Energy Storage Devices	2	40	60	100	45	60
3	60 PNT E2*	Professional Elective II	2	40	60	100	45	60
4	60 PNT E3*	Professional Elective III	2	40	60	100	45	60
PRACTICAL								
5	60 PNT 3P1	Project Work - Phase I	-	100	-	100	-	-

FOURTH SEMESTER

S. No.	Course Code	Name of the Course	Duration of Internal Exam	Weightage of Marks			Minimum Marks for Pass in End Semester Exam	
				Continuous Assessment*	End Semester Exam **	Max. Marks	End Semester Exam	Total
PRACTICAL								
1	60 PNT 4P1	Project Work - Phase II	-	40	60	100	45	100

* CA evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** End Semester Examination will be conducted for maximum marks of 100 and subsequently be reduced to 60 marks for the award of terminal examination marks

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60 PNT 101	Mathematical Modelling and Simulation	Category	L	T	P	Credit
		BS	3	1	0	4

Objectives

- To acquire knowledge of solving differential equations.
- To familiarize the concepts of numerical integration techniques.
- To get exposed to modeling equations and their applications.
- To acquire knowledge on various modeling and simulation techniques.
- To understand various methods in testing of hypothesis.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Solve differential equations using finite difference scheme.	Remember, Understand, Apply
CO2	Apply appropriate techniques for numerical integration	Remember, Understand, Apply
CO3	Crete a model that adequately describes the problems, using the appropriate technology.	Remember, Understand, Apply
CO4	Simulate Nano technological materials systems with the aid of computation.	Remember, Understand, Apply
CO5	Apply the statistical tests in data investigation.	Remember, Understand, Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3						2	2
CO2	3	3	3	3	2						2	2
CO3	2	2	2	2	2						2	2
CO4	2	2	2	2	2						2	2
CO5	3	3	3	3	3						2	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		Model Exam (Marks)	End Sem Examination (Marks)
	1	2		
Remember (Re)	10	10	10	10
Understand (Un)	10	10	30	30
Apply (Ap)	40	40	60	60
Analyze (An)	0	0	0	0
Evaluate (Ev)	0	0	0	0
Create (Cr)	0	0	0	0
Total	60	60	100	100

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60 PNT 101 - Mathematical Modelling and Simulation *

M.Tech – Nano Science and Technology

Semester	Hours/Week			Total hrs	Credit	Maximum Marks		
	L	T	P		C	CA	ES	Total
I	3	1	0	60	4	40	60	100

NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS **[9]**

Euler's method – Modified Euler's method – Runge-Kutta method (Fourth order only). Boundary value problems: Finite difference method – Poisson equation – Laplace's equation - Gauss-Seidal method – Parabolic equations – Hyperbolic equations.

NUMRICAL INTEGRATION **[9]**

Numerical integrations by Trapezoidal and Simpson's 1/3 and 3/8 rules – Two- and three-point Gaussian quadrature formula – Double intergrals using Trapezoidal and Simpson's rules. Finite Element method: Rayleigh-Ritz method – Galerkin method.

MATHEMATICAL MODELING **[9]**

Mathematical modeling – Physical simulation - Advantages and limitations - Process control - Transport phenomena- Concept of physical domain and computational domain - Assumptions and limitations in numerical solutions.

SIMULATION **[9]**

Basic concepts of simulation – Data manipulation, data exchange of the structure, properties and processing of materials – Monte Carlo method – Basics of the Monte Carlo method – Algorithms for Monte Carlo simulation – Modified Monte Carlo techniques.

TESTING OF HYPOTHESIS **[9]**

Testing of hypothesis for small samples using t-test, F-test**, Chi-square** test for independence of attributes and goodness of fit. ANOVA : One way classification – Completely Randomized Design – Two way classification – Randomized Block Design – Latin Square Design .

Total Hours: 45 + 15 (Tutorial) **60**

Text book(s):

1. S.C. Chapra and R.P.Canale, "Numerical methods for Engineers", Tata McGraw Hill, 6th Edition, New Delhi, 2010
2. D. Frenkel and B. Smith, "Understanding molecular simulation from algorithm to applications", Kluwar Academic Press, 2002

Reference(s):

1. M.K.Jain, S.R.K Iyengar and R.K.Jain, "Numerical Methods for Scientific and Engineering Computation", New Age International (P) Ltd., 6th Edition, 2012.
2. R.J. Schilling and S.L. Harris, "Applied Numerical Methods for Engineers using MATLAB and C", Thomson publishers, New Delhi, 2004..
3. Erwin Kreyzig, "Advanced Engineering Mathematics", John Wiley & Sons, 10th Edition, 2020
4. S.C.Gupta, and J.N.Kapoor, "Fundamentals of Mathematical Statistics", Sultan Chand and sons, 12th Edition, New Delhi, 2020.
5. Prof.Sourav Mondal, "Mathematical Modelling and Simulation of chemical engineering process", NPTEL Online video courses

***SDG:4- Quality Education and opportunities for all**

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Course Contents and Lecture Schedule

S.No.	Topic	No. of Hours
1.0	**NUMERICAL SOLUTION Of DIFFERENTIAL EQUATIONS**	
1.1	Euler's and Modified Euler's Method	1
1.2	Runge-Kutta method (Fourth order only).	1
1.3	Boundary value problems: Finite difference method	2
1.4	Poisson equation	2
1.5	Laplace's equation Gauss seidal method	1
1.6	Parabolic equations	2
1.7	Tutorial	3
2.0	**NUMERICAL INTEGRATION**	
2.1	Numerical integrations by Trapezoidal and Simpson's 1/3 and 3/8 rules	1
2.2	Two and Three point Gaussian quadrature formula	1
2.3	Double integrals using Trapezoidal and Simpson's rules	2
2.4	Finite Element method: Rayleigh-Ritz method	1
2.5	Finite Element method: Galerkin method	1
2.6	Finite Element method: Galerkin method problems	1
2.7	Tutorial	3
3.0	**MATHEMATICAL MODELING**	
3.1	Mathematical modeling introduction	1
3.2	Physical simulation	1
3.3	Mathematical modeling Advantages and limitations	2
3.4	Process control	2
3.5	Transport phenomena	1
3.6	Concept of physical domain and computational domain	1
3.7	Assumptions and limitations in numerical solutions	1
3.8	Tutorial	3
4.0	**SIMULATION**	
4.1	Basic concepts of simulation and data manipulation, data exchange of the structure	1
4.2	properties and processing of materials	2
4.3	Monte Carlo method	1
4.4	Basics of the Monte Carlo method	1
4.5	Algorithms for Monte Carlo simulation	1
4.6	Modified Monte Carlo techniques	2
4.7	Tutorial	3
5.0	**TESTING OF HYPOTHESIS**	
5.1	Testing of hypothesis for small samples using t-test	2
5.2	F-test, Chi-square test for independence of attributes and goodness of fit	1
5.3	Tutorial	1
5.4	ANOVA: One way classification – Completely Randomized Design	1
5.5	Two-way classification – Randomized Block Design	2
5.6	Latin Square Design	2
5.9	Tutorial	3
	Total	**60**

Course Designers

1. Dr.K.PRABAKARAN -prabakaran@ksrct.ac.in

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60 PNT 102	Quantum Mechanics

Category	L	T	P	Credit
PC	3	1	0	4

Objective

- To learn the Plank's quantum hypothesis
- To apply the function of operator
- To identify the operators and computation law
- To analysis the atom model
- To apply the principle of quantum mechanics

Prerequisite

Basics of quantum mechanics

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Recall basic knowledge of quantum theory	Remember
CO2	Analyze the wave mechanics	Apply, Analyze
CO3	Apply the operators in specific problems	Analyze
CO4	Apply the variation principle in different methods	Apply
CO5	Identify the types of approximation methods	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	20
Understand	10	10	20
Apply	10	10	30
Analyze	10	10	20
Evaluate	10	10	20
Create	10	10	10

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K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT 102 - Quantum Mechanics*								
Department of Nanoscience and Technology								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**C**	**E**	**Total**
I	3	1	0	60	4	40	60	100

INTRODUCTION Limitation of classical mechanics - Plank's quantum hypothesis - Einstein's photoelectric effect - Wave nature of particles - Heisenberg Uncertainty principle - Schrodinger's time dependent and independent wave equations - Particle in a one dimensional box - Harmonic oscillator.	[12]
WAVE MECHANICS Linear operator - Hermitian operator - Linear harmonic oscillator - Operator method – Postulates of quantum mechanics - Equations in motion – Ehrenfest's theorem - Hydrogen atom - Hydrogen orbitals - Matrix representation of wave functions.	[12]
OPERATORS AND COMPUTATION LAWS Linear momentum operator – Properties of Hermitian operator – Angular momentum operators – Ladder operators – Parity operator – Commuting and non-commuting operators – Commutation relation Lx and Ly - Commutation relation L^2 and Lx – Commutation relation L+ and L-.	[12]
VARIATION AT PRINCIPLES Variation at method - Ground state of hydrogen molecule - Ground state of Helium atom – Perturbation theory in non-degenerate case - First order perturbation – Harmonic perturbation - Transition to continuous states.	[12]
APPROXIMATION METHODS Klein-Gordon equation – Charge and current densities – Inadequacy of Klein-Gordon equation – Dirac's equation for a free particle - Dirac's matrices – Properties of Dirac's matrices – Negative energy states – Hartree-Fockequation.WKB Approximations-adiabatic approximation-Sudden approximation. Applications of quantum mechanics.	[12]
Total Hours (45+15)	**60**

Reference(s):

1	G. Aruldhass, "Quantum Mechanics", Prentice Hall of India pvt. Ltd. New Delhi, 2004.
2	Kurt Gottfried,Tung-Mowyan " Quantum Mechanics Fundamentals", Springer,2003.
3	Steven Weinberg "Lectures on Quantum Mechanics"USA Cambridge University press,2013
4	AjoyGhatak and Lokanathan "Quantum Mechanics:Theory and Applications", Kluwer Academic publications,2004

***SDG:4- Quality Education and opportunities for all**

Course Contents and Lecture Schedule

S. No	Topic	No. of Hours
1	**INTRODUCTION**	
1.1	Limitation of classical mechanics	1
1.2	Plank's quantum hypothesis	1
1.3	Einstein's photoelectric effect	1
1.4	Wave nature of particles	1
1.5	Heisenberg Uncertainty principle	1
1.6	Schrodinger's time dependent wave equations	2
1.7	Schrodinger's time independent wave equations	2
1.8	Particle in a one dimensional box	1
1.9	Harmonic oscillator	2
2	**WAVE MECHANICS**	
2.1	Linear operator	1

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2.2	Hermitian operator	1
2.3	Linear harmonic oscillator	1
2.4	Operator method	1
2.5	Postulates of quantum mechanics	1
2.6	Equations in motion	1
2.7	Ehrenfests theorem	2
2.8	Hydrogen atom - Hydrogen orbitals	2
2.9	Matrix representation of wave functions	2
3	**OPERATORS AND COMPUTATION LAWS**	
3.1	Linear momentum operator	1
3.2	Properties of Hermitian operator	1
3.3	Angular momentum operators	1
3.4	Ladder operators	1
3.5	Parity operator	1
3.6	Commuting and non-commuting operators	1
3.7	Commutation relation L_x and L_y	2
3.8	Commutation relation L^2 and L_x	2
3.9	Commutation relation L+ and L-	2
4	**VARIATION AT PRINCIPLES**	
4.1	Variation at method	1
4.2	Ground state of hydrogen molecule	1
4.3	Ground state of Helium atom	2
4.4	Perturbation theory in non-degenerate case	2
4.5	First order perturbation	2
4.6	Harmonic perturbation	2
4.7	Transition to continuous states	2
5	**APPROXIMATION METHODS**	
5.1	Klein-Gordon equation	1
5.2	Charge and current densities	1
5.3	Inadequacy of Klein-Gordon equation	1
5.4	Dirac's equation for a free particle	1
5.5	Dirac's matrices – Properties of Dirac's matrices	1
5.6	Negative energy states	1
5.7	Hartree-Fockequation.WKB Approximations	2
5.8	Adiabatic approximation - Sudden approximation.	2
5.9	Applications of quantum mechanics	1
	Total	45

Course Designer

Dr. S. Satheeskumar (satheeskumars@ksrct.ac.in)

60 PNT 103	Synthesis of Nanostructured Materials

Category	L	T	P	Credit
PC	3	0	0	3

Objective

- To practice the simple methods for the synthesis of nanomaterials.
- To synthesize nanomaterials by various chemical and physical routes.
- To study the merits of various process techniques.
- To inculcate different process techniques for nanostructure materials.
- To understand the biological and hybrid types of synthesis techniques.

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Prerequisite

NiL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Synthesis the various nanoscale materials by the application of chemical methods	Apply
CO2	Explain the thin film fabrication using physico chemical technique	Analyse
CO3	Sketch the mechanical approaches for nano materials production	Apply
CO4	Create the micro and nanoscale patterns by approaching Etching process	Create
CO5	Classify the bio and green synthesis process for nano materials	Analyse

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	2	2
CO2	3	2	1	2	2	3
CO3	2	3	2	3	2	2
CO4	3	2	1	2	2	3
CO5	2	3	2	2	2	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyze	10	10	30
Evaluate	10	10	10
Create	10	10	10

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT 103 - Synthesis of Nanostructured Materials*								
Department of Nanoscience and Technology								
Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
I	3	0	0	45	3	40	60	100
CHEMICAL METHODS Sol-gel synthesis –different types of coatings -Spin coating- Self-assembly- (Periodic) - starting points for self- assembly- Directed self-assembly using conventional lithography-Template self-assembly-Vapor liquid solid growth- Langmuir-Blodgett films – DNA self-assembly-Hummers method.								[9]
CVD AND PVD METHODS CVD Chemical vapor deposition –Atmospheric pressure CVD (APCVD) – Low pressure CVD (LPCVD) - Plasma enhanced chemical vapor deposition (PECVD) - The HiPCO method - Photo-enhanced chemical vapor deposition (PHCVD)- LCVD Laser–Induced CVD. Physical vapor deposition- Sputter technologies- Diode sputtering - Magnetron sputtering- Ion beam (sputter)								[9]

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deposition, ion implantation and ion assisted deposition – Cathodic arc deposition - Pulsed laser deposition- metal organic chemical vapor deposition (MOCVD) and Molecule beam epitaxy (MBE).	
MECHANICAL METHODS Micro milling – Micro drilling – Micro grinding processes - Electrical discharge machining (EDM) micro machining - laser micro/nanomachining - Dry etching- isotropic anisotropic etching - Reactive ion etching- Magnetically enhanced RIE- Ion beam etching.	[9]
ETCHING TECHNIQUES Important of etching process in semiconductor- Wet etching of silicon - Isotropic etching - Anisotropic etching – Electrochemical etching - Vapor phase etching - Dry etching- Other etching techniques-Wet chemical etching- Application and properties of different etchants.	[9]
Biological and green Synthesis Microbial synthesis- bacteria- yeast- algae -green synthesis –bio fertilizer- plant extract- neem-tridax-eucalyptus-fruit peel- advantages, limitations, applications.	[9]
Total Hours	**45**

Reference(s):	
1	M. J. Jackson, “Micro fabrication and Nano manufacturing”, CRC Press, 2005.
2	P.Rai-Choudhury, “Handbook of Micro lithography, Micro machining, and Microfabrication”, Vol. 2, SPIE Press, 1997.
3	G. Cao, “Nanostructures & Nanomaterials: Synthesis, Properties & Applications” Imperial College Press, 2004
4	W.T.S. Huck, “Nanoscale Assembly: Chemical Techniques (Nanostructure Science and Technology)”, Springer 2006

***SDG:8- Productive employment**

Course Content and Lecture Schedule

S. No	Topic	No. of Hours
1	**CHEMICAL METHODS**	
1.1	Sol-gel synthesis	1
1.2	Different types of coatings and spin coatings	1
1.3	Self-assembly (Periodic)	1
1.4	Starting points for self- assembly	1
1.5	Directed self-assembly using conventional lithography	1
1.6	Template self-assembly	1
1.7	Vapor liquid solid growth	1
1.8	Langmuir-Blodgett films	1
1.9	DNA self-assembly-Hummers method	1
2	**CVD AND PVD METHODS**	
2.1	CVD Chemical vapor deposition	1
2.2	Atmospheric pressure CVD (APCVD)	1
2.3	Low pressure CVD (LPCVD)	1
2.4	Plasma enhanced chemical vapor deposition (PECVD) - HiPCO	1
2.5	Photo-enhanced chemical vapor deposition (PHCVD)- LCVD Laser–Induced CVD	1
2.6	Physical vapor deposition- Sputter technologies- Diode sputtering	1
2.7	Magnetron sputtering- Ion beam (sputter) deposition, ion implantation and ion assisted deposition	1
2.8	Cathodicarc deposition - Pulsed laser deposition	1
2.9	Metal organic chemical vapor deposition (MOCVD) and Molecule beam epitaxy (MBE).	1
3	**MECHANICAL METHODS**	
3.1	Micromilling	1
3.2	Microdrilling	1
3.3	Microgrinding processes	1
3.4	Electrical discharge machining (EDM) micro machining	1

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3.5	laser micro/nanomachining	1
3.6	Dry etching- isotropic anisotropic etching	1
3.7	Reactive ion etching	1
3.8	Magnetically enhanced RIE	1
3.9	Ion beam etching.	1
4	**ETCHING TECHNIQUES**	
4.1	Important of etching process in semiconductor	1
4.2	Wet etching of silicon	1
4.3	Isotropic etching	1
4.4	Anisotropic etching	1
4.5	Electrochemical etching	1
4.6	Vapor phase etching	1
4.7	Dry etching	1
4.8	Other etching techniques, Wet chemical etching.	1
4.9	Application and properties of different etchants.	1
5	**BIOLOGICAL AND GREEN SYNTHESIS**	
5.1	Microbial synthesis	2
5.2	Bacteria- yeast- algae -green synthesis	1
5.3	Bio fertilizer- plant extract	1
5.4	Neem-tridax-eucalyptus-fruit peel	1
5.5	Advantages, limitations, applications.	1
	Total Hours	45

Course Designer

Dr. A. Karthik (karthik@ksrct.ac.in)

60 PNT 104	**Nanoelectronics**

Category	**L**	**T**	**P**	**Credit**
PC	3	0	0	3

Objective

- To help the learners to understand basic s about the particles and waves
- To provide an overview of the electron transport in semiconductors and nanostructure
- To familiarize learners with the basics of materials in nanoelectronics
- To familiarize the learners with the processing growth fabrication and measurement techniques
- To enlighten the learners to understand various methods, materials and its applications.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Learn an emerging idea of nanoelectronics and particles and waves	Understand
CO2	Implement the wave particle duality behavior in nanotechnology	Apply
CO3	Acquire the electron transport properties in semiconductor	Analyze
CO4	Recognize the electron transport in nanostructures	Apply
CO5	Capture the various materials for nanoelectronics and Identify the basic types of semiconductor heterostructure	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	2	3	2
CO2	3	3	2	1	3	3
CO3	2	2	3	2	2	2
CO4	3	2	2	2	3	2
CO5	2	3	2	2	2	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	20
Apply	10	10	20
Analyse	10	10	20
Evaluate	10	10	20
Create	10	10	10

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K.S.Rangasamy College of Technology – Autonomous R 2022

60 PNT 104- Nanoelectronics

PNT : M.Tech – Nano Science and Technology

Semester	Hours / Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	CA	ES	Total
I	3	0	0	45	3	40	60	100

Objective(s)	● To help the learners to understand basic s about the particles and waves ● To provide an overview of the electron transport in semiconductors and nanostructure ● To familiarize learners with the basics of materials in nanoelectronics ● To familiarize the learners with the processing growth fabrication and measurement techniques ● To enlighten the learners to understand various methods, materials and its applications.
Course Outcomes	**At the end of the course, the students will be able to** 1. Learn an emerging idea of nanoelectronics and particles and waves 2. Implement the wave particle duality behavior in nanotechnology 3. Acquire the electron transport properties in semiconductor. 4. Recognize the electron transport in nanostructures. 5. Capture the various materials for nanoelectronics and identify the basic types of semiconductor heterostructure.

Note: Hours notified against each unit in the syllabus are only indicative but are not decisive. Faculty may decide the number of hours for each unit depending upon the concepts and depth. Questions need not be asked based on the number of hours notified against each unit in the syllabus**.**

Basics of Nanoelectronics * Electrons flow, Classical free electron theory, Sommerfeld theory, The quantum of conductance, Coulomb blockade, Towards Ohm's law. The Elastic Resistor: Conductance of an Elastic Resistor, Elastic Resistor-Heat dissipation.	[9]
Semiconductor Diodes * Semiconductor – Types – Drift and Diffusion Carriers – P-N Junction Diode: Ideal Diode & Practical Diode – V-I Characteristics of a Diode – Diode specifications – Diode resistance & Capacitance – Load line analysis of a diode – Breakdown diodes: Avalanche & Zener diodes – Varactor diodes – Tunnel Diodes – Schottky Diodes Diode Testing	[9]
Bipolar Junction and Field Effect Transistors * Bipolar Junction Transistor (BJT): Construction –-Types of Operation – I/O Characteristics of CE, CB, and CC Configurations, Field Effect Transistor (FET) – Junction Field Effect Transistor (JFET): Construction – principle of operation Characteristic Curves – Effect of Temperature on JFET parameters – MOSFET	[9]
Electrons transport in low-dimensional structures * Time and length scales of the electrons in solids, Statistics of the electrons in solids and nanostructures, Electrons in quantum wells: Single modulation-doped heterojunctions, Numerical analysis of a single heterojunction, Control of charge transfer, Electron transport in quantum wires and quantum dots	[9]
Applications of Nanoelectronics Devices ** Nano ferroelectrics - Ferroelectric random access memory - Fe-RAM circuit design - ferroelectric thin – 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**.**	[9]
	Total hours: 45

Reference(s):

1.	Nanotechnology and Nanoelectronics Editors: Fahrner, Wolfgang (Ed.) Springer-Verlag Berlin Heidelberg 2005
2.	Viadimir V.Mitin.Viatcheslav A.Kochelap.Michel A Stroscio, "Introduction to Nanoelectronics", Cambridge University press 2008.
3.	Nanotechnology and Nanoelectronics Publisher: Neha Publishers & Distributors 2010

***SDG:4- Quality Education and opportunities for all**

***SDG:8- Protective employment**

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Course Content and Lecture Schedule

S. No	Topic	No. of Hours
1	**Basics of Nano electronics**	
1.1	Electrons flow	1
1.2	Classical free electron theory	1
1.3	Sommerfeld theory	1
1.4	The quantum of conductance	1
1.5	Coulomb blockade	1
1.6	Towards Ohm's law	1
1.7	The Elastic Resistor	1
1.8	Conductance of an Elastic Resistor	1
1.9	Elastic Resistor- Heat dissipation	1
2	**Semiconductor Diodes**	
2.1	Types of Semiconductor	1
2.2	Drift and Diffusion Carriers	1
2.3	P-N Junction Diode: Ideal Diode & Practical Diode	1
2.4	V-I Characteristics of a Diode	1
2.5	Diode resistance & Capacitance	1
2.6	Load line analysis of a diode	1
2.7	Breakdown diodes: Avalanche & Zener diodes	1
2.8	Varactor diodes and Tunnel Diodes	1
2.9	Schottky Diodes Diode Testing	1
3	**Bipolar Junction and Field Effect Transistors**	
3.1	Bipolar Junction Transistor (BJT): Construction	1
3.2	Types of Operation	1
3.3	I/O Characteristics of CE Configurations	1
3.4	I/O Characteristics of CB and CC Configurations	1
3.5	Junction Field Effect Transistor (JFET): Construction	1
3.6	principle of operation	1
3.7	Characteristic Curves	1
3.8	Effect of Temperature on JFET parameters	1
3.9	MOSFET	1
4	**Electrons transport in low-dimensional structures**	
4.1	Time and length scales of the electrons in solids	1
4.2	Statistics of the electrons in solids	1
4.3	Statistics of the electrons in nanostructures	1
4.4	Electrons in quantum wells	1
4.5	Single modulation-doped hetero junctions	1
4.6	Numerical analysis of a single hetero junction	1
4.7	Control of charge transfer	1
4.8	Electron transport in quantum wires	1
4.9	Electron transport in quantum dots	1

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5	**Applications of Nano electronics Devices**	
5.1	Nano ferroelectrics	1
5.2	Ferroelectric random access memory - Fe-RAM circuit design	1
5.3	Ferroelectric thin film properties and integration	1
5.4	Calorimetric sensors - electrochemical cells	1
5.5	Surface and bulk acoustic devices	1
5.6	Gas sensitive FETs - resistive semiconductor gas sensors	1
5.7	Electronic noses	1
5.8	Identification of hazardous solvents and gases	1
5.9	Semiconductor sensor array	1
	Total	45

Course Designers

1. Dr.T.Baranidharan - baranidharan@ksrct.ac.in

60 PNT 105	Nano Biotechnology	Category	L	T	P	Credit
		PC	3	0	0	3

Objective(s)

- To extend their knowledge of fundamentals of biology
- To recognize the basic knowledge of Nano biotechnology and DNA structures.
- To interpret the application of nanomaterials in biotechnology and acquire the knowledge about the DNA, proteins, amino acids, drug delivery, biomedicine etc.,

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able

CO1	To know about the basic concept of biology of cell functions and system	Remember, Understand, Apply
CO2	Overview of different types of devices used in interphase system	Remember, Understand, Aanalyze
CO3	Identify various protein based nanostructures and its uses	Remember, Understand, Analyze
CO4	Identify various DNA based nanostructures and its uses	Remember, Understand, Apply
CO5	Understand the properties and applications of nano biomaterials	Remember, Understand, Apply

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Mapping with Programme Outcomes

COURSE NAME	CO	PO						PSO		
		1	2	3	4	5	6	1	2	3
Nano Biotechnology	CO1	3	3	1	3	2	3	3	1	3
	CO2	2	2	2	2	3	2	3	1	3
	CO3	3	3	2	2	2	3	3	3	3
	CO4	2	3	3	2	2	2	3	1	3
	CO5	3	3	2	1	3	2	3	2	3

Note: 3 – Strong Contribution; 2 – Average Contribution; 1 – Some Contribution

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Semester Examination (Marks)
	1	2	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	20
Analyze	10	10	10
Evaluate	10	0	10
Create	10	0	10

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60 PNT 105- Nano Biotechnology								
M.Tech – Nano Science and Technology								
Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	CA	ES	Total
I	3	0	0	45	3	40	60	100

BIOLOGY OF CELL AND CELL FUNCTIONS* Introduction to biological systems – Types of cells – cellular components –astrocytes-oligodendroglia-fibroblasts-cell proliferation and differentaiton- cell division-pluripotency and totipotency-differentiated cells and cancer cells-sub cellular components-cell communication and cell signaling.	[9]
INTERPHASE SYSTEMS* Interphase systems of devices for medical implants – nano-biometrics – introduction – lipids as nano-bricks and mortar: self assembled nanolayers – nano analytical.	[9]
PROTEIN BASED NANOSTRUCTURES* Nanocircuitry S- layer Protein- structure -chemistry -assembly - Protein nanostructured building blocks and templates – proteins as transducers and amplifiers of biomolecular recognition events – nanobioelectronic devices and polymer nanocontainers – microbial production of inorganic nanoparticles – magnetosomes.	[9]
DNA BASED NANOSTRUCTURES* DNA based nanostructures -fabrication-topographic and electrostatic properties of DNA and proteins – hybrid conjugates of gold nanoparticles – DNA oligomers – Applications of DNA molecules in nano mechanics and computing.	[9]

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APPLICATIONS ** Metal nanoparticles and nucleic acid and protein based recognition groups – application in optical detection methods – nanotechnology in agriculture – fertilizers and pesticides - natural nanocomposites – silica nanoparticles in maize growth.	[9]
Total Hours	**45**

Text Book(s):	
1.	David I. Bainbridge, “Intellectual Property”, Longman, 9th Edition, 2012.
2	Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
Reference(s):	
1.	CM, Niemeyer, C.A. Mirkin, “Nano biotechnology: Concepts, Applications and Perspectives”, Wiley – VCH,
2.	T. Pradeep, “Nano: The Essentials”, McGraw – Hill education, 2007.
3.	Challa, S.S.R. Kumar, Josef Hormes, CarolaLeuschaer,”Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact”, Wiley – VCH, 2005.
4.	Nicholas A. Kotov, “Nanoparticle Assemblies and Superstructures”, CRC, 2006.

