K.S. Rangasamy College of Arts and Science
(Autonomous)
Tiruchengode– 637 215

Department of Physics (PG)

Details of Elective Course offered by the Department

ELECTIVE I

S.No	Subject code	Subject
1	18PPHEL201	Modern Optics
2	18PPHEL202	Nonlinear Dynamics
3	18PPHEL203	Biomaterials

ELECTIVE II

S.No	Subject code	Subject
1	18PPHEL301	Physics of Nanoscale
2	18PPHEL302	Crystal Growth and Thin Film Physics
3	18PPHEL303	Instrumental Methods of Analysis

List of Encl.:

- Syllabus copy of the courses

HOD

Dr.G.SURESH KUMAR, M.Sc.,M.Phil., Ph.D
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K.S. RANGASAMY COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)
CONTROLLER OF EXAMINATIONS

COE

Mr. M. PRASAD, M.Sc., M.B.A., M.r.....,
Controller of Examinations
K.S. Rangasamy College of Arts & Science (Autonomous)
Tiruchengode - 637 215. Tamilnadu. India.

SCHEME OF EXAMINATION

Subject Code	Subject	Hrs of Instruction	Exam Duration (Hrs)	Max Marks			Credit Points
				CA	CE	Total	
First Semester							
	Part A						
18PPHM101	Core I : Mathematical Physics	6	3	25	75	100	5
18PPHM102	Core II: Classical Mechanics	6	3	25	75	100	5
18PPHM103	Core III: Statistical Mechanics	6	3	25	75	100	5
18PPHM104	Core IV: Condensed Matter Physics	6	3	25	75	100	5
18PPHMP101	Core Practical