***SDG:4- Quality Education and opportunities for all**

****SDG:2- Sustainable agriculture**

Course Content and Lecture Schedule

S. No.	Topics	No. of hours
1.0	**BIOLOGY OF CELL AND CELL FUNCTIONS**	
1.1	Introduction to biological systems.	1
1.2	Types of cells – cellular components	1
1.3	astrocytes-oligodendroglia-fibroblasts	1
1.4	cell proliferation and differentaiton- cell division	1
1.5	pluripotency and totipotency	1
1.6	differentiated cells and cancer cells-sub cellular components-	2
1.7	Cell communication and cell signaling	2
2.0	**INTERPHASE SYSTEMS**	
2.1	Interphase systems of devices for medical implants	2
2.2	Nano-biometrics	1
2.3	Lipids as nano-bricks and mortar	2
2.4	Self assembled nanolayers	2
2.5	Nano analytical methods	2
3.0	**PROTEIN BASED NANOSTRUCTURES**	
3.1	Protein based nanostructures building blocks	1
3.2	Protein based templates	2
3.3	Proteins as transducers and amplifiers	1
3.4	Biomolecular recognition events	1
3.5	Nanobioelectronic devices	1
3.6	Polymer nanocontainers	1
3.7	Microbial production of inorganic nanoparticles	1
3.8	Magnetosomes	1
4.0	**DNA BASED NANOSTRUCTURES**	
4.1	DNA based nanostructures	1
4.2	Topographic and electrostatic properties of DNA	1
4.3	Properties of proteins	1

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4.4	Hybrid conjugates of gold nanoparticles	2
4.5	DNA oligomers	1
4.6	Use of DNA molecules in nanomechanics	2
4.7	DNA in computing	1
5.0	**APPLICATIONS**	
5.1	Metal nanoparticles	1
5.2	Nucleic acid and protein based recognition groups	2
5.3	Application in optical detection methods	1
5.4	Nanotechnology in agriculture	1
5.5	Fertilizers and pesticides	1
5.6	Natural nanocomposites	2
5.7	Silica nanoparticles in maize growth.	1
	Total	**45**

Course Designer

Dr.B. Kalpana – kalpana@ksrct.ac.in

60 PAC 001	**English for Research Paper Writing**

Category	L	T	P	Credit
AC	2	0	0	0

Objective

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

Prerequisite

NIL

Course Outcomes

On the success full completion of the course, students will be able to

CO1	Understand that how to improve your writing skills and level of readability
CO2	Learn about what to write in each section
CO3	Understand the skills needed when writing a Title
CO4	Understand the skills needed when writing the Conclusion
CO5	Ensure the good quality of paper at very first-time submission

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)	
	1	**2**
Remember	10	10
Understand	30	30
Apply	30	30
Analyse	30	30
Evaluate	0	0
Create	0	0

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Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	2	3	2
CO2	2	1	1	1	2	3
CO3	3	2	1	1	2	2
CO4	3	2	1	1	1	2
CO5	1	2	2	1	1	2

K.S.Rangasamy College of Technology–AutonomousR2022								
60 PCA 001 - English for Research Paper Writing*								
Common to all Branches								
Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	CA	ES	Total
I	2	0	0	30	0	100	-	100

Introduction to Research Paper Writing Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	[6]
Presentation Skills Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction	[6]
Title Writing Skills Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check	[6]
Result Writing Skills Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	[6]
Verification Skills Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first time submission	[6]
Total Hours	**30**

Text Book(s):

1.	Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2	Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006

Reference(s):

1.	Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
2.	Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.
3.	Phill Williams, Advanced Writing skills for students of English, Rumian Publishers, 2018
4.	Sudhir S. Pandhye, English Grammar and Writing Skills, Notion Press, 2017.

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60 PNT 1P1	Advanced Nanomaterials Synthesis Laboratory

Category	L	T	P	Credit
PC	0	0	4	2

Objective

- To prepare the various nanoscale materials through defend synthesis approach
- To develop the new synthesis method for nanomaterials preparation
- To acquire the technical skills required to prepare the nanoparticles
- To gain experience handling of nanomaterials and maintenance
- To understand the characteristics of nanomaterials by effect of various synthesis method.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Classify the synthesis of nanomaterials with different chemical methods	Understand
CO2	Distinguish the synthesis of nanomaterials with different physical methods	Analyse
CO3	Acquire the characteristics of nanomaterials	Create
CO4	Compare salient feature of nanomaterials	Apply
CO5	Identify the best suitable method for nanomaterials production for required applications	Analyse

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	2	2
CO2	2	3	2	2	1	2
CO3	3	2	2	2	2	3
CO4	2	3	3	2	3	3
CO5	2	3	2	3	2	3

Assessment Pattern

Bloom's Category	Model lab Assessment (Marks)		End Sem Examination (Marks)
	1	2	
Understand	0	0	10
Apply	20	20	30
Analyse	20	20	30
Create	20	20	30

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BoS Chairman

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT 1P1 - Advanced Nanomaterials Synthesis Laboratory *								
Department of Nanoscience and Technology								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**C**	**E**	**Total**
I	0	0	4	60	2	60	40	100

1. Preparation of the metal oxide Nanoparticles (TiO_2/ZnO) using Synthesis Sol-Gel process.
2. Preparation of SiO_2 nanoparticles from its bulk SiO_2 through mechanical attrition (Planetary Ball mill)
3. To synthesis the different size of CuO nanoparticles by Sono-chemical method
4. To prepare the metal nanoparticles (Ag/Au) through Chemical reduction method
5. Preparation of magnetitic nanoparticles (Fe_2O_3/Ni/Fe_2TiO_3) using Co-Precipitation method.
6. Green synthesis of Cu/SiO_2/Ag nanoparticles by Extraction/Reduction process
7. Preparation of bio nanocomposites (TiO_2-SiO_2) through wet chemical approach.
8. Mass production of Al_2O_3-ZrO_2 nanocomposite form natural mineral by hot air Spray pyrolysis.
9. Preparation of nano bioactive glass (SiO_2/CaO/P_2O_5)/HAp) through Hydrothermal method.
10. Preparation of Polymeric Nanofibers (PVA/MgO, TiO_2) through Electro spinning process.
11. Investigation of antimicrobial studies on (Ag/TiO_2/ZnO) nanoparticles.
12. Preparation of Perovskite Nanoparticles ($BaTiO_3$/$CaMgTiO_3$) by solid state methods
13. Synthesis of ZnO nanostructures by the microwave irradiation method
14. Preparation of Polymeric Nanomaterials Using Emulsion Polymerization

Lab Manual :	
1.	Synthesis of Nanomaterials Laboratory Manual", Department of NST, KSRCT, 2018
Reference(s):	
1.	Willard., Merritt., Dean. and Settle "Instrumental Methods of Analysis", CBS PUBS & DISTS New Delhi, 2007
2.	Ewing. Etal, "Instrumental Methods for Chemical Analysis", Tata McGraw Hill Pub, New Delhi 2010.

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Course Designer

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60 PNT 1P2	Nano Biotechnology Laboratory

Category	L	T	P	Credit
PC	0	0	4	2

Objective

- To understand the experimental component in the manipulation of bio molecules and nanoparticles.
- To demonstrate the release of drug from nanoparticles
- To learn the Practice the animal tissue culture media preparation and culture inoculation
- To learn the viability testing of animal cells treated with nanoparticles using Haemocytometer
- To learn the knowledge about the Practice of study of invitro bioactivity of natural/synthetic nanoparticles using simulated body fluid.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Demonstrate the bacterial inoculation and cultivation	Understand
CO2	Evaluate the antibacterial study using nanoparticles	Evaluate
CO3	Practice the antibacterial study using nanoparticles by turbidometric method	Apply
CO4	Analysis the antibacterial study using nanoparticles by using cottion fabrics	Analyze
CO5	Familiar about the drug encapsulation efficiency in nanoparticles	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	1	2	1
CO2	2	3	3	2	1	1
CO3	3	2	2	2	1	3
CO4	3	2	3	2	3	3
CO5	2	3	2	3	2	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Semester Examination (Marks)
	1	2	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	20
Analyze	10	10	10
Evaluate	10	10	10
Create	10	10	10

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BoS Chairman

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT 1P2 - Nano Biotechnology Laboratory *								
Department of Nanoscience and Technology								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**C**	**E**	**Total**
I	0	0	4	60	2	60	40	100

1. Preparation of culture media and Bacterial inoculation
2. Screeningofantibacterialpropertyofnatural/syntheticnanoparticlesbyMullerHintonAgarplate method
3. Screeningofbacterialgrowthinhibitoryactivityofnatural/syntheticnanoparticlesbyTurbidometric method
4. Determination of antibacterial activity of nanoparticles coated cotton fabrics
5. Demonstration of drug encapsulation efficiency
6. Determination of Stability of natural/synthetic nanoparticles
7. Drug release studies from nanoparticles at Physiological conditions
8. Animal tissue culture media preparation and culture inoculation
9. Viability testing of animal cells treated with nanoparticles using Haemocytometer
10. Study of *in vitro* bioactivity of natural/synthetic nanoparticles using simulated body fluid

Lab Manual :

1.	"Nanobiotechnology Lab Manual", Department of Nano Science and Technology, KSRCT.

Reference(s):

1.	CM, Niemeyer, C.A. Mirkin, "Nanobiotechnology: Concepts, Applications and Perspectives", Wiley – VCH,2004.
2.	Challa, S.S.R. Kumar, Josef Hormes, CarolaLeuschaer,"Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact", Wiley – VCH, 2005.
3.	Nicholas A. Kotov, "Nanoparticle Assemblies and Superstructures", CRC, 2006

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Course Designer

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BoS Chairman

60 PNT 201	Advanced Characterisation Techniques

Category	L	T	P	Credit
PC	3	0	0	3

Objective

- To analysis the relative methods of various characterisation techniques.
- Acquire the basic knowledge about the different characterization techniques.
- Study the application of scanning probe microscopy.
- Acquire the knowledge of various nanoscale materials through characterization techniques.
- Understand the role of mechanical characterization for materials properties analysis.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Distinguish the various microscopy Techniques.	Remember
CO2	Enumerate the characterization parameters of Scanning Probe Microscopy.	Analyse
CO3	Examine the principles of different types of Spectroscopic techniques.	Analyse
CO4	Manipulate the nanomaterials in mechanical characterization.	Apply
CO5	Analyse the types of structural parameters in characterization techniques.	Analyse

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	2	2	1
CO2	2	3	2	3	3	2
CO3	3	2	2	3	2	3
CO4	2	2	3	2	3	2
CO5	3	3	2	3	3	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyze	10	10	30
Evaluate	10	10	10
Create	10	10	10

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BoS Chairman

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT 201 - Advanced Characterisation Techniques *								
Department of Nanoscience and Technology								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**C**	**E**	**Total**
II	3	0	0	45	3	40	60	100

MICROSCOPY Optical microscopy – Confocal microscopy - Electron Microscopy: Scanning electron microscopy – Transmission electron microscopy-High resolution Transmission Electron microcopy– Scanning tunneling electron microscopy – Image collection in electron microscopes – Environmental transmission electron microscopy – In-situ measurements.	[9]
SCANNING PROBE MICROSCOPY Scanning Probe microscopy – Atomic manipulations – Atomic force microscopy – Scanning probe lithography – Scanning near field optical microscopy – Secondary ion mass (SIMS) spectrometry-Scanning tunneling electron microscopy.	[9]
SPECTROSCOPY Optical absorption and emission spectroscopy – Basics - AAS – ICP OES – Infrared surface spectroscopy – Raman spectroscopy X-ray photoelectron spectroscopy – Brillouin spectroscopy – Dynamic Light Scattering (DLS) – NMR Spectroscopy – Thermo gravimetric Analysis (TGA) – Differential Scanning Calorimetry (DSC) – Thermo mechanical Analysis (TMA).	[9]
MECHANICAL CHARACTERISATION Modulus and load carrying capability of nano region/ compression - micro hardness – Fatigue – Abrasion and wear resistance – Super plasticity – Nano Indentation-Single point – Multipoint. – Nano tribology – Nano tribometre – Surface Force apparatus – Quartz crystal microbalance – Friction force microscope.	[9]
STRUCTURAL CHARACTERISATION X- ray diffraction – Scherer formula – Rietveld refinement using FullProf- texturing - Micro strain macromolecular crystallography using synchrotron radiation – electron and neutron diffraction – UV-PL-Photoluminescence - Thermo luminescence – X-ray absorption Fine Structure (XAFS) – Extended X- ray absorption fine structure (EXAFS) – Electron spectroscopy for chemical Analysis (ESCA).	[9]
Total Hours	**45**

Reference(s):

1	T.Pradeep, “Nano: The Essentials”, Tata McGraw Hill, New Delhi, 2007.
2	Charles P Poole Jr and Frank J Ownes, “Introduction to Nanotechnology”, John Wiley Sons, 2003.
3	Mick Wilson, KamaliKannangara, Geoff Smith, Michelle Simmons, BurkarRaguse, “Nanotechnology: Basic sciences and emerging technologies”, Overseas Press, 2005.
4	Willard, Merritt, Dean, Settle “Instrumental Methods of Analysis”, CBS PUBS & DISTS New Delhi 2007.

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Course Content and Lecture Schedule

S. No	Topic	No. of Hours
1	**MICROSCOPY**	
1.1	Optical microscopy	1
1.2	Confocal microscopy - Electron Microscopy	1
1.3	Scanning electron microscopy	1
1.4	Transmission electron microscopy	1
1.5	High resolution Transmission Electron microcopy	1
1.6	Scanning tunneling electron microscopy	1

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1.7	Image collection in electron microscopes	1
1.8	Environmental transmission electron microscopy	1
1.9	In-situ measurements	1
2	**SCANNING PROBE MICROSCOPY**	
2.1	Scanning Probe microscopy	1
2.2	Atomic manipulations	1
2.3	Atomic force microscopy	1
2.4	Scanning probe lithography	1
2.5	Scanning near field optical microscopy	1
2.6	Secondary ion mass (SIMS) spectrometry	1
2.7	Scanning tunneling electron microscopy	1
3	**SPECTROSCOPY**	
3.1	Optical absorption and emission spectroscopy	1
3.2	Basics - AAS – ICP OES	1
3.3	Infrared surface spectroscopy	1
3.4	Raman spectroscopy X-ray photoelectron spectroscopy	1
3.5	Brillouin spectroscopy	1
3.6	Dynamic Light Scattering (DLS)	1
3.7	NMR Spectroscopy	1
3.8	Thermo gravimetric Analysis (TGA)	1
3.9	Differential Scanning Calorimetry (DSC)	1
3.10	Thermo mechanical Analysis (TMA).	1
4	**MECHANICAL CHARACTERISATION**	
4.1	Modulus and load carrying capability of nano region/ compression	1
4.2	micro hardness	1
4.3	Fatigue	1
4.4	Abrasion and wear resistance	1
4.5	Super plasticity	1
4.6	Nano Indentation	1
4.7	Single point – Multipoint	1
4.8	Nano tribology.	1
4.9	Nano tribometre.	1
4.10	Surface Force apparatus	1
4.11	Quartz crystal microbalance	1
4.12	Friction force microscope	1
5	**STRUCTURAL CHARACTERISATION**	
5.1	X- ray diffraction	2
5.2	Scherer formula	1
5.3	Rietveld refinement using FullProftexturing	1
5.4	Micro strain macromolecular crystallography using synchrotron radiation	1
5.5	electron and neutron diffraction	1
5.6	UV-PL-Photoluminescence	1
5.7	Thermo luminescence	1
5.8	X-ray absorption Fine Structure (XAFS)	1
5.9	Extended X- ray absorption fine structure (EXAFS)	1
5.10	Electron spectroscopy for chemical Analysis (ESCA).	1
	Total Hours	45

Course Designer

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60 PNT 202	Nano Photonics and its Applications

Category	L	T	P	Credit
PC	3	0	0	3

Objective

- Impart the knowledge about the photon technology of nano structured materials.
- To understand the basic ideas about the photonics and microscopy treatment.
- To learn the next generation nanophotonic technologies.
- To analysis nanophotonic applications in biotechnology
- To Learn the various photonic applications of nanomaterials

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Recall basic ideas and fundamentals of nano photonics	Remember
CO2	Acquire the knowledge about Confinement of Photons and Electrons	Apply
CO3	Analyze the Photonic Crystals and Fibers the nanolithography techniques	Analyze
CO4	Apply photonic technique into biosensing.	Apply
CO5	Classify the applications of photonics in various filed.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyze	10	10	30
Evaluate	10	10	20
Create	10	10	0

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K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT 202– Nano Photonics and its Applications								
Department of Nanoscience and Technology								
Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
II	3	0	0	45	3	40	60	100

INTRODUCTION Introduction, Photonics, Nanophotonics, Frontierin Nanotechnology, Impact of Nanophotonics, Trends in Nanophotonics, Opportunities for Basic Research and Development of New Technologies, scope of nanophotonics, electron tunneling, photon tunneling.	[9]
NANOPHOTONICS FOUNDATION Photons and Electrons, Similarities and Differences - Free-Space Propagation - Confinement of Photons and Electrons. Nanoscale Optical Interactions - Axial Nanoscopic Localization - Lateral Nanoscopic Localization. Nanoscale Confinement of Electronic Interactions - Nanoscopic Interaction Dynamics, New Cooperative Transitions, Nanoscale Electronic Energy Transfer, Cooperative Emission.	[9]
Properties of nanophotonic materials: Photonic Crystals and Fibers-Plasmonics – MetamaterialsStructures in Nanocomposite - rare-earth-doped glasses - Nanostructured Multiphasic Compostites- photonic band gap materials-Organic materials.	[9]
NANOPHOTONICS in BIOTECHNOLOGY* Near-Field Bioimaging, Nanoparticles for Optical Diagnosticsand Targeted Therapy, Semiconductor Quantum Dots for Bioimaging, Biosensing - Photonic Crystal Biosensors, Optical Nanofiber Sensors. Nanoclinics for Optical Diagnostics and Targeted Therapy.	[9]
APPLICATIONS * Quantum-Confined Lasers, optical switching -Organic Light Emitting Diodes (OLEDs): small molecule (SMOLED) -polymeric (PLED) -display technology and lighting.chip-to-chip interconnects.	[9]
Total Hours	**45**

Text Book(s):

1.	Paras N. Prasad, “Nanophotonics”, John Wiley & Sons, Inc. 2004. ISBN:9780471649885.
2.	Sergey V. Gaponenko, Introduction to Nanophotonics”, Cambridge University Press, 2010.

Reference(s):

1.	F. Graham Smith, Terry A. King and Dan Wilkins, “Optics and Photonics: An Introduction”, second edition, John Willey Sons limited, 2007.
2.	Connelly, Michael J. “Semiconductor Optical Amplifiers” Springer 2002. ISBN: 978-0-306- 48156-7.
3.	Marc J. Madou Fundamentals of Microfabrication: The Science of Miniaturization, Second EditionCRC Press, 2005
4.	W .R. Fahrner “Nanotechnology and Nanoelectronics” Publisher: Neha Publishers & Distributors 2010

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Course Content and Lecture Schedule

S.No	Topic	No. of Hours
1	**INTRODUCTION**	
1.1	Scope and nature of Photonics	1
1.2	Nanophotonics	1
1.3	Frontierin Nanotechnology	1
1.4	Impact of Nanophotonics	1
1.5	Trends in Nanophotonics	1

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1.6	Opportunities for Basic Research and Development	1
1.7	scope of nanophotonics	1
1.8	Electron tunneling	1
1.9	Photon tunneling	1
2	**NANOPHOTONICS FOUNDATION**	
2.1	Photons and Electrons	1
2.2	Similarities and Differences, Free-Space Propagation	1
2.3	Confinement of Photons and Electrons	1
2.4	Nanoscale Optical Interactions	1
2.5	Axial Nanoscopic Localization - Lateral Nanoscopic Localization	1
2.6	Nanoscale Confinement of Electronic Interactions	1
2.7	Nanoscopic Interaction Dynamics	1
2.8	New Cooperative Transitions	1
2.9	Nanoscale Electronic Energy Transfer, Cooperative Emission	1
3	**PROPERTIES OF NANOPHOTONIC MATERIALS**	
3.1	Photonic Crystals	1
3.2	Fibers-Plasmonics	1
3.3	Nanocomposite	1
3.4	Metamaterials Structures - Nanocomposite	1
3.5	Rare-earth-doped glasses	1
3.6	Nanostructured Multiphasic Compostites	1
3.7	Nanostructured Multiphasic Compostites properties	1
3.8	Photonic band gap materials	1
3.9	Organic materials	1
4	**NANO STRUCTURE DEVICES**	
4.1	Near-Field Bioimaging	1
4.2	Nanoparticles for Optical Diagnostics	1
4.3	Nanoparticles for Targeted Therapy	1
4.4	Bio imaging	1
4.5	Semiconductor Quantum Dots for Bio imaging	1
4.6	Biosensing - Photonic Crystal Biosensors	1
4.7	Optical Nanofiber Sensors	1
4.8	Nanoclinics for Optical Diagnostics	1
4.9	Targeted Therapy	1
5	**APPLICATION**	
5.1	Quantum-Confined Lasers	2
5.2	Optical switching	1
5.3	Organic Light Emitting Diodes (OLEDs)	1
5.4	Small molecule (SMOLED)	1
5.5	Polymeric (PLED)	1
5.6	Display technology	2
5.7	Lightingand chip-to-chip interconnects	2
	Total	45

Course Designer

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BoS Chairman

60 PNT 203	Nanolithography and Nanofabrication

Category	L	T	P	Credit
PC	3	0	0	3

Objective

- To knowledge about lithography
- To know about etching method
- To analyze the process of lithography technique
- To discuss the printing and soft stamping
- To apply the lithography in nanoscale

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understand the emerging ideas of lithography	Remember
CO2	To classify the lithography types	Apply
CO3	Describe the nanolithography techniques	Analyze
CO4	To analyze process of lithography technique	Apply
CO5	Identify the advantage of lithography application	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyze	10	10	30
Evaluate	10	10	10
Create	10	10	10

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BoS Chairman

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT 203 - Nanolithography and Nanofabrication								
Department of Nanoscience and Technology								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**C**	**E**	**Total**
II	3	0	0	45	3	40	60	100

Basics in lithography Principle of Lithographic Process-Mask for Lithography –Preparation-Photoresist - Positive and negative photo resistsExposure and Developing - Etching-Photoresist Removal- Printing - Chemical process - Refinements - The modern process– Lithography in artistic medium – Nanometer design for electronic circuits.	[9]
Optical lithography * Optical lithography – Light sources – Photo mask and alignment - Resolution in projection systems - Ultraviolet lithography -Mask less Optical Projection Lithography -Extreme Ultraviolet Lithography-Optical Interferometric Lithography- X ray Lithography - Proximity printing -X ray masks – X ray sources –holographic lithography.	[9]
Ion and electronbeam lithography * Ion beam lithography - Focused ion beam – Point sources of ion – Ion column – Beam writing – Masked ion beam lithography – Ion projection lithography - Electron lithography – Electron optics – Raster scan and vector scan – Electron proximity / Projection printing - Electron resists – Photon based Nanolithography-Electron beam applications.	[9]
Nanoimprint and Soft lithography * Nanoimprint Lithography - Hot Embossing - Process - Types - Benefits-Applications -Future of Nanoimprint-UV-Soft Lithography - Advantages - Molding-Printing with Soft Stamps – Edge Lithography-Stereo -lithography - Nanoscale 3D shapes – NEMS design -Dip-Pen Lithography - Principle - Materials - Applications.	[9]
Nanolithography tools * Tools for nanolithography - Molecular manipulation by STM and AFM – Nano pattern synthesis – Nano scratching – Resist and imaging layers.	[9]
Total Hours	**45**

Reference(s):

1	W.R.Fahrner, “Nanotechnology and Nanoelectronics – Materials, Devices, Measurement Techniques”, Springer, 2006.
2	David G.Bucknall,”Nanolithography and Patterning techniques in microelectronics”, CRC Press, 2005.
3	James R. Sheats, Bruce W. Smith, “Microlithography: Sciences and Technology”, CRC Press, 1998.
4	M.Gentili, Carlo Giovannella, Stefano Selci, “Nanolithography: A Borderland between STM, EB, IB, and X-Ray Lithographies”, 1stedition, Springer, 1994.

***SDG:8- productive employment and decent work for all**

Course Content and Lecture Schedule

S. No	Topic	No. of Hours
1	**BASICS IN LITHOGRAPHY**	
1.1	Principle of Lithographic Process	1
1.2	Mask for Lithography	1
1.3	Preparation - Photoresist - Positive and negative photo resists	1
1.4	Exposure and Developing	1

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1.5	Etching - Photoresist Removal	1
1.6	Printing - Chemical process	1
1.7	Refinements - The modern process	1
1.8	Lithography in artistic medium	1
1.9	Nanometer design for electronic circuits.	1
2	**OPTICAL LITHOGRAPHY**	
2.1	Optical lithography	1
2.2	Light sources	1
2.3	Photo mask and alignment	1
2.4	Resolution in projection systems	1
2.5	Ultraviolet lithography	1
2.6	Mask less Optical Projection Lithography - Extreme Ultraviolet Lithography	1
2.7	Optical Interferometric Lithography - X ray Lithography	1
2.8	Proximity printing - X ray masks – X ray sources	1
2.9	Holographic lithography	1
3	**ION AND ELECTRONBEAM LITHOGRAPHY**	
3.1	Ion beam lithography - Focused ion beam	1
3.2	Point sources of ion – Ion column	1
3.3	Beam writing – Masked ion beam lithography	1
3.4	Ion projection lithography - Electron lithography	1
3.5	Electron optics – Raster scan and vector scan	1
3.6	Electron proximity / Projection printing	1
3.7	Electron resists	1
3.8	Photon based Nanolithography	1
3.9	Electron beam applications	1
4	**NANOIMPRINT AND SOFT LITHOGRAPHY**	
4.1	Nanoimprint Lithography	1
4.2	Hot Embossing - Process - Types	1
4.3	Benefits-Applications - Future of Nanoimprint	1
4.4	UV-Soft Lithography – Advantages	1
4.5	Molding-Printing with Soft Stamps	1
4.6	Edge Lithography - Stereo - lithography	1
4.7	Nanoscale 3D shapes	1
4.8	NEMS design	1
4.9	Dip-Pen Lithography - Principle - Materials - Applications.	1
5	**NANOLITHOGRAPHY TOOLS**	
5.1	Tools for nanolithography	1
5.2	Molecular manipulation by STM	1
5.3	Molecular manipulation by AFM	1
5.4	Nano pattern synthesis	2
5.5	Nano scratching	2
5.6	Resist and imaging layers.	2
	Total	45

Course Designer

Dr. S.Satheeskumar (satheeskumars@ksrct.ac.in)

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60 PNT 204	Advanced Carbon Nanotubes and Applications

Category	L	T	P	Credit
PC	3	0	0	3

Objective

- To understand the different formation of CNT.
- To learn the various synthesis methods and fabrication technology
- To study the structural and electronic characteristics of CNT
- To acquire knowledge of CNT functionalization mechanism.
- To gain the knowledge of CNT through spectroscopy characterize tools and its applications

Prerequisite

Basics of Carbon Nanotubes

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Describe Nano diamond particles and diamond like carbon films	Remember
CO2	Analyze the properties of carbon nanotubes	Analyze
CO3	Illustrate the synthesis of carbon nanotubes	Analyze
CO4	Explain the applications of carbon Nanotubes	Apply
CO5	Demonstrate the various applications of Carbon Nanotubes	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	20
Analyze	10	10	30
Evaluate	10	10	20
Create	10	10	10

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K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT 204 – Advanced Carbon Nanotubes and Applications								
Department of Nanoscience and Technology								
Semester	Hours/Week			Total hrs	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
II	3	0	0	45	3	40	60	100

CARBON NANOTUBES PROPERTIES Carbon nanotube (CNT), structure of CNT, synthesis of CNT, electronic, vibrational, mechanical and optical properties of CNT; applications of CNT. fabrication of Fullerene (C60).	[9]
CARBON NANOFILMS Diamond-like Carbon films (DLC), classification of DLC, properties and applications of DLCs: internal stress and adhesion, coating morphology, porosity and diffusional property, DLC/graphite transformation, Optical properties, electrical properties, mechanical properties, chemical resistance, tribological properties; deposition techniques of DLC films.	[9]
CNT FUNCTIONALIZATION Functionalization of Carbon Nanotubes: covalent functionalization of CNTs, non covalent functionalization of CNTs, modification of CNTs via mechnochemical reactions, electrochemical deposition, electroless deposition; plasma activation of CNTs.	[9]
SPECTORSCOPIC PROPERTIES OF CNT Spectroscopic Properties of Carbon Nanotubes-Raman and Infrared Spectroscopyof CarbonNanotubes, Absorption and Emission Spectroscopy of Carbon Nanotubes, ESR-Spectroscopic Properties of Carbon Nanotubes.	[9]
CNT APPLICATIONS * Lithium & Hydrogen adsorption & storages, Fuel cell applications and energy storage, Chemical Sensors applications of CNTs. Computer applications (Nano chip), optical and telecommunication applications. Nano composites, silicon Nanowires	[9]
Total Hours	**45**

Text Book(s)	
1	Carbon Nanotubes: Properties and Applications-Michael J. O'Connell Artech House Press,2012.
2	Nanotubes and Nanowires-CNR Rao and A Govindaraj RCS Publishing, 2013.
3	Dar Djlah- Amman-Jordan, “Book-Carbon Nanotubes Synthesis and Applications, ISBN: ISBN:9957-71-307-2. 2021.
Reference(s)	
1	Michael J. O'Connell, “Carbon Nanotubes: Properties and Applications,” CRC Press., 2010.
2	Jiji Abraham, Sabu Thomas, Nandakumar Kalarikkal, “Handbook of Carbon Nanotubes” Springer Cham, 2022.

***SDG:8- productive employment**

Course Contents and Lecture Schedule

S.No	Topic	No. of Hours
1	**CARBON NANOTUBES PROPERTIES**	
1.1	Carbon nanotube (CNT)	1
1.2	Structure of CNT	1
1.3	Synthesis of CNT	1
1.4	Electronic properties	1
1.5	Vibrational properties	1
1.6	Mechanical properties of CNT	1
1.7	Optical properties of CNT	1
1.8	Applications of CNT	1

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1.9	Fabrication of Fullerene (C60).	1
2	**CARBON NANOFILMS**	
2.1	Diamond-like Carbon films (DLC)	1
2.2	Classification of DLC	1
2.3	Properties of DLCs	1
2.4	Applications of DLCs	1
2.5	Internal stress and adhesion, coating morphology, porosity and diffusional property	1
2.6	DLC/graphite transformation	1
2.7	Optical properties, electrical properties, mechanical properties, chemical resistance	1
2.8	Tribological properties; deposition techniques of DLC films.	1
2.9	Deposition techniques of DLC films.	1
3	**CNT FUNCTIONALIZATION**	
3.1	Functionalization of Carbon Nanotubes	1
3.2	Covalent functionalization of CNTs	2
3.3	Non covalent functionalization of CNTs	2
3.4	modification of CNTs via mechnochemical reactions	1
3.5	Electrochemical deposition	1
3.6	Electroless deposition	1
3.7	Plasma activation of CNTs	1
4	**SPECTORSCOPIC PROPERTIES OF CNT**	
4.1	Spectroscopic Properties of Carbon Nanotubes	1
4.2	Raman Spectroscopy of Carbon Nanotubes	2
4.3	Infrared Spectroscopy of Carbon Nanotubes	1
4.4	Absorption Spectroscopy of Carbon Nanotubes	1
4.5	Emission Spectroscopy of Carbon Nanotubes	2
4.6	ESR-Spectroscopic Properties of Carbon Nanotubes	2
5	**CNT APPLICATIONS**	
5.1	Lithium & Hydrogen Battery	1
5.2	Lithium & Hydrogen adsorption & storages	1
5.3	Fuel cell applications	1
5.4	Energy storage	1
5.5	Chemical Sensors applications of CNTs	1
5.6	Computer applications (Nano chip)	1
5.7	Optical and telecommunication applications	1
5.8	Nano composites	1
5.9	Silicon Nanowires	1
	Total	45

Course Designer

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60 PED 001 / 60 PDB E26	**Research Methodology and IPR**	**Category**	**L**	**T**	**P**	**Credit**
		PC	**3**	**0**	**0**	**3**

Objective(s)

- To understand the principles of research process.
- To develop knowledge in analytical skills for collection of research data.
- To understand the procedure in the preparation of reports.
- To accomplish basic idea about the process involved in intellectual property rights.
- To enlighten the process of patent filing.

Pre-requisite

Nil

Course Outcomes

On the successful completion of the course, students will be able

CO1	To understand the research process and design.	Remember, Understand, Apply
CO2	To gain the knowledge about sources and collection of research data	Remember, Understand, Aanalyze
CO3	To understand the procedure of data analysis, preparation of reports and checking plagiarism	Remember, Understand, Analyze
CO4	To gain the knowledge on Trade mark and functions of UNESCO in IPR	Remember, Understand, Apply
CO5	To enlighten the benefits, E-filing and Examinations related to patents	Remember, Understand, Apply

Mapping with Programme Outcomes

COURSE NAME	**CO**	**PO**						**PSO**		
		1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**
Research Methodology and IPR	CO1	3	3	2	2	2	2	3	1	3
	CO2	3	3	2	2	2	2	3	1	3
	CO3	3	3	2	2	2	2	3	1	3
	CO4	3	3	2	2	2	2	3	1	3
	CO5	3	3	2	2	2	2	3	1	3

Note: 3 – Strong Contribution; 2 – Average Contribution; 1 – Some Contribution

AssessmentPattern

Bloom'sCategory	**Continuous Assessment Tests (Marks)**		**Model Exam (Marks)**	**End Semester Examination (Marks)**
	1	**2**		
Remember	10	10	20	30
Understand	20	20	40	30
Apply	30	30	40	30
Analyse	0	0	0	10
Evaluate	0	0	0	0
Create	0	0	0	0

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Syllabus

K.S.Rangasamy College of Technology – Autonomous R2022								
60 PED 001 / 60 PDB E26 **- Research Methodology and IPR**								
Common to all Branches								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**CA**	**ES**	**Total**
II	3	0	0	45	3	40	60	100

Research Design Overview of research process and design- Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys, Selection of the Right Medium and Journal for publication, Translation of Research	[9]
Data Collection and Sources Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.	[9]
Data Analysis and Reporting Overview of Multivariate Analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation. Checks for Plagiarism, Falsification, Fabrication, and Misrepresentation	[9]
Intellectual Property Rights Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.	[9]
Patents Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.	[9]
Total Hours	**45**

Text Book(s):	
1.	David I. Bainbridge, “Intellectual Property”, Longman, 9th Edition, 2012.
2	Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
Reference(s):	
1.	Chawla H S., “Introduction to Intellectual Property Rights”, CBS PUB & DIST PVT Limited, INDIA, 2019.
2.	Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007
3.	David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007
4.	Arun K. Narasani, Kankanala K.C., Radhakrishnan V., “Indian Patent Law and Practice”, Oxford University Press, 2010.
5.	Richard Stim, “Patent, Copyright & Trademark - An Intellectual Property Desk Reference”, NOLO Publishers, 2020.
6.	The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

***SDG:4- Quality Education and opportunities for all**

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Course Content and Lecture Schedule

S. No.	Topics	No. of hours
1.0	**Research Design**	
1.1	Overview of research process and design	1
1.2	Use of Secondary and exploratory data to answer the research question	2
1.3	Qualitative research	1
1.4	Observation studies	1
1.5	Experiments and Surveys	1
1.6	Selection of the Right Medium and Journal for publication	2
1.7	Translation of Research	1
2.0	**Data Collection and Sources**	
2.1	Measurements, Measurement Scales	2
2.2	Questionnaires and Instruments	2
2.3	Sampling and methods	2
2.4	Data - Preparing, Exploring, examining and displaying	3
3.0	**Data Analysis and Reporting**	
3.1	Overview of Multivariate analysis	1
3.2	Hypotheses testing and Measures of Association	2
3.3	Presenting Insights	1
3.4	Findings using written reports and oral presentation	2
3.5	Checks for Plagiarism	1
3.6	Falsification	1
3.7	Fabrication, and Misrepresentation	1
4.0	**Intellectual Property Rights**	
4.1	Intellectual Property – The concept of IPR	1
4.2	Evolution and development of concept of IPR, IPR development process	2
4.3	Trade secrets, utility Models, IPR & Bio diversity	2
4.4	Role of WIPO and WTO in IPR establishments	1
4.5	Right of Property, Common rules of IPR practices	1
4.6	Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance	2
5.0	**Patents**	
5.1	Patents – objectives and benefits of patent, Concept, features of patent	2
5.2	Inventive step, Specification, Types of patent application	2
5.3	Process E-filling, Examination of patent	1
5.4	Grant of patent, Revocation	1
5.5	Equitable Assignments, Licences, Licensing of related patents	2
5.6	Patent agents, Registration of patent agents	1

CourseDesigner

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BoS Chairman

60 PAC 002	Disaster Management	Category	L	T	P	Credit
		AC	2	0	0	0

Objective

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches Teach how to improve writing skills and level of readability

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Ability to summarize basics of disaster
CO2	Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3	Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4	Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5	Ability to develop the strengths and weaknesses of disaster management approaches

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	1
CO2	1	1	1	1	1	1
CO3	1	1	1	1	1	1
CO4	1	1	1	1	1	1
CO5	1	1	1	1	1	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests(Marks)	
	1	2
Remember	20	20
Understand	20	20
Apply	30	30
Analyse	30	30
Evaluate	0	0
Create	0	0

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K.S.Rangasamy College of Technology–AutonomousR2022								
60 PAC 002 – Disaster Management *								
Common to all Branches								
Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	CA	E	Total
II	2	0	0	3	0	100	-	100

Introduction Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.	[6]
Repercussions of Disasters and Hazards Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	[6]
Disaster Prone Areas In India Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics	[6]
Disaster Preparedness and Management Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and other Agencies, Media Reports: Governmental and Community Preparedness.	[6]
Risk Assessment Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.	[6]
Total Hours	**30**

Text Book(s):

1. Goel S. L., Disaster Administration and Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. Nishitha Rai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company,2007.

Reference(s):

1. Sahni, Pardeep et.al.," Disaster Mitigation Experiences and Reflections", Prentice Hall of India, 2001.
2. Subramanian R,"Disaster Management", Vikas publishing Housing Pvt. Ltd., 2018.
3. Chu-huaKuei, Christian N Madu, Handbook of Disaster Management Risk Reduction & Management: Climate change and Natural Disaster, world scientific, 2017.
4. JankiAndharia, Disaster studies: Exploring Intersectional ties in Disaster Discourse, Springer, 2020.

***SDG:6- Sustainable management**

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60 PNT 2P1	Advanced Characterisation Laboratory

Category	L	T	P	Credit
PC	0	0	4	2

Objective

- To practice characterization tools and nanomaterials.
- To gain knowledge of working mechanism of instruments
- To learn data interpretation knowledge acquired from Instruments
- To facilitate the hands training experience
- To understand the chemical, physical behavior of Macro to nanoscale materials through comprehensive tools

Prerequisite

Nil.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Recognize requirement of various characterization tools and nanomaterials.	Remember
CO2	Practice the structural characterization of nanomaterials.	Analyse
CO3	Evaluate the band-gap energy of semiconductor nanoparticles.	Apply
CO4	Analysis the dielectric and electro-chemical properties of nanomaterials	Apply
CO5	Demonstrate various application of nanomaterials by exploring materials properties	Analyse

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	2	2	3
CO2	2	3	2	2	3	2
CO3	2	1	2	3	2	1
CO4	3	2	1	2	2	3
CO5	2	2	1	3	2	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	0	0	0
Understand	0	0	10
Apply	20	20	30
Analyze	20	20	30
Evaluate	10	10	20
Create	10	10	20

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K.S.Rangasamy College of Technology - Autonomous R 2022								
60 PNT 2P1 - Advanced Characterisation Laboratory								
Department of Nanoscience and Technology								
Semester	**Hours / Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	T	P		C	CA	ES	Total
II	0	0	4	60	2	60	40	100

1. Determination of functional and molecular structure of nanomaterial using Fourier transform infrared (FTIR)spectroscopy*****
2. Elemental analysis of nanocomposite using X-ray fluorescence (XRF)spectroscopy*****
3. Determination of surface topography and roughness by atomic force microscopy (AFM)*****
4. Structural characterization of nanomaterials using X-ray diffraction (XRD)analysis*****
5. Characterization of nano metal oxide using photoluminescence (PL)spectroscopy*****
6. Determination of band-gap energy using UV-Vis (UV)spectroscopy*****
7. Electrical characterization of nanomaterials using four-probe technique
8. Characterization of nanomaterials by electrochemical Impedance spectroscopy (EIS)*****
9. Particle size determination using dynamic light scattering (DLS)measurements*****
10. Determination of specific surface area using nitrogen physisorption measurements*****
11. Determine the wettability of polymeric materials through contact angle measurements*****
12. Hands on training for data analysis using Origin software

Lab Manual :

1	"Materials Characterisation Laboratory - II Manual", Department of NST, KSRCT 2022.

Reference(s) :

1	Richard Brundle.C, Charles A. Evans and Jr. Shaun Wilson., "Encyclopedia of Materials Characterization", Butterworth-Heinemann Publishers, 1992.
2	James B. Condon., "Surface Area and Porosity Determinations by Physisorption-Measurements and Theory", Elsevier, 2006.
3	Augus I Kirkland, and John L Hutchison., "Nanocharacterisation", The Royal Society of Chemistry, 2007.

***SDG:9- Build resilient infrastructure**

Course Designer

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60 PNT 2P2	Nanomaterials Device Fabrication and Analysis Laboratory

Category	L	T	P	Credit
PC	**0**	0	4	2

Objective

- To understand the basics of nanoscale coating on various metallic specimen.
- To acquire knowledge about thin film instruments hands on training.
- To analyze and result interpretation of various nanoscale materials and devices.
- To learn device fabrication and construction assembling process.
- To estimate various properties of nanoscale materials for energy harvesting and anticorrosion applications.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Benefit out the hands-on training experience in thin film technology.	Remember
CO2	Establish large scale engineering on nanoscale coating.	Analyse
CO3	Characteristize the materials scaling up properties through different instruments	Apply
CO4	Estimate corrosion resistance of organic/inorganic coatings.	Apply
CO5	Learn and fabricate small scale devices	Analyse

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	2	1	2
CO2	2	2	1	2	2	1
CO3	3	2	1	2	2	3
CO4	2	1	2	2	3	2
CO5	2	3	2	1	2	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	0	0	0
Understand	0	0	10
Apply	10	20	30
Analyze	20	20	30
Evaluate	20	10	20
Create	10	10	20

Passed in BoS Meeting held on 22/11/2023
Approved in Academic Council Meeting held on 23/12/2023

BoS Chairman

K. S. Rangasamy College of Technology - Autonomous R2022								
60 PNT 2P2 - Nanomaterials Device Fabrication and Analysis Laboratory								
Department of Nanoscience and Technology								
Semester	**Hours / Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**CA**	**ES**	Total
II	0	0	4	60	2	60	40	100

1. Design the nano structured coating (ZnO) on glass specimen using spin coating
2. Develop the metallic electrode layer over the glass substrate through sputtering Process.
3. Establish the large-scale anticorrosion coating (Al_2O_3-ZrO_2) on metallic specimen by hot-air spray pyrolysis.
4. Validate the mechanical properties of thin film deposition using Vickers's hardness.
5. Test the linear conductivity of metal oxides semiconductor using Keithley source meter.
6. Fabricate ZnO/PVDF thin film on glass substrate for oxygen gas sensing properties.
7. Design the thin film coated photoconductive/voltaic cell and test and tests the photocurrent using I-V tester.
8. Construct the triboelectric energy harvester and fabricate via contact separation mode*****
9. Fabricate and interface the self-powering piezo electric nano generator. *****
10. Evaluate $I_{(corrosion)}$ and $E_{(corrosion)}$ of graphene/polymer in presence of acid medium through electrochemical workstation.
11. Study the conductivity of the electrode materials/polymer using FRA Impedance spectroscopy.
12. Estimate the corrosion of properties of Al_2O_3-ZrO_2 composites coating through curve fitting method using FRA Impedance spectroscopy.
13. Fabricate sensor set up for detection of biological elements. ******
14. Develop photovoltaic cells to determine photocatalytic efficacy

Reference(s):

1	A. Karthik et al, Production of Al_2O_3-Stabilized Tetragonal ZrO_2 Nanoparticles for Thermal Barrier Coating. International Journal of Applied Ceramic Technology. 10, 887-899.
2	L. Arunraja et al, (2016) EDTA Decorated Nanostructured ZnO/CdS Thin Films for Oxygen Gas Sensing Applications, Journal of Electronic Materials, 45, 8, pp 4100–4107.
3	O.K. Simya et al, Dye-sensitized solar cells based on visible-light-active TiO_2 heterojunction nanoparticles. Synthetic metals. 188, 124–129
4	Zhong Lin Wang*, Guang Zhu, Ya Yang, Sihong Wang, and Caofeng Pan, Progress in nanogenerators for portable electronics, Materilas Today,2012, Vol.15(12)

Lab Manual

1. "**Device Fabrication and Testing Laboratory**, Department of Nano Science and Technology, KSRCT

***SDG:7- Modern energy for all**
****SDG:9 Build resilient infrastructure**

Course Designer

Dr. A. Karthik (karthik@ksrct.ac.in)

Passed in BoS Meeting held on 22/11/2023
Approved in Academic Council Meeting held on 23/12/2023

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Department of NST
K.S.Rangasamy College of Technology

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60 PNT 301	Applications of Nanocomposites

Category	L	T	P	Credit
PC	3	0	0	3

Objective

- To perceive the science and technology behind the nanocomposites.
- Acquire the knowledge on nanocomposite properties, features and processing of various nanocomposites.
- Impart knowledge on various testing methods, applications and recycling.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Acquire functional characteristic reinforced nanocomposite materials	
CO2	Apply the processing methodology for preparation of nanocomopsites.	
CO3	Demonstrate the basic properties organic-Inorganic materials.	
CO4	Learn the various testing methodology for nanomaterilas	
CO5	Use the nano materials as recycling for various industrial applications	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	2	1	2
CO2	2	3	2	1	2	3
CO3	3	2	2	1	2	2
CO4	2	2	2	3	2	3
CO5	2	3	3	2	2	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	20
Apply	10	10	30
Analyze	10	10	20
Evaluate	10	10	10
Create	10	10	10

Passed in BoS Meeting held on 22/11/2023
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Chairman Board of Studies
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K.S.Rangasamy College of Technology

BoS Chairman

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT 301 – Applications of Nanocomposites *								
Department of Nanoscience and Technology								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**C**	**E**	**Total**
III	3	0	0	45	3	40	60	100

Over view of nanocomposites Significance of composites, functions of matrix and reinforcement in composites, Classification of composites – particle reinforced – fibre reinforced – structural composite, Polymer, metal and ceramic matrix composites. Applications in automobiles –machine tools – aerospace and sports equipment.	[9]
PROCESSING OF NANOCOMPOSITES Viscosity - Types of flow – Non-Newtonian Flow – Low-viscosity processing - Solvent processing – Particle behavior – Insitu polymerization – Post – Forming-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.	[9]
PROPERTIES OF NANOCOMPOSITES Physics of modulus – Continuum measurements – Yield – Fracture – Rubbery elasticity and visco elasticity –Surface mechanical properties –Diffusion and permeability – Features of nanocomposite – basics of polymer nanocomposites–Nano reinforcements –Matrix materials–Hazards of particles.	[9]
TESTING AND VALIDATION Characterization – Experiment design – Sample preparation – Imaging –Structural characterization – Scales innanocomposites–Texture–Electromagneticenergy–Visualization–Physicochemicalanalysis–Characterization of physical properties –Identification – Mechanical – Surface mechanical – Exposure – Barrier properties –Recipes and standards.	[9]
APPLICATIONS AND RECYCLING OF NANOCOMPOSITES Nanocomposites–Optical, Structural Applications– nanoparticulate Systems With Organic Matrices–Applications–Biodegradable Protein–Ceramics–Food Preservatives – Dental Materials – Automatic Components – Corrosion Protection-Properties And Property Changes Over Virgin Material – Contaminants – Role of Contaminants In Property Change. Future Regulatory Issues on Polymer Nanocomposite Based On solid waste management.	[9]
Total Hours	**45**

Text Books	
1.	Applications of Nanocomposites, 1st Edition, Edited By Ahalapitiya Jayatissa, Published by CRC Press, Copyright 2022, , November 24, 2022
2.	Nanocomposites: Fundamentals, Technology and Applications Hardcover – Import, by Emmanuel Craig (Editor), Publisher -Larsen and Keller Education, 2017
Reference(s):	
1.	ThomasE. Twardowski, Introduction to Nanocomposite Material Properties,Processing,Characterization,DesTechPublications,April 2007
2.	Klaus Friedrich, Stoyko Fakivov, Zhony Shang, Polymer Composites from Nano–to Macro–scale,Springer,USA,2005
3.	RaySmith ,Biodegradable polymers for IndustrialApplications,CRCPress,2005
4.	Manas Chandarand Salil K.Roy,Plasticstechnologyhandbook,CRCPress,2006

***SDG:4 quality education and opportunities for all**

Course Content and Lecture Schedule

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S.No	Topic	No. of Hours
1	**INTRODUCTION**	
1.1	Significance of composites	**1**
1.2	Functions of matrix and reinforcement in composites,.	**1**
1.3	Classification of composites	**1**
1.4	Particle reinforced – fibre reinforced	**1**
1.5	Structural composite and Polymer	**1**
1.6	Metal and ceramic matrix composites.	**1**
1.7	Applications in automobiles	**1**
1.8	Machine tools and aerospace	**1**
1.9	sports equipments	**1**
2	**PROCESSINGOFNANOCOMPOSITES**	
2.1	Viscosity - Types of flow	**1**
2.2	Non-Newtonian Flow – Low-viscosity processing -	**1**
2.3	Solvent processing – Particle behavior –.	**1**
2.4	Insitu polymerization – Post – Forming-Melt, high-shear and direct processing	**1**
2.5	Melting and softening-	**1**
2.6	Melt processes with small shears or Low-	**1**
2.7	shear rates flow	**1**
2.8	Melt processes with large deformations or high-shear rates	**1**
2.9	Thermo-kineticprocesses	**1**
3	**PROPERTIESOFNANOCOMPOSITES**	
3.1	Physics of modulus	**1**
3.2	Continuum measurements	**1**
3.3	Yield – Fracture	**1**
3.4	Rubbery elasticity and visco elasticity	**1**
3.5	Surface mechanical properties	**1**
3.6	Diffusion and permeability	**1**
3.7	Features of nanocomposite	**1**
3.8	basics of polymer nano composites	**1**
3.9	Nano reinforcements –Matrix materials–Hazards ofparticles	**1**
4	**TESTINGANDVALIDATION**	
4.1	Characterization - Experiment design	**1**
4.2	Sample preparation – Imaging	**1**
4.3	Structural characterization	**1**
4.4	Scales innanocomposites–Texture	**1**
4.5	Electromagneticenergy–Visualization–Physicochemicalanalysis	**1**
4.6	Characterization of physical properties	**1**
4.7	Identification – Mechanical – Surface mechanical	**1**
4.8	Exposure – Barrierproperties	**1**
4.9	Recipes and standards	**1**
5	**APPLICATIONSANDRECYCLINGOFNANOCOMPOSITES**	
5.1	Nanocomposites–Optical, Structural Applications	**1**
5.2	Nanoparticulate Systems With Organic Matrices Applications	**1**
5.3	Biodegradable Protein–Ceramics–Food Preservatives	**1**
5.4	Dental Materials – Automatic Components	**1**
5.5	CorrosionProtection-PropertiesAndPropertyChangesOverVirginMaterial	**1**
5.6	Contaminants	**1**
5.7	Role of Contaminants In Property Change	**1**
5.8	Future Regulatory Issues on Polymer Nanocomposite Based On solid waster management.	**1**

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5.9	Future Regulatory Issues on Polymer Nanocomposite Based On solid waste management.	**1**
	Total	45

Course Designer

Dr. S. Satheeskumar (satheeskumars@ksrct.ac.in)

60 PNT 302	**Nanotechnology in Energy Storage Devices**

Category	**L**	**T**	**P**	**Credit**
PC	3	0	0	3

Objective

- To study the basic knowledge of Nanomaterials in Energy storage, Fundamentals, Rechargeable Batteries, Super capacitors, Fuel Cells and Advanced Batteries for Electric Vehicles and Emerging application.
- To Explore the application of Nanomaterials in Energy Storage and
- Acquire the knowledge about cell reaction, cell components and characteristics etc.,

Prerequisite

Basics of electronics

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understand the basic principles and concepts of energy storage	Remember
CO2	Acquire knowledge on Nanomaterials in energy storage devices	Remember
CO3	Know the basic concepts related to primary batteries	Apply
CO4	Understand the types and importance of primary batteries	Analyze
CO5	Know the basic concepts related to rechargeable batteries	Apply

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	3	2	2	1
CO2	2	3	3	3	2	2
CO3	3	2	3	2	2	1
CO4	3	3	3	3	2	3
CO5	3	2	3	2	2	2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests (Marks)**		**End Sem Examination (Marks)**
	1	**2**	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30

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Analyse	10	10	30
Evaluate	10	10	20
Create	10	10	0

K.S.Rangasamy College of Technology - Autonomous Regulation

60 PNT 302 - Nanotechnology in Energy Storage Devices

Department of Nanoscience and Technology

Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
III	3	0	0	45	3	40	60	100

Over view of energy storage devices* 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. Solar energy conversion: Photovoltaic- Photoelectrochemical- Photothermal and Thermoelectric systems.	[9]
Primary Batteries* Introduction – Classification - Cell components - Performance characteristics of primary batteries Zinc/carbon batteries - lithium primary batteries - Solid electrolyte batteries – Cell reactions – Cell Construction- Performance characteristics - Nanomaterials in Specialized Primary Batteries - Peace makers and Torpedo Batteries.	[9]
Rechargeable Batteries* Introduction - Classification - Characteristics Lead- acid batteries –VRLA - Ni-MH - Lithium-Ion batteries - Cell reactions - Cell Components - Bulk and Nanomaterials in Cell Construction - Performance characteristics - Recent advancement in Nano - electrode materials.	[9]
Solar Energy system* Solar cells - types of solar cells - semiconducting material- Solar cell properties and design- p-n junction photodiodes- depletion region- electron and holes transports - charge carrier generation - I-V characteristics - output power -Single junction and triple-junction solar panels - metal-semiconductor hetero junctions.	[9]
Fuel Cells and Super capacitors ** Types - PEMFC - SOFC - Fuel cells- characteristics and Operation of the fuel cell- Mechanism for H_2 evaluation and challenging of H_2 Fuel Storge - Innovative designs for low wattage fuel cells - Applicable fuel cell technologies - Advantages of Nanomaterials in Fuel Cells. Super capacitors - -Construction - Nanomaterials electrode design - Performance characteristics- application - Advantage of Nanomaterials in Super capacitors.	[9]
Total Hours	**45**

Text Books

1.	Nanomaterials for Electrochemical Energy Storage Devices, 1st Edition, Poulomi Roy, Suneel Kumar Srivastava, Scrivener Publishing LLC, 2019.
2.	Nanostructured Materials for Electrochemical Energy Production and Storage, Edson Roberto Leite, Springer New York, NY,2010.

Reference(s):

1.	Thomas Reddy, “Linden’s Handbook of Batteries”, McGraw Hill Professional, USA, 2010.
2.	Ronald M. Dell David A. J. Rand, “Understanding Batteries”, RSC, UK, 2001.
3.	Conway, B. E., “Electrochemical Super capacitors”, Springer , UK , 2015
4.	Huggins, Robert A., “Energy Storage - Fundamentals, Materials and Applications” Springer, UK, 2014
5.	Lefrou C., Fabry P., Poignet J.-C.., “Electrochemistry” Springer, UK, 2014

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****SDG:7 Reliable, sustainable and modern energy for all**

Course Content and Lecture Schedule

S.No	Topic	No. of Hours
1	**INTRODUCTION**	
1.1	Nanotechnology for sustainable energy	1
1.2	Energy conversion process	1
1.3	Indirect and direct energy conversion	1
1.4	Materials for light emitting diode	1
1.5	Batteries and advanced turbines	1
1.6	Catalytic reactors	1
1.7	Capacitors and fuel cells	1
1.8	Solar energy conversion	1
1.9	Photovoltaic systems	1
2	**PRIMARY BATTERIES**	
2.1	Introduction to primary batteries	1
2.2	Classification of primary batteries	1
2.3	Performance characteristics of primary batteries	1
2.4	Zinc/carbon batteries characteristics	1
2.5	Lithium primary batteries	1
2.6	Solid electrolyte batteries	1
2.7	Cell reactions and constructions	1
2.8	Nanomaterials in specified primary batteries	1
2.9	Peacemakers and torpedo batteries	1
3	**RECHARGEABLE BATTERIES**	
3.1	Introduction to rechargeable batteries	1
3.2	Characteristics of lead acid batteries	1
3.3	VRLA batteries	1
3.4	Lithium ion batteries	1
3.5	Bulk and nanomaterials in cell constructions	1
3.6	Performance characteristics of rechargeable batteries	1
3.7	Nickel-MH batteries	1
3.8	Comparison between different rechargeable batteries	1
3.9	Recent advancement in nano electrode materials	1
4	**SOLAR ENERGY SYSTEM**	
4.1	Introduction to solar cells	1
4.2	Working principle of solar cells	1
4.3	Types of solar cells	1
4.4	Semiconducting materials	1
4.5	Properties of solar cells	1
4.6	Design of p-n junction photodiodes	1
4.7	Charge carrier generation of solar cells	1

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4.8	I-V characteristics of solar cells	1
4.9	Metal semiconductor heterojunctions	1
5	**FUEL CELLS AND SUPERCAPACITORS**	
5.1	Introduction to fuel cells and supercapacitors	2
5.2	Types of fuel cells	1
5.3	PEMFC fuel cells	1
5.4	SOFC fuel cells	1
5.5	Characteristics and operation of fuel cells	1
5.6	Innovative designs for low wattage fuel cells	1
5.7	Applications of fuel cell technologies	1
5.8	Advantages of nanomaterials in fuel cells and supercapacitors	1
5.9	Performance characteristics of supercapacitors	1
	Total	45

Course Designers

Mr. R. Mohanraj (mohanrajr@ksrct.ac.in)

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60 PNT 3P1	Project Work-Phase I

Category	L	T	P	Credit
EEC	0	0	12	6

Objective

- To help the students apply their academic knowledge and technical skills in a specific domain
- To facilitate the students to identify, formulate and solve engineering problems
- To help the students design a system, component or process to meet the desired needs within realistic constraint
- To work and communicate efficiently in multidisciplinary terms
- To develop an understanding of professional and ethical responsibility in students

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

At the end of the course, the students will be able to

CO1	Identify engineering problems in their domain of interest and carry out literature review in the chosen technical area	Apply
CO2	Analyze and identify an appropriate technique to solve the problem.	Analyse
CO3	Design engineering solution, do experimentation / simulation / programming / fabrication/ collect and interpret data utilizing a systems approach	Create
CO4	Communicate effectively in oral and written forms	Apply
CO5	Demonstrate the knowledge, skills and attitudes of a professional engineer as an individual and member of a team	Analyze, Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	3	3
CO2	2	3	2	2	2	3
CO3	3	2	3	3	3	3
CO4	3	3	3	2	3	3
CO5	3	3	2	2	3	3

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K.S.Rangasamy College of Technology

BoS Chairman

K. S. Rangasamy College of Technology - Autonomous R2022						
60 PNT 3P1 - Project Work-Phase I *						
Department of Nanoscience and Technology						
Semester	**Hours / Week**			**Total hrs.**	**Credit**	**Maximum Marks**
	L	**T**	**P**		**C**	Total
III	0	0	12	60	6	100

Guideline/Instrution to students

- A committee is constituted with the project coordinator, project guide and HOD/Senior professor in the department
- Three reviews have to be conducted by the committee
- Problem should be selected by every batch of students
- Students must do a literature survey collecting a minimum of 1 survey paper and 2 technical papers related to their work
- Report has to be prepared by the students as per the format

Preliminary implementation can be done if possible Internal evaluation has to be done based on the three reviews for 100 marks

	Week	**Activity**
Execution	I	Allotment of Faculty Guide by the HOD
	II	Finalizing the topic with the approval of Faculty Guide
	III-IV	Collection of Scientific papers
	V – VI	Mid semester presentation
	VII – VIII	Report writing
	IX	Report Submission
	X-XI	Final presentation

Evaluation

- 100% Continuous Assessment
- 30 hrs/week and 2 credits

Component	**Weightage**
Review – I Presentation	20 %
Review – II Presentation	20 %
Review – III Presentation	20 %
Report preparation and Submission	30 %
Vivo- Voce	10 %
Total	100%

***SDG:8 productive employment**

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BoS Chairman

K. S. Rangasamy College of Technology - Autonomous R2022								
60 PNT 4P1 - Project Work - Phase II *								
Department of Nanoscience and Technology								
Semester	**Hours / Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**CA**	**ES**	Total
IV	0	0	24	60	12	40	60	100
Objective(s)	• To make the students with Innovative Ideas. • To provide exposure to the students to new areas of nanotechnology. • To solve a scientific problem in both practically and theoretically							
Methodology	• 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 60 such Research papers published in the last 5years. • Using Power point, the student has to make presentation for 15-20 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 project report for about 30-60 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.							

Evaluation

- 60 % Continuous Assessment and 40 % End semester exam
- 60hrs/and 12credits

Component	**Weightage**
Review – I Presentation	10 %
Review – II Presentation	20 %
Review – III Presentation	30 %
End semester Report preparation and Submission	40 %
Total	100%

***SDG:8 productive employment**

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60 PNT E11	Polymers In Nanotechnology

Category	L	T	P	Credit
PE	3	0	0	3

Objective

- To understand the formation of polymer chain
- To learn strength of the polymer and crystallinity
- To classify the types of nanocomposite
- To analysis the behavior of nanoscale organic transistor
- To compare properties of the natural and synthetic polymer

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Recall basic ideas of polymerization technique	Remember
CO2	Acquire the knowledge about strength of the polymer	Apply
CO3	Analyze the behavior of nanocomposite	Analyze
CO4	Differentiate different types of LED's	Apply
CO5	Classify the different types of polymers	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	20
Apply	10	10	30
Analyze	10	10	30
Evaluate	10	10	10
Create	10	10	0

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BoS Chairman

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT E11 - Polymers In Nanotechnology *								
Department of Nanoscience and Technology								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**C**	**E**	**Total**
II	3	0	0	45	3	40	60	100

INTRODUCTION Classification, formation of polymers - chain growth and step growth polymerisation, copolymerisation – electropolymerisation thermoplastics and thermosets – micro - nanostructures in polymers – polymer length, molecular weight, amorphous and crystalline.	[9]
PROPERTIES Polymer morphology- Crystallinity, Tensile strength, Surface tension, Young's modulus – Phase behaviour- glass transition temperature, mixing behavior, inclusion of plasticizers – types of polymerisation – mechanisms– polymer degradation.	[9]
NANOPOLYMERS Preparation and characterisation of diblock copolymer based nano hybrids, Nanoparticles polymer ensembles; Assembly of polymer – polymer nanocomposite from polymerisation; polymers/clay nanocomposites.	[9]
NANOPOLYMERS IN ELECTRONICS Printing and patterning techniques - nanoscale behaviour in organic transistors - transition of sensing response by organic transistor from micro to nanoscale - organic field effect transistor, organic light emitting diode. Molecularelectronics.	[9]
NANOPOLYMERS IN TEXTILES Hydrogels, synthetic and natural polymers in electrospinning - controlling parameters and morphology of nanofibers, nanoparticles - electro static self-assembled nanolayer films and coating in textiles.	[9]
Total Hours	**45**

Reference(s):

1	Harry R allcock, Frederick W lampe and James E Mark," Contemporary polymer chemistry", person education, 2003
2	K cousins, keith cousins," polymers in electronics" smithers Rapra technology publishers, 2006
3	P J Brown and K Stevens," nanofibers and nanotechnology in textiles" CRC press, 2007
4	Frances Gardiner, Eleanor carter,: polymer electronics – a flexible technology", ismithers, 2009

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BoS Chairman

Course Content and Lecture Schedule

S.No	Topic	No. of Hours
1	**INTRODUCTION**	
1.1	Classification of Polymer	1
1.2	Function of polymers	1
1.3	Polymerization	1
1.4	Copolymerization	1
1.5	Electro polymerization	1
1.6	Thermoplastics and thermosets	1
1.7	Micro - nanostructures in polymers	1
1.8	Polymer length, molecular weight	1
1.9	Amorphous and crystalline	1
2	**PROPERTIES**	
2.1	Polymer morphology	1
2.2	Crystallinity	1
2.3	Tensile strength, Surface tension, Young's modulus	1
2.4	Phase behavior	1
2.5	Glass transition temperature	1
2.6	Mixing behavior	1
2.7	Plasticizers	1
2.8	Types of polymerization, mechanisms	1
2.9	Polymer degradation	1
3	**NANOPOLYMERS**	
3.1	Preparation diblock copolymer	1
3.2	Characterisation of diblock copolymer based nano hybrids	2
3.3	Nanoparticles polymer ensembles	1
3.4	Assembly of polymer	1
3.5	Polymer nanocomposite from polymerization	2
3.6	Polymers nanocomposites.	1
3.7	clay nanocomposites.	1
4	**NANOPOLYMERS IN ELECTRONICS**	
4.1	Printing techniques	1
4.2	Patterning techniques	1
4.3	Nanoscale behaviour in organic transistors	2
4.4	Transition of sensing response by organic transistor from micro to nanoscale	2
4.5	Organic field effect transistor	1
4.6	Organic light emitting diode.	1
4.7	Molecularelectronics	1
5	**NANOPOLYMERS IN TEXTILES**	
5.1	Hydrogels	1
5.2	Synthetic polymers in electrospinning	1
5.3	Natural polymers in electrospinning	1
5.4	Controlling parameters of nanofibers	2
5.5	Morphology of nanofibers	2
5.6	Electro static self-assembled nanolayer films and coating in textiles	2
	Total	45

Course Designer

Dr. S. Satheeskumar (satheeskumars@ksrct.ac.in)

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K.S.Rangasamy College of Technology
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BoS Chairman

60 PNT E12	Nanotechnology in Biomedical Instrumentation

Category	L	T	P	Credit
PE	3	0	0	3

Objective

- To familiarize students with various aspects of measuring electrical parameters from living body.
- To introduce students with the characteristics of medical instruments and related errors.
- To illustrate various types of amplifiers used in biomedical instruments.
- To familiarize students with biomedical recorders.
- To introduce students with patient monitoring system & its characteristics.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Describe and characterize the sources of biomedical signals and needs of using biomedical instruments & their limitations.	Remember, Apply
CO2	Understand & describe pc based medical instrumentation & regulation of medical devices.	Remember, Apply, Evaluate
CO3	Describe and characterize medical instruments as per their specifications, static & dynamic characteristics and understand data acquisition system.	Remember, Understand, Analyze
CO4	Describe, analyze, characterize and design Bio-amplifiers.	Remember, Understand, Analyze
CO5	Understand, describe, characterize and design various medical recording systems & their components.	Remember, Understand, Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	1	2	1
CO2	3	2	2	2	2	2
CO3	3	2	3	2	2	3
CO4	3	3	2	3	2	2
CO5	2	3	2	3	1	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember (Re)	10	10	10
Understand (Un)	10	10	20
Apply (Ap)	10	10	30
Analyze (An)	10	10	30
Evaluate (Ev)	10	10	10
Create (Cr)	10	10	0

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K.S.Rangasamy College of Technology – AutonomousR2022								
60 PNT E12 Nanotechnology in Biomedical Instrumentation *								
M.Tech – Nano Science and Technology								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**CA**	**ES**	**Total**
II	3	0	0	45	3	40	60	100

MEDICAL INSTRUMENTATION Sources of Biomedical Signals, Basic medical Instrumentation system, Performance requirements of medical Instrumentation system, Microprocessors in medical instruments, PC based medical Instruments, General constraints in design of medical Instrumentation system, Regulation of Medical devices.	**[9]**
MEASUREMENT SYSTEMS Specifications of instruments, Static & Dynamic characteristics of medical instruments, Classification of errors, Statistical analysis, Reliability, Accuracy, Fidelity, Speed of response, Linearization of technique, Data Acquisition System.	**[9]**
BIOELECTRIC SIGNALS AND BIOELECTRIC AMPLIFIERS Origin of bioelectric signals, Electrodes, Electrode-tissue interface, Galvanic Skin Response, BSR, Motion artifacts, Instrumentation amplifiers, Special features of bioelectric amplifiers, Carrier amplifiers, Chopper amplifiers, Phase sensitive detector.	**[9]**
BIOMEDICAL RECORDING SYSTEMS Basic Recording systems, General consideration for signal conditioners, Preamplifiers, Differential Amplifier, Isolation Amplifier, Electrocardiograph, Vectorcardiograph, Phonocardiograph, Electroencephalograph, Electromyography, Other biomedical recorders, Biofeedback instrumentation, Electrostatic and Electromagnetic coupling to AC signals, Proper grounding, Patient isolation and accident prevention.	**[9]**
Patient Monitoring Systems System concepts, Cardiac monitor, selection of system parameters, Bedside monitors, Central monitors, Heart rate meter, Pulse rate meter, Holter monitor and Cardiac stress test, Cardiac cauterization instrumentation, Organization and equipments used in ICCU & ITU.	**[9]**
Total Hours	**45**

Textbook(s):

1.	R. S. Khandpur “Handbook of Bio-Medical Instrumentation”, 2nd Edition, Tata McGraw Hill
2.	J.J.Carr&J.M.Brown, “Introduction to Biomedical Equipment Technology” Pearson Education, Asia

Reference(s):

1.	Cromwell, Weibell& Pfeiffer, “Biomedical Instrumentation & Measurement”, Prentice Hall, India
2.	Joseph Bronzino, “Biomedical Engineering and Instrumentation”, PWS Engg . , Boston.
3.	J.Webster, “Bioinstrumentation”, Wiley & Sons.
4.	Joseph D.Bronzino, “The Biomedical Engineering handbook”, CRC Press.

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Course Contents and Lecture Schedule

S.No.	Topic	No.of Hours
1	**MEDICAL INSTRUMENTATION**	1
1.1	Sources of Biomedical Signals	1
1.2	Basic medical Instrumentation system	1
1.3	Performance requirements of medical Instrumentation system	2
1.4	Microprocessors in medical instruments	1
1.5	PC based medical Instruments	1
1.6	General constraints in design of medical Instrumentation system	1
1.7	Regulation of Medical devices	2
2	**NUMERICAL INTEGRATION**	
2.1	Specifications of instruments	1
2.2	Static & Dynamic characteristics of medical instruments	1
2.3	Classification of errors	1
2.4	Statistical analysis	1
2.5	Reliability, Accuracy	1
2.6	Fidelity	1
2.7	Speed of response	1
2.8	Linearization of technique	1
2.9	Data Acquisition System	1
3	**MATHEMATICAL MODELING**	
3.1	Origin of bioelectric signals	1
3.2	Electrodes	1
3.3	Electrode-tissue interface	1
3.4	Galvanic Skin Response	1
3.5	BSR, Motion artifacts	1
3.6	Instrumentation amplifiers	1
3.7	Special features of bioelectric amplifiers	1
3.8	Carrier amplifiers-Chopper amplifiers	1
3.9	Phase sensitive detector	1
4	**BIOMEDICAL RECORDING SYSTEMS**	
4.1	Basic Recording systems	1
4.2	General consideration for signal conditioners	1
4.3	Preamplifiers, Differential Amplifier, Isolation Amplifier	1
4.4	Electrocardiograph, Vectorcardiograph, Phonocardiograph	1
4.5	Electroencephalograph, Electromyography	1
4.6	Other biomedical recorders, Biofeedback Instrumentation	1
4.7	Electrostatic and Electromagnetic coupling to AC signals	1
4.8	Proper grounding	1
4.9	Patient isolation and accident prevention	1

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5	**PATIENT MONITORING SYSTEMS**	
5.1	System concepts	1
5.2	Cardiac monitor	1
5.3	selection of system parameters	1
5.4	Bedside monitors	1
5.5	Central monitors	1
5.6	Heart rate meter, Pulse rate meter	1
5.7	Holter monitor and Cardiac stress test	1
5.8	Cardiac cauterization instrumentation	1
5.9	Organization and equipments used in ICCU & ITU	1
	Total	45

Course Designers

Mr. R. Mohanraj (mohanrajr@ksrct.ac.in)

60 PNT E13	**Nanosensors and Applications**

Category	**L**	**T**	**P**	**Credit**
PE	3	0	0	3

Objective

- Acquire knowledge in Characteristics of Sensors
- To understand the concept of Nano based sensors.
- To Identify the basic types of sensors and transducers
- Tostudy the types and working of gas and thermal sensors
- To understand the different in applications of sensors in nano filed.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understand the basics, classification, fundamentals and configuration of sensors	Understand
CO2	Understand the parameters and physical nature of sensors	Understand
CO3	Describe the various features of transducers	Analyze
CO4	To understand the nature of piezoelectric materials.	Apply
CO5	Discuss the various industrial Applications of sensors	Analyze

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	2	3	3
CO2	3	3	2	3	3	3
CO3	3	3	2	3	3	2

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CO4	3	3	2	3	3	3
CO5	3	3	3	2	3	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	40
Analyse	10	10	20
Evaluate	10	10	20
Create	10	10	10

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT E13 - Nanosensors and Applications								
Department of Nanoscience and Technology								
Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
II	3	0	0	45	3	40	60	100

Note: Hours notified against each unit in the syllabus are only indicative but are not decisive. Faculty may decide the number of hours for each unit depending upon the concepts and depth. Questions need not be asked based on the number of hours notified against each unit in the syllabus**.**

Characteristics of Sensors Sensors principle -Types of Sensors -Active and Passive sensors – Static characteristic - Accuracy, offset and linearity – Dynamic characteristics - First and second order sensors – Physical effects involved in signal transduction- Photoelectric effect – Photoluminescence effect – Electroluminescence effect – chemiluminescence effect – Piezoelectric effect – Pyroelectric effect.	[9]
Nano based sensors Density of state in 3D, 2D, 1D and 0D nanomaterials – one dimensional gas sensors:- gas sensing with nanostructured thin films, nanofiber, nano rod and quantum dot absorption on surfaces –metal oxide modifications by additives – surface modifications –organic–inorganic hybrid nanocomposite sensors- nano optical sensors – nano mechanical sensors – plasmon resonance sensors.	[9]
Self -powering device and transducers ** Sensor Technologies and Energy Harvester Fabrication/Construction of Sensor Devices-Smart Sensors–Self Powering Sensors- Photoacoustic-Nano generator: Triboelectric-Piezoelectric-Types-Materials-Hybrid Generator. Conductometric and capacitive transducers – optical waveguide based transducers – optical fiber based transducers – Interferometric optical transducers — electrochemical transducers– schottky diode based transducers.	[9]
GAS AND THERMAL SENSORS Criteria for the choice of materials, Experimental aspects – materials, properties - measurement of gas sensing property, sensitivity - Discussion of sensors for various gases - Gas sensors	[9]

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based on semiconductor devices - Thermal energy sensors - temperature sensors - heat sensors- Optical and radiation sensors.	
APPLICATIONS * Cantilever array sensors -Cantilever sensors for diagnosis of diabetes mellitus and cancer diagnosis -Nanotube based sensors for DNA detection and capnography -Nanowire based sensors and single viruses - biomolecules and bio sensors– Electrochemical sensor and pesticide detectors-Night vision systems.	[9]
Total Hours (45+15)	**45**

Text Books	
1	Vinod Kumar Khanna, "Nanosensors Physical, Chemical, and Biological" 2 nd Edition, CRC Press, 2021.
2	K. Goser, P. Glosekotter and J. Dienstuhl, "Nanoelectronics and Nanosystems-From Transisto, rs toMolecular Quantum Devices", Springer, 2004.
3	Teik-Cheng Lim, "Nanosensors Theory and Applications in Industry, Healthcare and Defense" , Ist Edition, CRC Press, 2010.
4	Zhong Lin Wang, Nanogenerators for Self-powered Devices and Systems, first edition, Georgia Institute of Technology, Atlanta, USA 2011,
Reference Books	
1	K.E. Drexler, "Nano systems", Wiley India, 2010.
2	W.R.Fahrner, "Nanotechnology and Nanoelectronics – Materials, Devices and Measurement Techniques" Springer, 2006.
3	Herve Rigneault, Jean-Michel Lourtioz, Claude Delalande, Ariel Levenson, "Nanophotonics", Wiley-IST -2006.

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****SDG:7 Reliable, sustainable and modern energy for all**

Course Content and Lecture Schedule

S.No	Topic	No. of Hours
1	**CHARACTERISTICS OF SENSORS**	
1.1	Sensors principle -Types of Sensors -Active and Passive sensors	1
1.2	Static characteristic - Accuracy, offset and linearity	1
1.3	Dynamic characteristics	1
1.4	First and second order sensors	1
1.5	Physical effects involved in signal transduction	1
1.6	Photoelectric effect	1
1.7	Photoluminescence effect, Electroluminescence effect	1
1.8	Chemiluminescence effect	1
1.9	Piezoelectric effect and Pyroelectric effect.	1
2	**NANO BASED SENSORS**	
2.1	Density of state in 3D, 2D, 1D and 0D nanomaterials	1
2.2	One dimensional gas sensors	1
2.3	Gas sensing with nanostructured thin films	1
2.4	Nanofiber, nano rod and quantum dot absorption on surfaces	1
2.5	Metal oxide modifications by additives	1
2.6	Surface modifications	1

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2.7	Organic–inorganic hybrid nanocomposite sensors	1
2.8	Nano optical sensors – nano mechanical sensors	1
2.9	Plasmon resonance sensors	1
3	**SELF-POWERING DEVICE AND TRANSDUCERS**	
3.1	Sensor Technologies and Energy Harvester Fabrication	1
3.2	Construction of Sensor Devices	1
3.3	Smart Sensors–Self Powering Sensors	1
3.4	Photoacoustic sensor	1
3.5	Nano generator: Triboelectric-Piezoelectric-Types, Materials-Hybrid Generator	1
3.6	Conductometric and capacitive transducers	1
3.7	Optical waveguide based transducers and optical fiber based transducers	1
3.8	Interferometric optical transducers and electrochemical transducers	1
3.9	Schottky diode based transducers	1
4	**GAS AND THERMAL SENSORS**	
4.1	Criteria for the choice of materials	1
4.2	Experimental aspects – materials, properties	1
4.3	Measurement of gas sensing property	1
4.4	Sensitivity	1
4.5	Discussion of sensors for various gases	1
4.6	Gas sensors based on semiconductor devices	1
4.7	Thermal energy sensors	1
4.8	Temperature sensors - heat sensors	1
4.9	Optical and radiation sensors	1
5	**APPLICATIONS**	
5.1	Cantilever array sensors	1
5.2	Cantilever sensors for diagnosis of diabetes mellitus and cancer diagnosis	1
5.3	Nanotube based sensors for DNA detection and capnography	1
5.4	Nanowire based sensors and single viruses	1
5.5	Biomolecules and bio sensors	1
5.6	Electrochemical sensor	1
5.7	Pesticide detectors	1
5.8	Night vision systems	1
	Total	45

Course Designers

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BoS Chairman

60 PNT E14	Nanodevices

Category	L	T	P	Credit
PE	3	0	0	3

Objective

- To analyse the development of nano electronics.
- To study the principle behind the nanodevices.
- To explore the application of nano devices.
- To analyse and study the molecular and bioelectronics on nano application.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	To impart the knowledge on the semiconductor nanodevices	Apply
CO2	Realize electron conduction in metal based nanoparticles	Analyze
CO3	To impart fundamental knowledge about crystallography, conducting, superconducting, magnetic, dielectric, semiconducting materials	Remember
CO4	Understand the emerging ideas of challenges of synthesis of nanomaterials	Remember
CO5	Discuss the applications of nano electronics	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	3	3	3
CO2	2	2	3	3	2	2
CO3	2	3	3	3	1	1
CO4	3	2	2	2	2	1
CO5	3	3	3	3	1	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyse	10	10	30
Evaluate	10	10	20
Create	10	10	0

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K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT E14 – Nanodevices *								
Department of Nanoscience and Technology								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**C**	**E**	**Total**
II	3	0	0	45	3	40	60	100

QUANTUM DEVICES Quantum electronic devices – Electrons in mesocopic structures – Short-channel MOS transistor – Split gate transistor – Electron wave transistor – Electron spin transistor – Quantum cellular automata – Quantum dot array – Quantum computer- Bit and Qubit – Coherence and Entanglement – Quantum parallelism.	[9]
TUNNELING DEVICES Tunneling element – Tunnel effect and tunneling elements -Tunneling diode – Resonant tunneling diode – Three-terminal resonate tunneling devices -Technology of RTD - Memory applications – Basics logic circuits – Dynamic logic gates - Digital circuits design based on RTBT – Single electron transistor (SET).	[9]
SUPERCONDUCTING DEVICES Basics - Macroscopic characteristics – Macroscopic model - Super conducting switching devices – Cryotron - Josephson tunneling devices - Elementary circuits – Associative or Content – Addressable memory - SQUID – Flux quantum device – LC - Gate – Magnetic flux quantum – Quantum cellular automata - Quantum computer with single flux devices – SFQD - RSFQD – Application of super conducting devices.	[9]
CHALLENGES IN NANODEVICES Limitations of integrated electronics - Survey of limits – Replacement of technologies – Energy supply and Heat dissipation – Parameter spread as limiting effect – Limits due to thermal particle motion - Debye length – Thermal noise - Reliability as limiting factor – Physical limits – Thermodynamic limits - Relativistic limits – Equal failure rates by tunneling and thermalnoise	[9]
BIOELECTRONICS Bioelectronics – Molecular processor – DNA analyser molecular electronics – Switches based on fullerenes andnanotubes–Polymerelectronic–Selfassemblingcircuits–Opticalmolecularmemories–DNAcomputer- Information processing with chemical reaction – Nano machines – Parallel processing.	[9]
Total Hours	**45**

Reference(s):

1	K. Goser, P. Glosekotter and J. Dienstuhl, “Nanoelectronics and Nanosystems-From Transistors to Molecular Quantum Devices”, Springer, 2004.
2	HerveRigneault, Jean-Michel Lourtioz, Claude Delalande, Ariel Levenson, “Nanophotonics”, ISTE.
3	W.R.Fahrner, “Nanotechnology and Nanoelectronics – Materials, Devices and MeasurementTechniques” Springer, 2006.

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Course Content and Lecture Schedule

S.No	Topic	No. of Hours
1	**QUANTUM DEVICES**	
1.1	Quantum electronic devices	1

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1.2	Electrons in mesoscopic structures	1
1.3	Short channel MOS transistor	1
1.4	Split gate transistor	1
1.5	Electron wave transistor and electron spin transistor	1
1.6	Quantum cellular automation	1
1.7	Quantum dot array and quantum computer	1
1.8	Bit and qubit	1
1.9	Coherence and quantum parallelism	1
2	**TUNNELING DEVICES**	
2.1	Introduction about tunneling elements	1
2.2	Resonant tunneling diodes	1
2.3	Three terminal resonant tunneling diodes	1
2.4	Technology of RTD	1
2.5	Memory applications of RTD	1
2.6	Basics of logic circuits	1
2.7	Dynamic logic gates	1
2.8	Digital circuits design based on RTBT	1
2.9	Single electon transistor	1
3	**SUPERCONDUCTING DEVICES**	
3.1	Mesoscopic characteristics	1
3.2	Superconducting switching devices	1
3.3	Cryotron and josephson tunneling devices	1
3.4	Associative or content memory	1
3.5	Addressable memory	1
3.6	SQUID and flux quantum devices	1
3.7	Magnetic flux quantum and quantum cellular automation	1
3.8	Quantum computer with single flux devices	1
3.9	SFQD and RSFQD and its applications	1
4	**CHALLENGES IN NANODEVICES**	
4.1	Limitations of integrated electronics	1
4.2	Replacement of technologies in nanodevices	1
4.3	Energy supply and heat dissipation of nanodevices	1
4.4	Limits due to thermal particle motion	1
4.5	Debye length and thermal noise	1
4.6	Reliability as limiting factor	1
4.7	Physical limits and thermodynamic limits	1
4.8	Relativistic limits of nanodevices	1
4.9	Equal failure rates by tunneling	1
5	**BIOELECTRONICS**	
5.1	Basics of bioelectronics	2
5.2	Molecular processor	1
5.3	DNA analyser molecular electronics	1

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5.4	Switch based on fullerenes and nanotubes	1
5.5	Polymer electronic devices	1
5.6	Self assembling circuits	1
5.7	Optical molecular memories	1
5.8	DNA computer and information processing	1
5.9	Nano machines and parallel processing	1
	Total	45

Course Designers

Mr. R. Mohanraj (mohanrajr@ksrct.ac.in)

60 PNT E15	**Advanced Solid State Materials**

Category	**L**	**T**	**P**	**Credit**
PE	3	0	0	3

Objective

- To identify the structure of crystal
- To know about dielectric concept
- To analyze the properties of magnetic material
- To recall the semiconducting properties
- To apply the smart materials to modern tool usage

Prerequisite

Solid state Physics

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Recognize the knowledge of the crystal	Remember
CO2	Analyze the dielectric properties	Apply
CO3	Classify the magnetic materials	Analyze
CO4	Compare the direct and indirect band gap materials	Apply
CO5	Identify the new usage of smart materials	Analyze

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	1

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Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyze	10	10	30
Evaluate	10	10	10
Create	10	10	10

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT E15 - Advanced Solid State Materials *								
Department of Nanoscience and Technology								
Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
II	3	0	0	45	3	40	60	100
CRYSTALLOGRAPHY crystalline solids-amorphous solids-lattice-basis-unit cell-crystallographic axes-primitives-lattice parameters- primitive cell -seven crystal systems - miller indices -crystal structure of materials-simple cubic - body centered cubic-face centered cubic – hexagonal structure-types of symmetry-bonding in solids-primary bonds- secondary bonds- imperfections-point, line, surface & volume – color centers								[9]
DIELECTRIC MATERIALS Basic concepts of dielectric materials-dielectric properties - types of polarization - classification of dielectric materials based on temperature – Claussius-Mosotti relation Dielectric Constant and Dielectric Loss – breakdown mechanism - ferroelectric material –multiferroics - applications.								[9]
MAGNETIC MATERIALS Dia-para-ferro and anti-ferromagnetic materials and its properties -Ferrites-hard and soft magnetic materials- ferrites-structural and its properties-magnetic optical recording materials-magnetic computer data storage- - NMR imaging-MR imaging-storage-memory-recording and imaging.								[9]
SEMICONDUCTING MATERIALS Preparation of Semiconducting Materials-Band Gap-Direct, Indirect Band gap-Semiconductor Band Gaps-P- type-N-type –Fermi level-Fermidirac - Brillouin Zone-Advanced Semiconducting Materials-Functionalization of Charge –Hall effect-Charge Carriers- Basics of quantum dot, wire and well materials and quantum laser.								[9]
SMART MATERIALS Shape memory alloys-Phase Transformations - Properties of SMA – classification of metal alloys-Ferrous alloys-Phase diagram-Titanium alloys- Nonferrous alloys - applications – Micro valve & pump. Metallic glasses– preparation – properties – applications.								[9]
Total Hours								**45**
Reference(s):								
1	V. Rajendran, Materials Science, Tata McGraw Hill, New Delhi, 2011.							
2	A.J. Dekker, Solid state Physics, Macmillan India Ltd, New Delhi, 2012.							
3	S.O. Pillai, Solid state Physics,New Age International(p)Ltd, 2007 Revised Edition							
4	C. Kittle, Introduction to Solid State Physics 8thEdition, Wiley publishers, 2005.							

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Course Contents and Lecture Schedule

S.No	Topic	No. of Hours
1	**CRYSTALLOGRAPHY**	
1.1	Crystalline solids	1
1.2	Amorphous solids - lattice-basis-unit cell	1
1.3	Crystallographic axes – primitives - lattice parameters - primitive cell	1
1.4	Seven crystal systems	1
1.5	Miller indices - crystal structure of materials - simple cubic	1
1.6	Body centered cubic - Face centered cubic – Hexagonal structure	1
1.7	Types of symmetry – types of bonding in solids	1
1.8	Imperfections-point, line, surface & volume – color centers	1
1.9	Plank's quantum hypothesis	1
2	**DIELECTRIC MATERIALS**	
2.1	Basic concepts of dielectric materials	1
2.2	Dielectric properties - types of polarization	1
2.3	Classification of dielectric materials based on temperature	1
2.4	Claussius-Mosotti relation	1
2.5	Dielectric Constant and Dielectric Loss	1
2.6	Breakdown mechanism	1
2.7	Ferroelectric material	1
2.8	Multiferroics	1
2.9	Multiferroics - applications	1
3	**MAGNETIC MATERIALS**	
3.1	Dia – Para - Ferro magnetic materials	1
3.2	Anti-ferromagnetic materials and its properties	1
3.3	Ferrites	1
3.4	Hard and soft magnetic materials	1
3.5	Ferrites - structural and its properties	1
3.6	Magnetic optical recording materials	1
3.7	Magnetic computer data storage	1
3.8	NMR imaging -MR imaging	1
3.9	Storage – Memory - Recording and imaging	1
4	**SEMICONDUCTING MATERIALS**	
4.1	Preparation of Semiconducting Materials	1
4.2	Band Gap - Direct, Indirect Band gap	1
4.3	Semiconductor Band Gaps P - type	1
4.4	Semiconductor Band Gaps N-type	1
4.5	Fermi level	1
4.6	Fermi Dirac	1
4.7	Brillouin Zone - Advanced Semiconducting Materials	1
4.8	Functionalization of Charge – Hall effect - Charge Carriers	1

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4.9	Basics of quantum dot, wire and well materials and quantum laser	1
5	**SMART MATERIALS**	
5.1	Shape memory alloys - Phase Transformations	1
5.2	Properties of SMA	1
5.3	Classification of metal alloys	1
5.4	Ferrous alloys - Phase diagram -	1
5.5	Titanium alloys	1
5.6	Nonferrous alloys - applications	1
5.7	Micro valve & pump	1
5.8	Metallic glasses – preparation	1
5.9	Metallic glasses – properties – applications.	1
	Total	45

Course Designer

Dr. S. Satheeskumar (satheeskumars@ksrct.ac.in)

60 PNT E16	**Thin Film Science and Technology**

Category	L	T	P	Credit
PE	**3**	**0**	**0**	**3**

Objective

- To understand the basic knowledge of thin film technology.
- To learn the application of nanomaterials in thin film technology
- To acquire the knowledge about various coating technique and modification of surface
- To understand the basic properties of Thin film and its characterization techniques.
- To learn the basic applications of Thin film and its industrial

Prerequisite

Basics of Thin film technology

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Address basic principles and concepts of thin film techniques	Remember
CO2	Acquire knowledge on nanomaterial characterization techniques	Analyze
CO3	Verify the basic concepts of absorption and diffusion in thin films	Analyze
CO4	Identify the various stress in thin film	Analyze
CO5	Analyze the modification of surfaces of film	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	1

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Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyze	10	10	30
Evaluate	10	10	10
Create	10	10	10

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT E16 - Thin Film Science and Technology *								
Department of Nanoscience and Technology								
Semester	Hours/Week			Total hrs	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
II	3	0	0	45	3	40	60	100

THIN FILM DEPOSITION TECHNIQUES Introduction – Kinetic theory of gases - Physical vapor deposition techniques – Physics and Chemistry of Evaporation - Thermal evaporation – Pulsed laser deposition - Chemical methods – CVD Thermal and Plasma – Spin and Dip coating – Electro plating and Electroless plating – Deposition mechanisms	[9]
CHARACTERIZATION TECHNIQUES Surface analysis techniques – Auger Electron spectroscopy – Photoelectron Spectroscopy – Secondary Ion Mass Spectroscopy – X-ray Energy Dispersive Analysis- Imaging Analysis Techniques – Scanning Electron Microscopy – Transmission Electron Microscopy – Optical analysis Techniques – Ellipsometry – Photoluminescence Spectroscopy	[9]
ADSORPTION AND DIFFUSION IN THIN FILMS Physisorption – Chemisorption – Work function changes induced by adsorbates – Two-dimensional phase transitions in adsorbate layers – Adsorption kinetics – Desorption techniques. Fundamentals of diffusion – Grain Boundary Diffusion – Thin Film Diffusion Couples - Inter Diffusion -Electromigration in thin films – Diffusion during film growth.	[9]
STRESS IN THIN FILMS Origin of Thin film stress - Classifications of stress – Stress in epitaxial films – Growth Stress in polycrystalline films – Correlation between film stress and grain structure – Mechanisms of stress evolution – film stress and substrate curvature – Stoney formula – Methods of curvature measurement – Scanning laser method.	[9]
MODIFICATION OF SURFACES AND FILMS Introduction – Laser and their Interactions with Surfaces – Laser modification effects and applications – Laser sources and Laser scanning methods - Thermal analysis of Laser annealing - Laser surface alloying - Ion implantation effects in solids – Energy loss and structural modification – compositional modification - Ion beam modification phenomena and applications.	[9]
Total Hours	**45**

Text Book(s)	
1	Rointan F. Bunshah, Hand Book of Deposition technologies for Thin Films and coatings by Science Technology and Applications ,Second Edition , Noyes Publications, (1993).
2	Harald Ibach, Physics of Surfaces and Interfaces, Springer Publishers (2006).
Reference(s)	
1	Amy E. Wendt, Thin Films - High density Plasmas, Volume 27, Springer Publishers. (2006).
2	Milton Ohring, Materials Science of Thin films Published by Academic Press Limited(1991)

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3	L.B. Freund and S.Suresh, Thin Film Materials, (2003).
4	Hans Luth, Solid surfaces, Interfaces and Thin Films' 4th Edition, Springer Publishers (2010)

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Course Contents and Lecture Schedule

S.No	Topic	No. of Hours
1	**THIN FILM DEPOSITION TECHNIQUES**	
1.1	Introduction – Kinetic theory of gases	1
1.2	Physical vapor deposition techniques	1
1.3	Physics and Chemistry of Evaporation	1
1.4	Thermal evaporation	1
1.5	Pulsed laser deposition	1
1.6	Chemical methods – CVD Thermal and Plasma	1
1.7	Spin and Dip coating	1
1.8	Electro plating and Electroless plating	1
1.9	Deposition mechanisms	1
2	**CHARACTERIZATION TECHNIQUES**	
2.1	Surface analysis techniques	1
2.2	Auger Electron spectroscopy	1
2.3	Photoelectron Spectroscopy	1
2.4	Secondary Ion Mass Spectroscopy	1
2.5	X-ray Energy Dispersive Analysis	1
2.6	Imaging Analysis Techniques SEM, TEM	1
2.7	Optical analysis Techniques	1
2.8	Ellipsometry & Photoluminescence Spectroscopy	2
3	**ADSORPTION AND DIFFUSION IN THIN FILMS**	
3.1	Physisorption – Chemisorption	1
3.2	Work function changes induced by adsorbates	1
3.3	Two-dimensional phase transitions in adsorbate layers	1
3.4	Adsorption kinetics – Desorption techniques	1
3.5	Fundamentals of diffusion	1
3.6	Grain Boundary Diffusion	1
3.7	Thin Film Diffusion Couples	1
3.8	Inter Diffusion - Electromigration in thin films	1
3.9	Diffusion during film growth	1
4	**STRESS IN THIN FILMS**	
4.1	Origin of Thin film stress	1
4.2	Classifications of stress – Stress in epitaxial films	2
4.3	Growth Stress in polycrystalline films	1
4.4	Correlation between film stress and grain structure	1
4.5	Mechanisms of stress evolution	1
4.6	Film stress and substrate curvature	1
4.7	Stoney formula – Methods of curvature measurement	1
4.8	Scanning laser method.	1
5	**MODIFICATION OF SURFACES AND FILMS**	
5.1	Introduction – Laser and their Interactions with Surfaces	1
5.2	Laser modification effects and applications	1

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5.3	Laser sources and Laser scanning methods	1
5.4	Thermal analysis of Laser annealing	1
5.5	Laser surface alloying	1
5.6	Ion implantation effects in solids	1
5.7	Energy loss and structural modification	1
5.8	Compositional modification	1
5.9	Ion beam modification phenomena and applications.	1
	Total	45

Course Designer

Dr. S. Satheeskumar (satheeskumars@ksrct.ac.in)

60 PNT E21	**Nanotribology**

Category	**L**	**T**	**P**	**Credit**
PE	3	0	0	3

Objective

- To provide the knowledge and importance of tribology
- To understand the principles of lubrication and tailoring surface
- Emphasize the knowledge of scientific disciplines in understanding tribological phenomenon.
- To understand the lubrication fluid mechanism
- To address the applications of tribology

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understanding the basic of tribology.	Remember
CO2	Gain the knowledge about Surface Forces.	Analyze
CO3	Describe about Lubrication, Friction and Wear.	Apply
CO4	Produce effective Mechanical Properties of materials.	Apply
CO5	Explaining about the application of tribology.	Analyze

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO 3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	2
CO2	3	3	2	3	2	2
CO3	2	1	3	2	2	1
CO4	2	2	3	2	2	1
CO5	2	3	3	3	3	3

Assessment Pattern

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Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyse	10	10	30
Evaluate	10	10	20
Create	10	10	0

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60 PNT E21 – Nanotribology *								
Department of Nanoscience and Technology								
Semester	Hours/Week			Total hrs	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
III	3	0	0	45	3	40	60	100

Introduction to Tribology History of tribology, origin and Significance of micro/nanotribology Purpose of lubrication, modes of lubrication- hydrodynamic, Hydrostatic. Boundary lubrication, elasto hydrodynamic lubrication, Extreme pressure lubrication Lubricants - types and lubricating oils- Lubricant properties-effect of temperature and pressure, oxidation stability, thermal conductivity, type of additives.	[9]
Surface Forces and Measuring Techniques Methods used to study surface forces- force laws- Surface force apparatus (SFA)- Force between dry surface, force between surfaces in liquid- Adhesion and capillary forces, modes of deformation-Surface roughness and friction force, Adhesion- Scratching, wear and machining-boundary lubrication- Failure mechanism: Physical- chemical degradation.	[9]
Lubrication, Friction and Wear Lubricant States, viscosity of lubricant - Fluid film lubrication- Theories of hydrodynamics lubrication- Lubrication design of typical mechanical elements, transformation- Parameter of surface topography- Liquid mediated contact, interfacing temperature of sliding surfaces- Types of wear mechanism-Failure mechanism in elastic degradation	[9]
Scale Effects in Mechanical Properties and Tribology Nomenclature, scale effect in mechanical properties- Yield strength, shear strength- Scale effect on surface roughness and contact parameters- Scale effects in friction – adhesion. Types of deformation-Two body deformation -Three body deformation- Ratchet mechanism, elastic to plastic regime- Tailoring surfaces: Modifying surface composition and structure for application in Tribology	[9]
Applications of Tribology Introduction to various tribological phenomenon– Tribology in the human body, artificial organs-Coating application - sliding bearings, rolling contact- Bearings, gears, erosion and scratch resistant-Magnetic recording devices-Micro component- wind turbine.	[9]
Total Hours	**45**

Text Book(s):	
1	Bharat Bhushan, Nanotribology and Nanomechanics An Introduction, Springer Berlin, Heidelberg, 2008.
2	Bharat Bhushan, Handbook of Micro/Nano Tribology, 2nd Edition, CRC Press, 2020.
Reference(s):	
1	Nicholas D. Spencer, “Tailoring surfaces”, World Scientific IISC Press, 2011
2	H.G. Phakatkar and R.R. Ghorpade, “Tribology”, Nirali publication, 2009
3	Bharat Bhushan, ”Principles and Applications to Tribology”, Wiley Publication, 2013

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Course Content and Lecture Schedule

S. No	Topic	No. of Hours
1	**INTRODUCTION TO TRIBOLOGY**	
1.1	History of tribology	1
1.2	Significance of nanotribology	1
1.3	Purpose of lubrication	1
1.4	Modes of lubrication	1
1.5	Hydrodynamic and hydrostatic	1
1.6	Boundary lubrication	1
1.7	Extreme pressure lubrication	1
1.8	Types of lubricating oil	1
1.9	Types of additives	1
2	**SURFACE FORCES AND MEASURING TECHNIQUES**	
2.1	Methods used to study surface forces	1
2.2	Force laws	1
2.3	Surface force apparatus	1
2.4	Force between dry surface	1
2.5	Force between surface in liquid	1
2.6	Adhesion and capillary forces	1
2.7	Modes of deformation	1
2.8	Surface friction	1
2.9	Failure mechanism	1
3	**LUBRICATION,FRICTION AND WEAR**	
3.1	Lubricant states	1
3.2	Viscosity of lubricants	1
3.3	Fluid film lubrications	1
3.4	Theories of hydrodynamics	1
3.5	Lubrication design	1
3.6	Parameter of surface topography	1
3.7	Liquid mediated contact	1
3.8	Interfacing temperature of sliding surfaces	1
3.9	Types of wear mechanism	1
4	**SCALE EFFECTS IN MECHANICAL PROPERTIES AND TRIBOLOGY**	
4.1	Nomenclature	1
4.2	Scale effect in mechanical properties	1
4.3	Yield strength and shear strength	1
4.4	Scale effect on surface roughness	1
4.5	Types of deformation	1
4.6	Ratchet mechanism	1
4.7	Elastic to plastic regime	1

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4.8	Tailoring surfaces	1
4.9	Modifying surface composition	1
5	**APPLICATIONS OF TRIBOLOGY**	
5.1	Introduction to tribological phenomena	1
5.2	Biotribology	1
5.3	Tribology in human body	1
5.4	Artificial organs	1
5.5	Coating applications	1
5.6	Sliding bearings	1
5.7	Rolling contact	1
5.8	Erosion and scratch resistant	1
5.9	Magnetic reco	1
	Total	45

Course Designers

R. Mohanraj (mohanrajr@ksrct.ac.in)

60 PNT E22	**Nanotechnology in Automobiles**

Category	**L**	**T**	**P**	**Credit**
PE	3	0	0	3

Objective

- To provide exposure to the students on nanotechnology in automobiles.
- To study the various mateials used in automobiles systems and its applications
- To Understand the properties of nanomaterials for nanocoatings.
- To Acquire knowledge about nanosensors in automobiles.
- To Understand the challenges and opportunities of nanotechnology in automobiles.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	To know about the basic concept of nano fuels	Remember
CO2	Understand the world wide status of nano fluids in automobile nanotechnology	Apply
CO3	Evaluation of the interaction of nano fluids in automobiles	Apply
CO4	Identify various nano enabled component in automobile technology	Analyze
CO5	Identify various applications of nanomaterials in automobiles	Apply

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1

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CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyse	10	10	30
Evaluate	10	10	20
Create	10	10	0

K.S.Rangasamy College of Technology - Autonomous Regulation

60 PNT E22 - Nanotechnology in Automobiles

Department of Nanoscience and Technology

Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
III	3	0	0	45	3	40	60	100

NANOFUELS Nanofuel - Engine performance-Emissions-Burning characteristics-Ignition delay-Stable suspensions of nanoparticles of Al, Fe and Boron in diesel were used as fuels- Fuel consumption materials -specific fuel consumption for Al as compared to diesel. -reduced environmental impact materials- efficiency of nanofuel materials- Nanostructured lubricant -reduced frictional loss- Reduced friction-surface finish and affinity or oil	[9]
NANOFLUIDS * Synthesis of Nanofluids- methods-Smart Cooling Nanofluids- thermal properties of Nanofluids - Thermal insulation -higher operating temperature-Reduced friction -surface finish and affinity or oil-Reduce dimension weight -replaces cast iron block/liner- Nanofluids for Sensing Applications - Heat transfer improvement using Nanofluids - Nanofluids for solar collectors- molecular fluid-advanced flow and heat transfer fluids-magnetic Nanofluids - Nanofluids in Fuel Brake and Other Vehicular Nanofluids Cooling of Microchips Micro scale Fluidic Applications	[9]
NANO COATINGS * Nanocoating materials -Carbon based nanostructure materials- vehicle weight reduction-aluminium alloy engine-polycarbonate window-scratch resistant-UV resistant and self healing car paints -interior-automotive paints-dirt resistant paints- Nano-coatings for engine application- vehicles windows and wipers-automotive textiles- nanoparticles fillers for tires	[9]
NANOSENSORS * Micro scale physical - temperature, acceleration, pressure, strain - chemical sensors - oxygen and hydrogen - Safety-Additional airbags and sensors-Satellite sensing modules-Roll over sensing-Occupant position– Occupant Classification Sensors -Tyre pressure monitoring sensor-Lane Departure Warning - Driver drowsiness monitor-Night vision –Comfort –Convenience - Passive authentication-Door handle operation-Power door closure sliding/lift –Anti-trap, position- Multizone HVAC Temperature and humidity	[9]
CHALLENGES AND OPPORTUNITIES Improving fuel cell performance of future generations of hydrogen powered cars-flexible hydrogen sensors nanostructured materials- Improve fuel efficiency - polymer glazing-fuel cell-solar cell-electro chromatic layers- High performance automobile systems	[9]
Total Hours	**45**
Text Books	

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1.	Huaihe Song, Tuan Anh Nguyen, Ghulam Yasin, Nakshatra Bahadur Singh, Ram K. Gupta, “Nanotechnology in the Automotive Industry, Elsevier, 2022.
2.	Huaihe Song, Tuan Anh Nguyen, Ghulam Yasin, “Nanotechnology in the Automotive Industry (Micro and Nano Technologies), Kindle Edition, 2022.
Reference(s):	
1	Joao Paulo Carmo and Joao Eduardo Ribeiro, New Advances in Vehicular Technology and AutomotiveEngineering", ISBN 978-953-51-0698-2, Published: August 1, 2012
2	Yuwen Zhang ,Nanofluids: Research, Development and Applications, Nova Science Pub Inc (June 30, 2013)
3	Michael Berger.” Nanotechnology in the automotive industry” Copyright Nanowerk 2010

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Course Content and Lecture Schedule

S. No	Topic	No. of Hours
1	**NANOFUELS**	
1.1	Introduction to nanofuels	1
1.2	Engine performance and emission burning characteristics.	1
1.3	Stable suspension of different nanoparticles	1
1.4	Environmental impacts of nanomaterials	1
1.5	Efficiency of nanofuel materials	1
1.6	Nanostructured lubricants	1
1.7	Reduced frictional loss	1
1.8	Surface finish and affinity	1
1.9	Fuel consumption of different materials	1
2	**NANOFLUIDS**	
2.1	Synthesis methods of nanofluids	1
2.2	Smart cooling nanofluids	1
2.3	Different properties of nanofluids	1
2.4	Thermal insulation of nanofluids	1
2.5	Nanofluids for sensing applications	1
2.6	Heat transfer improvements using nanofluids	1
2.7	Nanofluids for solar collectors	1
2.8	Advanced flow and heat transfer nanofluids	1
2.9	Nanofluid cooling of microchips	1
3	**NANOCOATINGS**	
3.1	Introduction to nanocoatings	1
3.2	Carbon based nanostructured materials	1
3.3	Vehicle weight reduction methods	1
3.4	Aluminium alloy engines	1
3.5	Scratch resistant and UV resistant	1
3.6	Self healing car paints and automative paints	1
3.7	Nanocoating for engine applications	1
3.8	Nanocoating in automative textiles.	1
3.9	Nanoparticle fillers for tires	1

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4	**NANOSENSORS**	
4.1	Physical, temperature and acceleration sensors.	1
4.2	Additional air bags and sensors	1
4.3	Satellilte sensing modules	1
4.4	Roll over sensor and occupant positioning sensor	1
4.5	Tyre pressure monitoring sensor	1
4.6	Lane departure warning system	1
4.7	Driver drowsiness monitor	1
4.8	Passive authentication and door handle operation system	1
4.9	HVAC temperature and humidity sensor	1
5	**CHALLENGES AND OPPORTUNITIES**	
5.1	Improving fuel cell performance	2
5.2	Future generations of hydrogen powered cars	1
5.3	Flexible hydrogen sensor	1
5.4	Improving fuel efficiency	1
5.5	Polymer glazing	1
5.6	Fuel cell and solar cell	1
5.7	Electrochromatic layers	1
5.8	High performance automobile systems	1
5.9	Different opportunities of nanotechnology in automobiles	1
	Total	45

Course Designers

R. Mohanraj (mohanrajr@ksrct.ac.in)

60 PNT E23	**CORROSION ENGINEERING**

Category	**L**	**T**	**P**	**Credit**
PE	3	0	0	3

Objective

- To study the basic principle corrosion
- To understand the different form of corrosion.
- To explore the corrosion testing &monitoring.
- To minimize & prevent the corrosion.
- To study the corrosion control in industries

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Identify the types, mechanism, and factors influencing corrosion and describe its control measures	Analyze
CO2	Recognize types and theories of chemical bonding.	Understand
CO3	Review the types of chemical reactions	Analyze
CO4	Imbibe the concepts of chemical equilibrium.	Apply

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CO5	Analyze and assess theory of adsorption and its applications.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	3
CO2	3	3	3	3	2	3
CO3	3	3	2	3	3	3
CO4	3	3	2	3	3	3
CO5	3	3	2	3	3	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	30
Apply	10	10	40
Analyse	10	10	20
Evaluate	10	10	0
Create	10	10	0

K.S.Rangasamy College of Technology - Autonomous Regulation

60 PNT E23 - Corrosion Engineering *

Department of Nanoscience and Technology

Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
III	3	0	0	45	3	40	60	100

Note: Hours notified against each unit in the syllabus are only indicative but are not decisive. Faculty may decide the number of hours for each unit depending upon the concepts and depth. Questions need not be asked based on the number of hours notified against each unit in the syllabus**.**

Introduction to Corrosion Chemical and electrochemical corrosions- mechanism of electrochemical and galvanic corrosions- concentration cell corrosion- passivity-Pourbaix diagram- soil, pitting, inter-granular, water line, stress and microbiological corrosions- galvanic series- factors influencing corrosion - measurement of corrosion rate.	[9]
DIFFERENT FORMS OF CORROSION Atmospheric/uniform, pitting crevice, intergranular, stress corrosion, corrosion fatique, dealloying, high temperature oxidation-origin and mechanism with specific examples.	[9]
CORROSION TESTING AND MONITORING Non-Elecrochemical and Electrochemical methods: weight loss method, Tafel Linear polarization and Impedance techniques, Lab, semi plant & field tests, susceptibility test.	[9]
CORROSION PROTECTION Material selection and design Corrosion prevention through design, nano coatings, inhibitors, electrochemical protection-cathodic, anodic protection, specific applications, economics of corrosion control.	[9]

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CORROSION & ITS CONTROL IN INDUSTRIES Power, Process, Petrochemical, ship building, marine and fertilizer industries. Some case studies-Corrosion and its control in different engineering materials: concrete structures, duplex, super duplex stainless steels, ceramics, composites and polymers. Corrosion auditing in industries, Corrosion map of India.	[9]
Total Hours	**45**

Text Books	
1.	Fontana Mars G, Corrosion Engineering, 3rd Edition, Publisher: McGraw Hill Education,2020
2.	Pietro Pedeferri , Corrosion Science and Engineering, Springer Cham, 2018.
Reference(s):	
1	B. J. Little, Microbiologically Influenced corrosion, Wiley-Intersciene (2007)
2	C.A. C.Sequeira, Microbial Corrosion,European Federation of Corrosion, Maney Pub.(2000).
3.	Denny A Jones,Principles and Prevention of Corrosion (second edition),PrenticeHall, N. J.(1996).
4.	H.Videla, J. F. Wilkes, R.A.Silva, Manual of Biocorrosion, CRC Press (1996).

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Course Content and Lecture Schedule

S. No	Topic	No. of Hours
1	**PRINCIPLES OF CORROSION PHENOMENON**	
1.1	Define corrosion	1
1.2	Introduction to Thermodynamics and kinetics	1
1.3	Emf series	1
1.4	Galvanic series	1
1.5	Pourbaix diagram	1
1.6	exchange current density	1
1.7	Passivity	1
1.8	Evans diagram	1
1.9	flade potential	1
2	**DIFFERENT FORMS OF CORROSION**	
2.1	Atmospheric corrosion	1
2.2	Uniform corrosion	1
2.3	Pitting crevice	1
2.4	Intergranular	1
2.5	Stress corrosion	1
2.6	Corrosion fatique	1
2.7	Dealloying	1
2.8	High temperature oxidation-origin	1
2.9	High temperature oxidation -mechanism with specific examples	1
3	**CORROSION TESTING AND MONITORING**	
3.1	Non-Electrochemical methods	1
3.2	Electrochemical methods	1
3.3	Corrosion weight loss method	1
3.4	Tafel Linear polarization	1
3.5	Impedance techniques	1

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3.6	Corrosion lab test	1
3.7	Corrosion test in semi plant	1
3.8	field tests	1
3.9	susceptibility test	1
4	**CORROSION PROTECTION**	
4.1	Corrosion prevention through design	1
4.2	Corrosion prevention through design	1
4.3	Corrosion coatings	1
4.4	Corrosion inhibitors	1
4.5	Cathodic protection	1
4.6	Cathodic protection application	1
4.7	Anodic protection	1
4.8	Specific applications	1
4.9	economics of corrosion control	1
5	**CORROSION & ITS CONTROL IN INDUSTRIES**	
5.1	Power, Process	2
5.2	Petrochemical, ship building, marine and fertilizer industries	1
5.3	Some case studies-Corrosion and its control in different engineering materials	1
5.4	Concrete structures, duplex, super duplex stainless steels	1
5.5	Ceramics, composites	1
5.6	Polymers	1
5.7	Corrosion auditing in industries	1
5.8	Corrosion map of India	1
	Total	45

Course Designers

Dr.A. Karthik - karthik@ksrct.ac.in

60 PNT E24	**Nano safety and Environmental Issues**

Category	**L**	**T**	**P**	**Credit**
PE	3	0	0	3

Objective

- To study the need of safety and environmental issues
- To understand the concept of Nanotoxicology.
- To Identify the basic types of Analytical Methods
- To learn the ethics and applications of nanotechnology in industry
- To understand the different challenges in applications.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	To understand the specific challenges for nanomaterials	Analyze
CO2	Understand the Challenges in Nanotoxicological management.	Understand

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CO3	Identify the basic types of Analytical Methods	Analyze
CO4	Discuss the applications of nanotechnology in industry.	Apply
CO5	Analyze the different challenges in applications	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	3
CO2	3	3	2	3	3	3
CO3	3	2	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	2	3	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	30
Apply	10	10	20
Analyse	10	10	20
Evaluate	10	10	20
Create	10	10	0

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT E24 – Nano safety and Environmental Issues								
Department of Nanoscience and Technology								
Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
III	3	0	0	45	3	40	60	100
Note: Hours notified against each unit in the syllabus are only indicative but are not decisive. Faculty may decide the number of hours for each unit depending upon the concepts and depth. Questions need not be asked based on the number of hours notified against each unit in the syllabus**.**								
Over view of Nano safety Identification of Nano - Specific Risks- Responding to the Challenge -Human health hazard – Risk reduction – Standards – Safety – transportation of NP– Emergency responders. Risk assessment –Environmental Impact – Predicting hazard – Materials Characterization. Risk Assessment related to nanotechnology – Environmental and policy making- Ecotoxicity measurement of Polychlirinated biphenyl and intermediates in their degradation								[9]
NANOTOXICOLOGY * Inhalation of nanomaterials – Overview. Introduction- Inhalation deposition and Pulmonary clearance of Insoluble Solids – Bio –persistence of Inhaled solid material. Systemic Translocation of inhaled Particles. Pulmonary effects of SWCNT- Pulmonary Inflammatory Responses to SWCNTs In Vivo - Interactions of pulmonary Inflammation with oxidative stress – Interactions of SWCNTs with Macrophages								[9]
EXPERIMENTAL ISSUES * Nanoparticle exposure and systematic cardiovascular effects – experimental data – respiratory particulate matter exposure and cardiovascular toxicity, Nanoparticles – Hypothesis and								[9]

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research approaches. SWCNT – Experimental data. Toxicity of polymeric nanoparticles with respect to their application as drug carriers. Particle exposure through the indoor air environment –Measurement of indoor of PM and experimental study.	
ETHICS * Needs for regulations, training and education for health protection and environmental security of nanotechnologies – definitions and essence – general benefits – benefits for health and medical practice – potential risks – The approaches to assessment of exposure to the nanotechnology. Bioethics and legal aspects of potential health and environmental risks in nanotechnology – Legal regulatory considerations of nanotechnology.	[9]
CHALLENGES IN NANOTECHNOLOGY * Nanotechnology – the frame of worker training, public education, and participation – Introduction – Nanotoxicity – Workers protection – International documents – protection of medical staff – Nurses education – Public information. Occupational risk assessment and management – focus on Nanomaterials.	[9]
Total Hours	**45**

Text Books	
1.	Matthew Hull, Diana Bowman, Nanotechnology Environmental Health and Safety, Risks, Regulation, and Management, 3rd Edition, Imprint: Elsevier, 2018.
2.	Mark R. WiesnerJean-Yves Bottero, Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw-Hill Companies, 2007.
Reference(s):	
1	P.P. Simeonova, N. Opopol and M.I. Luster, “Nanotechnology - Toxicological Issues and Environmental Safety”, Springer 2006.
2	Vinod Labhasetwar and Diandra L. Leslie, “Biomedical Applications of nanotechnology”, A John Willy & son Inc,NJ, USA, 2007 .
3	Miyawaki, J.; *et.al* Toxicity of Single-Walled Carbon Nanohorns. *ACS Nano 2* (213–226) 2008.
4	Hutchison, J. E. Green Nanoscience: A Proactive Approach to Advancing Applications and Reducing Implications of Nanotechnology. *ACS Nano 2*, (395–402) 2008.

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Course Content and Lecture Schedule

S. No	Topic	No. of Hours
1	**INTRODUCTION**	
1.1	Identification of Nano - Specific Risks	1
1.2	Responding to the Challenge	1
1.3	Human health hazard – Risk reduction	1
1.4	Standards – Safety – transportation of NP	1
1.5	Emergency responders. Risk assessment –Environmental Impact	1
1.6	Predicting hazard	1
1.7	Materials Characterization. Risk Assessment related to nanotechnology	1
1.8	Environmental and policy making	1
1.9	Ecotoxicity measurement of Polychlirinated biphenyl and intermediates in their degradation	1
2	**NANOTOXICOLOGY**	
2.1	Inhalation of nanomaterials – Overview	1
2.2	Introduction of Inhalation deposition and Pulmonary	1
2.3	Inhalation deposition and Pulmonary clearance of Insoluble Solid	1
2.4	Bio –persistence of Inhaled solid material	1
2.5	Systemic Translocation of inhaled Particles	1
2.6	Pulmonary effects of SWCNT	1

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2.7	Pulmonary Inflammatory Responses to SWCNTs *In Vivo*	1
2.8	Interactions of pulmonary Inflammation with oxidative stress	1
2.9	Interactions of SWCNTs with Macrophages	1
3	**EXPERIMENTAL ISSUES**	
3.1	Nanoparticle exposure and systematic cardiovascular effects	1
3.2	Experimental data – respiratory particulate matter exposure and cardiovascular toxicity	1
3.3	Nanoparticles – Hypothesis	1
3.4	Nanoparticles – research approaches	1
3.5	SWCNT – Experimental data	1
3.6	Toxicity of polymeric nanoparticles with respect to their application as drug carriers	1
3.7	Particle exposure through the indoor air environment	1
3.8	Measurement of indoor of PM	1
3.9	Experimental study of indoor of PM	1
4	**ETHICS**	
4.1	Needs for regulations, training and education for health protection	1
4.2	Environmental security of nanotechnologies	1
4.3	Definitions and essence – general benefits	1
4.4	Benefits for health and medical practice	1
4.5	Potential risks	1
4.6	The approaches to assessment of exposure to the nanotechnology.	1
4.7	Bioethics of potential health and environmental risks in nanotechnology	1
4.8	Legal aspects of potential health and environmental risks in nanotechnology	1
4.9	Legal regulatory considerations of nanotechnology	1
5	**CHALLENGES AND FUTURES**	
5.1	Nanotechnology – the frame of worker training	2
5.2	Public education, and participation	1
5.3	Introduction – Nanotoxicity	1
5.4	Workers protection	1
5.5	International documents	1
5.6	protection of medical staff – Nurses education , Public information	1
5.7	Occupational risk assessment and management	1
5.8	Focus on Nanomaterials	1
	Total	45

Course Designers

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60 PNT E25	Micro and Nano Electro Mechanical Systems

Category	L	T	P	Credit
PE	3	0	0	3

Objective

- To impart the knowledge about the synthesis of nano structured semiconducting materials.
- To understand the basic about semiconducting properties of nanomaterials
- To impart the knowledge on the semiconductor nanodevices
- To understand concepts and principles of MEMS and NEMS
- To learn the basic and commercial applications of the Nanostructured materials.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Distinguish the properties between bulk and Nano-Semiconductors	Analyze
CO2	Learn the various Components and structure of Nano Semiconductors	Understand
CO3	Know the Advantages and Disadvantages of Nanostructured Semiconductors	Analyze
CO4	Analyze the concept of quantum confinement effect	Analyze
CO5	Distinguish the type of Nanostructured semiconductors	Analyze

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	2
CO2	2	2	3	3	2	2
CO3	2	3	2	3	2	2
CO4	3	2	2	2	2	3
CO5	2	2	2	2	3	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	20
Analyse	10	10	30
Evaluate	10	10	20
Create	10	10	10

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60 PNT E25 - Micro and Nano Electro Mechanical Systems *								
PNT : M.Tech – Nano Science and Technology								
Semester	**Hours / Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**CA**	**ES**	**Total**
III	3	0	0	45	3	40	60	100

Fundamentals of MEMS MEMS Introduction - Low Cost - Redundancy and Disposability – Scaling – Made – Substrates – Processing – Mask – Developing – Etching - Road Map and Perspective Silicon Substrate – Silicon Growth – Crystal - Miller Indices – Semiconductor – Doping - Additive Techniques.	[9]
Fabrication and Pattern Transformation of MEMS Photolithographic Process - Clean room - Photo Resist - Positive Resist - Negative Resist -Working with Resist – Applying Photo Resist - Exposure and Pattern Transfer - Printing Methods - Contact-Proximity – Projection Printing - Development and Post Treatment -Masks – Resolution -Sensitivity and Resist Profiles – Mask Alignment - Permanent Resists.	[9]
Fundamentals of NEMS NEMS Introduction – Basic properties - Benefits of Nanomachines – Miniaturization - NEMS Memory – Importance of AFM - Top-Down Approach - NEMS devices - NEMS Advantages**.**	[9]
Fabrication and Pattern Transformation of NEMS Materials – Carbon Allotropes - Carbon Based Materials - Metallic Carbon Nanotubes -Difficulties – Simulations - Transduction Techniques - Current Challenges and future of NEMS - Deposition processes – Lithography – Etching processes.	[9]
Applications of MEMS and NEMS Pressure sensor - Piezoresistive sensor - Capacitive sensor – Inertial sensor – Accelerometer - Gyroscope – Optical MEMS - Digital Micro mirror Device - Precision Optical Platform - Optical Data Switching - RF MEMS - MEMS switches - MEMS Resonators – Nano electro mechanical (NEM) relay – Bio MEMS & NEMS-Fabrication - Operation.	[9]
	Total hours: 45

Text Books	
1	Sergey Edward Lyshevski, Nano- and Micro-Electromechanical Systems Fundamentals of Nano- and Microengineering, Second Edition, CRC Press, 2005.
2	Thomas M.Aadams Richard A. Layton “Introductory MEMS” Fabrication and Applications, Springer 2014
Reference(s):	
1	Tai-Ran Hsu, “MEMS & MICRO SYSTEMS Design and Manufacture” McGraw Hill Education PVT Ltd 2013.
2	Rai-Choudhury “MEMS and MOEMS Technology and Applications” PHI Learning PVT Ltd 2012
3	Bhushan.B “MEMS/NEMS and Bio MEMS/NEMS” Springer Handbook of Nanotechnology, Springer 2007

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Course Content and Lecture Schedule

S. No	Topic	No. of Hours
1	**Fundamentals of MEMS**	
1.1	MEMS Introduction	1
1.2	Low Cost	1
1.3	Redundancy and Disposability	1
1.4	Scaling ,Made Substrates	1
1.5	Processing ,Mask and Developing	1
1.6	Road Map and Perspective Silicon Substrate	1
1.7	Silicon Growth Crystal - Miller Indices	1
1.8	Semiconductor Doping	1
1.9	Additive Techniques	1
2	**Fabrication and Pattern Transformation of MEMS**	
2.1	Photolithographic Process	1
2.2	Clean room	1
2.3	Photo Resist - Positive Resist , Negative Resist	1
2.4	Working with Resist – Applying Photo Resist	1
2.5	Exposure and Pattern Transfer Printing Methods	1
2.6	Contact Proximity and Projection Printing	1
2.7	Development and Post Treatment Masks and Resolution	1
2.8	Sensitivity and Resist Profiles	1
2.9	Mask Alignment and Permanent Resists.	1
3	**Fundamentals of NEMS NEMS**	
3.1	Introduction	1
3.2	Basic properties	1
3.3	Benefits of Nanomachines	1
3.4	Miniaturization	1
3.5	NEMS Memory	1
3.6	Importance of AFM	1
3.7	Top-Down Approach	1
3.8	NEMS devices	1
3.9	NEMS Advantages.	1
4	**Fabrication and Pattern Transformation of NEMS**	
4.1	Materials	1
4.2	Carbon Allotropes	1
4.3	Carbon Based Materials	1
4.4	Metallic Carbon Nanotubes	1
4.5	Difficulties, Simulations	1
4.6	Transduction Techniques, Current Challenges and future of NEMS	1
4.7	Deposition processes	1
4.8	Lithography	1
4.9	Etching processes.	1
5	**Applications of MEMS and NEMS**	
5.1	Pressure sensor	1
5.2	Piezoresistive sensor, Capacitive sensor	1

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5.3	Inertial sensor , Accelerometer	1
5.4	Gyroscope, Optical MEMS	1
5.5	Digital Micro mirror Device, Precision Optical Platform	1
5.6	Optical Data Switching, RF MEMS	1
5.7	MEMS switches	1
5.8	MEMS Resonators	1
5.9	Nano electro mechanical (NEM) relay –Fabrication, Operation.	1
	Total	45

Course Designers

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60 PNT E26	**Nanotechnology in Industry**

Category	**L**	**T**	**P**	**Credit**
PE	**3**	**0**	**0**	**3**

Objective

- To understand the fundamental concept of contacting industrial concepts
- To study the basics structure about industrial based nanotechnology development
- To acquire knowledge of Nanotechnology In Industrial Production & Manufacturing
- To learn the Environmental, Health & Safety Issues
- To understand the industrial concepts in nanotechnology

Prerequisite

Basics of industry applications

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understand the basics concept of industrial requirements	Remember
CO2	Address about the surface interaction of micro and nanoscale object	Analyze
CO3	Explain the fundamental theories and experimental effects of Nanotechnology	Apply
CO4	Illustrate the experimental mechanical characterization of nanomaterials	Analyze
CO5	Distinguish the applications of nanotechnology in various industrials.	Apply

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	1

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Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyze	10	10	30
Evaluate	10	10	20
Create	10	10	10

K.S.Rangasamy College of Technology - Autonomous Regulation

60 PNT E26 – Nanotechnology in Industry *

Department of Nanoscience and Technology

Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
III	3	0	0	45	3	40	60	100

Nanotechnology in Electrical and Electronics Industry Advantages of nano electrical and electronic devices – Electronic circuit chips – Nanosensors and actuators, Optical switches – Diodes and Nano-wire transistors - Memory storage – Lighting and displays – Filters (IR blocking) – Quantum computers – Energy devices – Medical diagnosis – Conductive additives - Lead-free solder – Nanocoatings –EMI shielding.	[9]
Nanotechnology in Textiles and Cosmetics Nano finishing in textiles (UV resistant, anti-bacterial, hydrophilic, self-cleaning, flame retardant finishes) – Modern textiles (Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof clothes), Nanopolymers in medical textiles. Cosmetics: Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) – Sun-screen dispersions for UV protection using titanium oxide – Colour cosmetics.	[9]
Nanotechnology in industrial water treatment Mechanism for remediation of aqueous contaminants, photocatalyst; membranes incorporating nanomaterials, transport processes in membrane technology; nanomaterial based adsorbents for water and wastewater treatment – adsorption at metal oxide surfaces, hybrid adsorbents; case studies. Hierarchical self-assembled nano-structures and nanomaterials for adsorption of heavy metals.	[9]
Nanotechnology in food industry: Food and New Ways of Food Production - Efficient Fractionation of Crops Efficient Product Structuring -Optimizing Nutritional Values - Applications of Nanotechnology in Foods : Sensing, Packaging, Encapsulation, Engineering Food Ingredients to Improve Bioavailability - Nanocrystalline Food Ingredients - NanoEmulsions - Nano-Engineered Protein Fibrils as Ingredient Building Blocks Preparation of Food Matrices - Concerns about Using Nanotechnology in food production.	[9]
Nanotechnology in Defence Military applications of Nanotechnology - Artificial intelligence materials - Propulsion – Vehicles - Propellants and Explosives – Camouflage distributed sensors - Amour protection - Conventional weapons - Soldier systems - Implanted systems, Body manipulation - Autonomous systems - Mini-/Micro robots - Bio-technical hybrids - Small satellites and Space launchers - Nuclear weapons - Chemical weapons - Biological weapons - Chemical/Biological protection.	[9]
Total Hours	**45**

Text Book(s)

1	P. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead publication, London, 2006.
2	J. Altmann, Routledge, Military Nanotechnology: Potential Applications and Preventive Arms Control, Taylor and Francis Group, 2006

Reference(s)

1	Diallo, M., Duncan, J., Savage, N., Street, A., and Sustich, R. (Eds). "Nanotechnology Applications for Clean Water" William Andrew. 2008
2	P. J. Brown and K. Stevens, "Nanofibers and Nanotechnology in Textiles", Woodhead Publishing Limited, Cambridge, 2007
3	Q. Chaudry, L.Castle and R. Watkins Nanotechnologies in Food, RSC Publications,

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	2010.
4	Tian C.Z., Rao Y.S., Keith C.K.L., Zhiqiang H.,Tyagi R.D., Irene M.C.L, "Nanotechnologies For Water Environment Applications", ASCE publications, 2009

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Course Contents and Lecture Schedule

S.No	Topic	No. of Hours
1	**INDUSTRIAL APPLICATIONS OF NANOTECHNOLOGY**	
1.1	Nanotechnology in Consumer Products Inventory – Textiles	1
1.2	Cosmetics	1
1.3	Paint and Sports	1
1.4	Health care industry	1
1.5	Nanotechnology in Electronics	1
1.6	Automobile Industry	1
1.7	National Security	1
1.8	Defense – camaflaudge nuclear weapon	1
1.9	Space launcher- chemical and biological weapons	1
2	**THERMAL INSULATION AND ENERGY SAVINGS**	
2.1	Thermal Insulation	1
2.2	Insulation Works	1
2.3	R –Values, Types of Insulation	1
2.4	Insulation Materials, Radiant barriers	1
2.5	Moisture Control Ventilation, Calculating requirements	1
2.6	Factors influencing performance, Energy Saving	1
2.7	Energy Design for efficiency – Electricity & Fuel,	1
2.8	Electronics, Automobile, Planning renewable systems Solar electric systems	1
2.9	Wind electric systems, Hybrid wind and solar, Micro hydropower systems	1
3	**INDUSTRIAL ECOLOGY**	
3.1	Material flows in chemical manufacturing	1
3.2	Industrial parks	1
3.3	Assessing opportunities for waste exchanges and by product synergies	2
3.4	Lead Encapsulation	1
3.5	Reduce Carbon Footprint and Green House Gases (GHG)	1
3.6	Leadership In Energy & Environmental Design	1
3.7	LEED For Buildings	1
3.8	LEEDs in Home, Schools	1
4	**NANOTECHNOLOGY IN INDUSTRIAL PRODUCTION & MANUFACTURING**	
4.1	Nanotechnology in Construction	1
4.2	Cement-Steel-Wood-Glass-Coatings	1
4.3	Fire Protection and detection	1
4.4	Risks in construction	1
4.5	Nanostructured materials in Manufacturing	1
4.6	Nanocomposites	1
4.7	Nanocrystals- Nano clays and nanocomposites	1
4.8	Nanocomposite coatings	1
4.9	Nanotubes, Nano catalysts, Nano filters	1
5	**INDUSTRIAL LAWS AND ENVIRONMENTAL CONCERNS**	

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5.1	Economic Impacts & Commercialization of Nanotechnology	1
5.2	Environmental, Health & Safety Issues	1
5.3	Social & Ethical Implications	1
5.4	Industrial Approach- Sustaining the Impact of Nanotechnology on Productivity	1
5.5	Sustainability and Equity	1
5.6	The Emerging Nano Economy	1
5.7	Key Drivers, Challenges & Opportunities	1
5.8	Regulation Of Nanotechnology In Consumer Products	1
5.9	Legal Policy Issues	1
	Total	45

Course Designer

Dr. S. Satheeskumar (satheeskumars@ksrct.ac.in)

60 PNT E31	**Social Impact of Nanotechnology**

Category	**L**	**T**	**P**	**Credit**
PE	3	0	0	3

Objective

- To help the learners to understand the challenges of synthesis nano materials
- To provide an overview of the Challenges in Storage and fabrication
- To familiarize learners with Challenges in Nanotoxicological management
- To familiarize the learners Challenges in health care and biomedical area
- To enlighten the learners to understand various methods, materials and it applications

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understand the emerging ideas of challenges of synthesis of nanomaterials	Remember
CO2	To understand the specific challenges for nanomaterials	Apply
CO3	Describe the Challenges in Storage	Analyze
CO4	Recognize the Challenges fabrication of nanomaterials	Apply
CO5	Understand the Challenges in Nano toxicological management	Analyze

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	1

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Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyze	10	10	20
Evaluate	10	10	20
Create	10	10	10

K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNTE31 - Social Impact of Nanotechnology								
Department of Nanoscience and Technology								
Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
III	3	0	0	45	3	40	60	100

Protocols in Nanomaterials Challenges - Green synthesis of Nanoparticles - Iron Oxide Nanoparticles -Critical needs and Significant - Development and Potential Impact of Microfluidic Systems on Different Steps - Specific Challenges-Nanomaterials Design – Synthesis of Nanomaterials.	[9]
Fabrication and Storage of Nanomaterials Challenges in fabrications - Nano composites Thin Films -Surface Energy-Surface Area -Size, Uniform Size Distribution-Morphology-Crystallinity, Chemical Composition-Storage - Microstructure-Nanomaterials-Solid State Hydrogen Storage- Lithium Based Rechargeable Batteries.	[9]
Nano toxicological Management** Toxicant Analysis and Quality Assurance Principles – General Policies Related to Analytical Laboratories – Standard Operating Procedures (SOPs) - QA/QC Manuals – Procedural Manuals –Analytical Methods Files – Laboratory Information Management System (LIMS) – Analytical Measurement System – Quality Assurance (QA) Procedures – Quality Control (QC) Procedures	[9]
Protocols in Health care and Biomedical Area * Challenges - Understanding Environmental and Biological Impacts of Nanoparticles-Self Assembly-Molecular Manufacturing - Nanoparticle Safety - Pesticides - Food - Water - Air - Soil-BiodegradableandBiocompatible-ToxicologyinCardiovascularChallenges.	[9]
Implementation of Nanotechnology In Industry ** Factor - Effecting of The Implementation - Role of Advanced Technology In Implementation- Strategic Involved in Implementation – Commercialization Challenges – Market Opportunities and Challenges – Critical Success Factor - Nano Regulating Mechanism.	[9]
Total Hours	**45**

Textbook(s):	
1.	Takuya Tsuzuki "Nanotechnology Commercialization, Pan Stanford Publishing, Taylor & Francis Group, 2013.
2.	RobertA.Varin, Tomasz C zujko, Zbigniew S. Wronski" Nanomaterials for Solid State Hydrogen Storage" springer, 2009.
Reference(s):	
1.	David A Dana "The nanotechnology challenge" Cambridge university press, 2012.
2.	Ernest Hodgson "A Text Book Of Modern Toxicology", Wiley & Sons, Inc Publication, 20017
3.	Ahmed S. Khan, Nanotechnology Ethical and Social Implications, 1st Edition, CRC Press, 2012.

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***SDG :11 safe, resilient and sustainable**
***SDG:12 Ensure sustainable consumption and production patterns**

Course Content and Lecture Schedule

S.No	Topic	No. of Hours
1	**PROTOCOLS IN NANOMATERIALS**	
1.1	Challenges - Green synthesis of Nanoparticles	1
1.2	Iron Oxide Nanoparticles	1
1.3	Critical needs and Significant	1
1.4	Development and Potential Impact of Microfluidic Systems on Different Steps	1
1.5	Specific Challenges	1
1.6	Nanomaterials Design	1
1.7	Synthesis of Nanomaterials	1
2	**FABRICATION AND STORAGE OF NANOMATERIALS**	
2.1	Challenges in fabrications – Nanocomposites	1
2.2	Thin Films – Surface Energy	1
2.3	Surface Area - Size, Uniform Size Distribution	1
2.4	Morphology – Crystallinity	1
2.5	Chemical Composition	1
2.6	Storage	1
2.7	Microstructure	1
2.8	Nanomaterials – Solid State Hydrogen Storage	1
2.9	Lithium Based Rechargeable Batteries	1
3	**NANOTOXICOLOGICAL MANAGEMENT**	
3.1	Toxicant analysis	1
3.2	Quality assurance principles	1
3.3	General policies related to analytical laboratories	1
3.4	Standard operating procedures (SOPs)	1
3.5	QA/QC Manuals – Procedural Manuals	1
3.6	Analytical Methods Files	1
3.7	Laboratory Information Management System (LIMS)	1
3.8	Analytical Measurement System	1
3.9	QualityAssurance(QA), Procedures-QualityControl(QC) Procedures	1
4	**PROTOCOLS IN HEALTH CARE AND BIOMEDICAL AREA**	
4.1	Challenges	1
4.2	Understanding Environmental and Biological Impacts of Nanoparticles	1
4.3	Self Assembly	1
4.4	Molecular Manufacturing	1
4.5	Nanoparticle Safety - Pesticides - Food - Water - Air – Soil	1
4.6	Biodegradable Biocompatible	2
5	**IMPLEMENTATION OF NANOTECHNOLOGY IN INDUSTRY**	
5.1	Effecting of The Implementation-	1
5.2	Role of Advanced Technology In Implementation	1
5.3	Strategic involved in implementation	1
5.4	Commercialization Challenges	1
5.5	Market opportunities and challenges	1
5.6	Critical success factor	2
5.7	Nano regulating mechanism	2
	Total	45

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Course Designers

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60 PNT E32	Computer Modeling and Simulation

Category	L	T	P	Credit
PE	3	0	0	3

Objective

- To study the basic computation methods
- To understand the modeling analysis.
- To study the Boundary analysis.
- To introduced various system modeling & mathematical approaches simulation techniques
- To highlight the different application areas.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Relate the appropriate characteristics of nanoparticles by correlating the theoretical	Understand
CO2	Draw the modeling and simulation of a digital control design approach.	Apply
CO3	Analyze various problem solving techniques with categories of software	Analyze
CO4	Discuss the monte - carlo simulation of particles in a Box - Diffusion using Matlab.	Apply
CO5	Recognize the generation and application of computers	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	2
CO2	2	3	3	3	3	3
CO3	3	3	3	2	3	3
CO4	3	3	2	3	3	3
CO5	3	3	2	3	3	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	20
Analyse	10	10	30
Evaluate	10	10	20
Create	10	10	10

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K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT E32 - Computer Modeling and Simulation *								
Department of Nanoscience and Technology								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**C**	**E**	**Total**
III	3	0	0	45	3	40	60	100

REVIEW OF COMPUTATIONAL METHODS Solution of ordinary differential equations, Initial value and boundary value problems.	[9]
MODELING Classification, Functions, Limitations and interrelationship of different types of models, Types and development of mathematical model. Development of rigorous and semirigorous physical models.	[9]
BOUNDARY ANANLYSIS Solution of partial differential equations, Initial value and boundary value problems, Hyperbolic, parabolic and elliptic equations, Explicit and Implicit methods, Finite difference methods. Finite element method.	[9]
SIMULATION Survey of simulation techniques, Molecular dynamics and Monte- Carlo simulations. Fuzzy Logic, neural networks and genetic algorithms.	[9]
APPLICATIONS Application of above to model materials behavior and metallurgical processes.	[9]
Total Hours	**45**

Text Books	
1.	Louis G. Birta , Gilbert Arbez , Modelling and Simulation Exploring Dynamic System Behaviour, Springer Cham, 2019.
2.	Boris Igelnik, Computational Modeling and Simulation of Intellect Current State and Future Perspectives 2011 Edition, IGI Global, 2011.
Reference(s):	
1.	Tuncer Ören, Bernard P. Zeigler, and Andreas Tolk, Body of Knowledge for Modeling and Simulation: A Handbook by the Society for Modeling and Simulation International, MTRE corporation, 2023
2.	Vladimir Mityushev, Wojciech Nawalaniec, Natalia Rylko, Introduction To Mathematical Modeling And Computer Simulations Hardcover, Chapman and Hall/CRC, 2018
3.	Riccardo De Asmundis, Modeling, Programming and Simulations Using LabVIEW™ Software Hardcover, In Tech, 2011.

***SDG :4 quality education and promote lifelong learning opportunities for all**

Course Content and Lecture Schedule

S. No	Topic	No. of Hours
1	**REVIEW OF COMPUTATIONAL METHODS**	
1.1	Basics of ordinary differential equations	1
1.2	Basics of ordinary differential equations	1
1.3	Solution of ordinary differential equations	1
1.4	Review of Initial value problems	1
1.5	Solve Initial value problems	1
1.6	Review of boundary value problems	1
1.7	Solve boundary value problems	1

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1.8	Relate the appropriate characteristics of nanoparticles by correlating the theoretical	1
1.9	Review of Computational Methods	1
2	**MODELING**	
2.1	Introduction to modeling analysis	1
2.2	Classification	1
2.3	Functions	1
2.4	Limitations of different types of models	1
2.5	Interrelationship of different types of models	1
2.6	Types of mathematical model	1
2.7	Development of mathematical model	1
2.8	Development of rigorous physical models	1
2.9	Development of semi rigorous physical models	1
3	**BOUNDARY ANANLYSIS**	
3.1	Solution of partial differential equations	1
3.2	Initial value problems	1
3.3	boundary value problems	1
3.4	Hyperbolic	1
3.5	parabolic and elliptic equations	1
3.6	Explicit methods	1
3.7	Implicit methods	1
3.8	Finite difference methods	1
3.9	Finite element method	1
4	**SIMULATION**	
4.1	Survey of simulation techniques	1
4.2	Molecular dynamics simulation	1
4.3	Basics of Fuzzy Logic	1
4.4	Basics of neural networks	1
4.5	Basics of genetic algorithms	1
4.6	Monte- Carlo simulations	1
4.7	Fuzzy Logic simulation techniques	1
4.8	Neural networks simulation techniques	1
4.9	Genetic algorithms simulation techniques	1
5	**APPLICATIONS**	
5.1	Molecular dynamics simulation to model material	2
5.2	Monte- Carlo simulations to model material	1
5.3	Fuzzy Logic simulation techniques to model material	1
5.4	Neural networks simulation techniques to model material	1
5.5	Genetic algorithms simulation techniques to model material	1
5.6	Behavior process	1
5.7	Metallurgical processes	1
5.8	Application of behavior and metallurgical processes	1
	Total	45

Course Designers

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60 PNT E33	Nanotechnology in Defense and Security

Category	L	T	P	Credit
PE	3	0	0	3

Objective

- To provide exposure to the students on nano science and technology in defence activities
- To explore various nanomaterials used in multifunctional systems and applications.
- To enlighten the learners to understand various applications areas of nanomaterials
- To understand Nano rods based chemical sensors for underwater applications.
- To study about the potential applications of Nanotechnology in defence activities

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Observe the military applications of nanotechnology in various propellants and explosives.	Remember
CO2	Develop protection the Satellites against Missile Attacks using quantum dots.	Create
CO3	Analyze the nanotechnology usage in Camouflage, Stealth, Ablative Applications.	Analyse
CO4	Address different applications of sensors with the use of Nano-enabled sensors.	Analyse
CO5	Acquire knowledge of Nanotechnology in safety and environment applications	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	3	2
CO2	2	3	2	3	2	1
CO3	3	2	3	2	2	2
CO4	3	2	3	2	3	2
CO5	2	2	2	3	2	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	30
Apply	10	10	20
Analyse	10	10	20
Evaluate	10	10	20
Create	10	10	0

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K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT E33 - Nanotechnology in Defense and Security *								
Department of Nanoscience and Technology								
Semester	Hours/Week			Total hrs	Credit	Maximum Marks		
	L	T	P		C	C	E	Total
III	3	0	0	45	3	40	60	100

Nano Science and Technology activities Pathways to physical protection – Responding to a new threat environment – Nanotechnology enabled bio chemical weapons – Nuclear Bio Chemical (NBC) Sensor- Military applications – Propulsion and vehicles – Propellants and Explosives – Artificial intelligence materials.	[9]
Countermeasure and Aerospace Strategies Detection and diagnostics of chemical and biological agents – Quantum Dots to protect satellites from missile attacks – Nanotechnology for camouflage and stealth Applications – Nano-reinforced composites for structural and ablative applications – Nanocomposite as burning rate catalysts for composite solid propellants.	[9]
Sensors and Actuators Nano-mechanical Sensors for Security and Surveillance Systems – Nuclear Technology – Real Time Anti-vibration mount using a Nano shear thickening fluid – Nano-crystallites for Transducer Applications – Nanomaterials for sensors - Underwater, LPG and Chemical agent.	[9]
Applications of Nanocomposites Role of Nanotechnology in Next Generation Permanent Magnets – Nano Structured Steels for next generation power plants – Polymer Nanocomposites for Defence applications – Nanofluids in reinforcing soft body armour materials – Super hydrophobic coatings – Nano electron emitters for vacuum electron devices.	[9]
Nanotechnology in Safety, Environment and Healthcare Nanotechnology for environmental safety – Green nanocatalyst – Nanoparticles in bio-sensing and early diagnostics in contaminant food – Nanomaterials in Dentistry – Nanomaterilas in biomedical and cancer hyperthermia Applications – Carbon nanotube for mobile water purification unit - Textiles - Biological and medical applications - Membrane based water purification, Energy and Environment - Solar cells and Batteries	[9]
Total Hours	**45**

Text Books	
1	Madhuri Sharon, Angelica S. L. Rodriguez, Chetna Sharon, Pio Sifuentes Gallardo, Nanotechnology in the Defense Industry: Advances, Innovation, and Practical Applications, Wiley,Scrivener Publisher, 2019.
2	Terri A. Camesano, Nanotechnology to Aid Chemical and Biological Defense (NATO Science for Peace and Security Series A: Chemistry and Biology) 1st Edition, Springer, 2015.
Reference(s):	
1	R. Mahajan, “Nanotech Insights”, Issue 3 Centre for Knowledge Management of Nanosci. &Technology , India, 2014.
2	Christian Ngo, Marcel H. Van de Voorde, “Nanotechnology for Defense and Security”, Springer, 2014.
3	Jerome. C. Glenn, “Nanotechnology: Future military environmental health considerations”, Elsevier, 2006.
4	Chang W.N., “Nanofibres fabrication, performance and applications’, Nova Science Publishers Inc, 2009

***SDG :8 productive employment**

Course Content and Lecture Schedule

S.No	Topic	No. of Hours
1	**NANO SCIENCE AND TECHNOLOGY ACTIVITIES**	
1.1	Pathways to physical protection	1
1.2	Responding to a new threat environment	1

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1.3	Nanotechnology enabled bio chemical weapons – Nuclear Bio Chemical (NBC) Sensor	1
1.4	Military applications	1
1.5	Directed self-assembly using conventional lithography	1
1.6	Propulsion and vehicles	1
1.7	Propellants and Explosives	1
1.8	Artificial intelligence materials	1
2	**COUNTERMEASURE AND AEROSPACE STRATEGIES**	
2.1	Detection and diagnostics of chemical and biological agents	1
2.2	Quantum Dots to protect satellites from missile attacks	1
2.3	Nanotechnology for camouflage and stealth Applications	1
2.4	Nano-reinforced composites for structural and ablative application	1
2.5	Nanocomposite as burning rate catalysts for composite solid propellants	1
3	**SENSORS AND ACTUATORS**	
3.1	Nano-mechanical Sensors for Security and Surveillance Systems	1
3.2	Nuclear Technology	1
3.3	Real Time Anti-vibration mount using a Nano shear thickening fluid	1
3.4	Nano-crystallites for Transducer Applications	1
3.5	Nanomaterials for sensors	1
3.6	Underwater, LPG and Chemical agent.	1
4	**APPLICATIONS OF NANOCOMPOSITES**	
4.1	Role of Nanotechnology in Next Generation Permanent Magnets	1
4.2	Nano Structured Steels for next generation power plants – Polymer Nanocomposites for Defence applications	1
4.3	Nanofluids in reinforcing soft body armour materials	1
4.4	Super hydrophobic coatings	1
4.5	Nano electron emitters for vacuum electron devices	1
5	**NANOTECHNOLOGY IN SAFETY, ENVIRONMENT AND HEALTHCARE**	
5.1	Nanotechnology for environmental safety	1
5.2	Green nanocatalyst	1
5.3	Nanoparticles in bio-sensing and early diagnostics in contaminant food	1
5.4	Nanomaterials in Dentistry	1
5.5	Nanomaterilas in biomedical and cancer hyperthermia Applications	1
5.6	Carbon nanotube for mobile water purification unit	1
5.7	Textiles	1
5.8	Biological and medical applications	1
5.9	Membrane based water purification, Energy and Environment	1
5.10	Solar cells and Batteries	1
	Total hours	45

Course Designer

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60 PNT E34	Nanotechnology in Food Preservation and Safety Management

Category	L	T	P	Credit
PE	3	0	0	3

Objective

- To acquire extensive knowledge in food safety and quality control.
- To understand food safety management in different packing process
- To study the food Laws and its standard measurement system
- To analysis food equipment, disposal of waste, importance food preservation materials.
- To learn the Nanotechnology in Food Packaging techniques, advantages and its applications.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Explore basic principles of food safety quality control and the safety measures in Handling of food equipment and disposal of waste.	Apply
CO2	Recognize the importance of food quality management and the importance of GLP, GMP and HACCP concept.	Analyze
CO3	Follow the regulations of FSSAI, ISO, food Adulteration Act and the importance of export opportunities and its regulations related to food products	Apply
CO4	Identify the significance of packaging, the regulations and designing for packaged foods.	Remember
CO5	Analyze the roles of nanotechnology in packaging, the types of Nanocoating and food packaging applications	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	3	3	1
CO2	3	2	2	2	2	3
CO3	3	2	2	3	3	1
CO4	3	3	3	3	2	3
CO5	3	3	3	1	2	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyse	10	10	20
Evaluate	10	10	20
Create	10	10	10

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K.S.Rangasamy College of Technology - Autonomous Regulation								
60 PNT E34 - Nanotechnology in Food Preservation and Safety Management *								
Department of Nanoscience and Technology								
Semester	**Hours/Week**			**Total hrs.**	**Credit**	**Maximum Marks**		
	L	**T**	**P**		**C**	**C**	**E**	**Total**
III	3	0	0	45	3	40	60	100

Food safety implementation Principles of food safety and quality control -Training & Education for safe methods of handling food in industries; cleaning and sanitization of processing plants; principles of cleaning and sterilization - types ; selecting and installing equipment; Safety limits of sanitizers; pest control; management and disposal of waste.	[9]
Food Safety Management Food safety and quality management systems- Physical, chemical and Microbial hazards and their control in food industry; Good laboratory practice (GLP); Good manufacturing practices (GMP); Hazard analysis of critical controlpoints(HACCP).	[9]
Food laws Food Safety and Standards Act (FSSAI), ISO 22000 – Importance and Implementation; Prevention of Food Adulteration Act, QA Audit, IPR and Patents, Export opportunities for food products - APEDA (Agricultural and Processed Foods Export Development Authority);WTO	[9]
Food Packaging Packaging – it's importance, essential features of an ideal package; various food packaging materials and their characteristics, methods of package testing, modern and traditional packaging material recent trends in the field of packaging (active packaging, intelligent packaging, RFID), regulations and designing for packaged foods , nutritional labeling.	[9]
Nanotechnology in Food Packaging Nanotechnology in food industry and packaging, Food processing and bio-security –Contaminant detection – Smart packaging, Antimicrobial Functionality, Nano Structured Coating, Natural biopolymers, advantages of nanomaterials in food packaging applications.	[9]
Total Hours	**45**

Text Books	
1	Arun Sharma, P.S. Vijayakumar, ... Ritesh Kumar, Nanotechnology Applications for Food Safety and Quality Monitoring, Elsevier, Imprint, Academic Press, 2022.
2	Veslesmoy Anderson, Food Saftey Management, A Practical guide for food Industry,2 nd Edition, Elsevier, Academic Press, 2023.
Reference(s):	
1	Athalye AS. Plastics in Food Packaging Tata McGraw Hill Publishing Company 1992.
2	Mortimone, Sara and Wallace, Carot, —HACCP (Food Industry Briefing Series), Blackwell Science,
3	RadomirLásztity, FOOD QUALITY AND STANDARDS – Vol. III - Food Laws and Regulation - 2009
4	Yasmine Motarjemi, Huub Lelieveld, Food safety management – A practical guide for the food industry (pp.559-621): Chapter: Hygiene in primary production – Fish hygiene Publisher: 2014.

***SDG :2 food security and improved nutrition and promote sustainable agriculture**

Course Content and Lecture Schedule

S.No	Topic	No. of Hours
1	**FOOD SAFETY IMPLEMENTATION**	
1.1	Principles of food safety.	1
1.2	Food safety quality control.	1
1.3	Cleaning and sanitization.	1
1.4	Sterilization-physical methods.	1
1.5	Sterilization- Chemical methods and filtration.	1

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1.6	Pest control methods.	1
1.7	Training and education for food handling.	1
1.8	Safety limits of sanitizers.	1
1.9	Disposal of wastes.	1
2	**FOOD SAFETY MANAGEMENT**	
2.1	Food safety management introduction.	1
2.2	Food safety quality management system.	1
2.3	Types of hazards.	1
2.4	Control of hazards.	1
2.5	Good laboratory practices.	1
2.6	Training on GLP.	1
2.7	Good manufacturing practices.	1
2.8	Hazard analysis of critical control points.	1
2.9	HACCP principles.	1
3	**FOOD LAWS**	
3.1	Introduction to food laws	1
3.2	FSSAI	1
3.3	ISO 22000	1
3.4	Prevention of food adulteration.	1
3.5	QA audit	1
3.6	Intellectual property rights	1
3.7	Export opportunities of food	1
3.8	APEDA	1
3.9	World Trade Organization	1
4	**FOOD PACKAGING**	
4.1	Food packaging introduction	1
4.2	Essential features of an ideal packaging	1
4.3	Various food packaging materials	1
4.4	Methods of package testing	1
4.5	Modern and traditional packaging	1
4.6	Active packaging methods	1
4.7	Intelligent packaging and RFID packaging	1
4.8	Regulations and designing for packaged foods.	1
4.9	Nutritional labelling	1
5	**NANOTECHNOLGOY IN FOOD PACKAGING**	
5.1	Nanotechnology in food industry	2
5.2	Food processing methods	1
5.3	Biosecurity	1
5.4	Contaminant detection methods	1
5.5	Smart packaging techniques	1
5.6	Antimicrobial functionality of materials	1
5.7	Nanostructured coatings.	1
5.8	Natural biopolymers	1
5.9	Advantages of nanomaterials in food packaging	1
	Total	45

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BoS Chairman

Course Designers

Mr. R. Mohanraj (mohanrajr@ksrct.ac.in)

60 PNT E35	**Nanotechnology in Textile and Agriculture Industry**

Category	L	T	P	Credit
BS	3	0	0	3

Objective

- To provide an insight into the fundamentals of Nanomaterials based fabrics.
- To address modern trends in nano Nano Fiber Production
- To help the learners to understand Nano Finishing In Textiles
- To obtain the knowledge of the Agricultural Nanotechnology
- To know the role of nanoparticles in Precision farming and Plant Resource Management for future amelioration.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Learn the scientific concepts underlying engineering and technological applications in Nano-textiles	Understand
CO2	Identify suitable nanoparticles & Nano fibers in design methodology in textiles	Analyze
CO3	Successful completion of Nano Composites implementation in textiles	Analyze
CO4	Evaluate agricultural technology for precision farming using Nano sensors	Apply
CO5	Familiarize with the regulations and guidelines in agricultural sector	Remember

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	2
CO2	2	3	2	3	2	2
CO3	3	3	2	2	2	3
CO4	2	2	2	2	3	3
CO5	3	3	2	2	2	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Sem Examination (Marks)
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	10	10	30
Analyse	10	10	20
Evaluate	10	10	20
Create	10	10	10

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60 PNT E35 - Nanotechnology in Textile and Agriculture Industry

PNT : M.Tech – Nano Science and Technology

Semester	Hours / Week			Total Hours	Credit	Maximum Marks		
	L	T	P		C	CA	ES	Total
III	3	0	0	45	3	40	60	100

Properties of Nano fibers Physical properties - Mechanical properties- Thermal properties - Chemical properties - Self-assembly- Hydrophobic and Hydrophilic properties - Electrical properties -Super paramagnetic coating.	[9]
Production and Functionality of Nano fibers Electro spinning of Nano fibers – Characterization analysis of Nanofibers - Continuous yarns from electro spun Nano fiber - Controlling the morphologies of electro spun Nano fiber - Nanostructured polymers with cyclodextrins – Electrospinning by capillary method and charge injection method- Preparation of polymer/clay Nano composites.	[9]
Fabrication of nano composites in Textiles Scaffold fabrication and electrospinning- scaffolds for tissue engineering - Synthesis of smart switchable coatings - Anti-adhesive nanocoating of fibers and textiles - Polymer fiber using melt spinning- Multifunctional polymer Nano composites - nylon-6 Nano composites from polymerization.	[9]
Nanotechnology in Agriculture * Natural resource management- Soil fertility management- Precision farming and smart delivery system- Precision agriculture monitoring system- Smart delivery systems- Crop improvement- Crop protection- Seed germination, growth and development- Sensing of air pollutant by nanomaterial-soil remediation-plant Nano bionics	[9]
Applications in Textile and Agriculture * Agriculture: Nano formulations of agrochemicals- nano sensors in crop protection -identification of diseases and residues- nano sensor for air pollution control- - Nano pesticides- smart fertilizer for crop nutrition-Nano robotics in agriculture. Textile : Soil resistance, wrinkle resistance, anti-bacteria, anti-static and UV-protection, flame retardation, improvement of dye ability and Self-cleaning fabrics	[9]
	Total hours: 45

Text Books

1	Aminoddin Haji, Luqman Jameel Rather, Mohd Shabbir, Sustainable Practices in the Textile Industry, Wiley, 2021
2	Baby Kumari, M. Anwar Mallick, Manoj K. Solanki, Suresh Kumar Verma, Nanotechnology in Sustainable Agriculture, CRC Press, 2021

Reference(s):

1	Javed N. Sheikh, Mohd Shabbir, Shakeel Ahmed, Frontiers of Textile Materials Polymers, Nanomaterials, Enzymes, and Advanced Modification Techniques, Wiley, 2020
2	Mangala Joshi, Nanotechnology in Textiles Advances and Developments in Polymer Nanocomposites, Jenny Stanford Publishing, 2020.
3	Challa, S.S.R. Kumar, Josef Hormes, Carola Leuschaer,"Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact", Wiley – VCH, 2005.

***SDG :2 Promote sustainable agriculture**

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Course Content and Lecture Schedule

S. No	Topic	No. of Hours
1	**Properties of Nano fibers**	
1.1	Physical properties	1
1.2	Mechanical properties	1
1.3	Thermal properties	1
1.4	Chemical properties	1
1.5	Self-assembly	1
1.6	Hydrophobic properties	1
1.7	Hydrophilic properties	1
1.8	Electrical properties	1
1.9	Super paramagnetic coating	1
2	**Production and Functionality of Nano fibers**	
2.1	Electro spinning of Nano fibers	1
2.2	Characterization analysis of Nanofibers	1
2.3	Continuous yarns from electro spun Nano fiber	1
2.4	Controlling the morphologies of electro spun Nano fiber	1
2.5	Nanostructured polymers with cyclodextrins	1
2.6	Electrospinning by capillary method	1
2.7	charge injection method	1
2.8	Preparation of polymer Nano composites	1
2.9	Preparation of clay Nano composites	1
3	**Fabrication of nano composites in Textiles**	
3.1	Scaffold fabrication	1
3.2	Electrospinning	1
3.3	scaffolds for tissue engineering	1
3.4	Synthesis of smart switchable coatings	1
3.5	Anti-adhesive nanocoating of fibers	1
3.6	Anti-adhesive nanocoating of textiles	1
3.7	Polymer fiber using melt spinning	1
3.8	Multifunctional polymer Nano composites	1
3.9	nylon-6 Nano composites from polymerization	1
4	**Nanotechnology in Agriculture**	
4.1	Natural resource management	1
4.2	Soil fertility management	1
4.3	Precision farming and smart delivery system	1
4.4	Precision agriculture monitoring system	1
4.5	Smart delivery systems	1
4.6	Crop improvement	1
4.7	Crop protection- Seed germination, growth and development	1
4.8	Sensing of air pollutant by nanomaterial	1
4.9	soil remediation-plant Nano bionics	1
5	**Applications**	
5.1	Agriculture: Nano formulations of agrochemicals	1
5.2	nano sensors in crop protection	1
5.3	Identification of diseases and residues	1
5.4	Nano sensor for air pollution control, Nano pesticides	1

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5.5	Smart fertilizer for crop nutrition-Nano robotics in agriculture.	1
5.6	Textile : Soil resistance, wrinkle resistance	1
5.7	anti-bacteria, anti-static and UV-protection	1
5.8	flame retardation	1
5.9	Improvement of dye ability and Self-cleaning fabrics.	1
	Total	45

Course Designers

Dr.T.Baranidharan - baranidharan@ksrct.ac.in

60 PNT E36	Self Assembly of Nanostructures	Category	L	T	P	Credit
		PE	3	0	0	3

Objective(s)

- To extend their knowledge of design of innovative nanostructured materials based on basic chemistry, physics, biology
- To apply the self-assembly concepts in nanoelectronics, nano photovoltaic and energy materials

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able

CO1	To know about the basic concept of self-assembled nanostructures	Remember, Understand, Apply
CO2	To know more about the nanomanipulators and design of materials	Remember, Understand, Aanalyze
CO3	Identify the fabrication of nanostructured materials	Remember, Understand, Analyze
CO4	Identify the natural nanomaterials	Remember, Understand, Apply
CO5	Understand the applications of nanomaterials in biological materials	Remember, Understand, Apply

Mapping with Programme Outcomes

COURSE NAME	CO	PO						PSO		
		1	2	3	4	5	6	1	2	3
Self-Assembly of Nanostructures	CO1	3	3	1	3	2	3	3	1	3
	CO2	2	2	2	2	3	2	3	1	3
	CO3	3	3	2	2	2	3	3	3	3
	CO4	2	3	3	2	2	2	3	1	3
	CO5	3	3	2	1	3	2	3	2	3

Note: 3 – Strong Contribution; 2 – Average Contribution; 1 – Some Contribution

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Assessment Pattern

Bloom's Category	Continuous Assessment Tests (Marks)		End Semester Examination (Marks)
	1	2	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	20
Analyze	10	10	10
Evaluate	10	10	10
Create	10	10	10

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60 PNT E36 - Self Assembly of Nanostructures *								
M.Tech – Nano Science and Technology								
Semester	Hours/Week			Total hrs.	Credit	Maximum Marks		
	L	T	P		C	CA	ES	Total
III	3	0	0	45	3	40	60	100

Introduction of self-assembly process Self-organization of nanomaterials-Growth mechanism-self-assembly of nanostructures-chemical, physical, biological self-assembly- Assembling and patterning of particles-self organization of different Nano morphologies-Quantum dots-Nanorods-Nanowires-Nanotubes	[9]
FABRICATION METHODS Self-assembled monolayers(SAM)-guided self-assembly-Nanolithography-Surface Topography-Surface wetting-Electrostatic force-Nanomanipulators-Grippers-Design-gripper arm geometry	[9]
BOTTOM UP APPROACH Bottom up manufacturing-bottom up approach-self-assembly of single electron transistor-photovoltaic related devices-Langmuir bladgett films(LB)-principle of formation of monolayer formation-from molecules to nanoparticles-compression of monolayer-fabrication of LB films-applications	[9]
NANOSCALE MATERIALS Self-assembly by micro contact printing-creating the stamp-substrate-creating self-assembled monolayers-applications-Macroscopic expressions of Natural nanomaterials-Hierarchical ordering in natural nanoscale materials	[9]
APPLICATIONS OF SELF-ASSEMBLE NANOMATERIALS Bio inspired approach for complex super structures and biological world-self-assembly in biological systems-superhydrophobicity-self-cleaning property-multi scaling ordering and function in biological nanoscale materials: proteins-lipids-DNA and RNA-shell as a composite materials.	[9]
Total Hours	45

Text Book(s):

1.	Shafigh Mehraeen, Self-Assembly of Nanostructures and Patchy Nanoparticles, IntechOpen, 2020
2	Himadri B. Bohidar, Kamla Rawat, Design of Nanostructures Self-Assembly of Nanomaterials, Wiley 2017

Reference(s):

1.	Alexandru Grumezescu, Fabrication and Self-Assembly of Nanobiomaterials Applications of Nanobiomaterials, Elsevier Science,2016.
2.	Hao Wang, Li-Li Li, In Vivo Self-Assembly Nanotechnology for Biomedical Applications, Springer Nature Singapore, 2018.
3.	James Lewis, Markus Krummenacker, Prospects in Nanotechnology Toward Molecular Manufacturing, Wiley, 1995.

***SDG :4 quality education and learning opportunities for all**

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Course Content and Lecture Schedule

S. No.	Topics	No. of hours
1.0	**INTRODUCTION**	
1.1	Self-organization of nanomaterials	1
1.2	Growth mechanism	2
1.3	Self-assembly of nanostructures	1
1.4	Chemical,physical,biological self-assembly	1
1.5	Assembling and patterning of particles	1
1.6	Self-organization of different Nano morphologies	2
1.7	Quantum dots	1
1.8	Nanorods-nanowires-nanotubes	
2.0	**FABRICATION METHODS**	
2.1	Self-assembled monolayers(SAM)	1
2.2	Guided self-assembly	1
2.3	Nanolithography	2
2.4	Surface topography	1
2.5	Surface wetting	1
2.6	Grippers-Design-gripper arm geometry	1
2.7	Electrostatic force	1
2.8	Nanomanipulators	1
3.0	**BOTTOM UP APPROACH**	
3.1	Bottom up manufacturing-	1
3.2	Self-assembly of single electron transistor	2
3.3	Photovoltaic related devices	1
3.4	Langmuir bladgett films(LB)	1
3.5	Principle of formation of monolayer formation	1
3.6	From molecules to nanoparticles	1
3.7	Compression of monolayer-fabrication of LB films	1
3.8	Applications	1
4.0	**NANOSCALE MATERIALS**	
4.1	Self-assembly by micro contact printing	1
4.2	Creating the stamp	1
4.3	Creating self-assembled monolayers	1
4.4	Substrate applications	2
4.5	Macroscopic expressions of Natural nanomaterials	2
4.6	Hierarchical ordering in natural nanoscale materials	2
5.0	**APPLICATIONS**	
5.1	Bio inspired approach for complex super structures and biological world	2
5.2	Self-assembly in biological systems	1
5.3	Super hydrophobicity	1
5.4	Self-cleaning property	1
5.5	Multi scaling ordering and function in biological nanoscale materials	1
5.6	Proteins-lipids	2
5.7	DNA and RNA	1
5.8	Shell as a composite materials	1

Course Designer

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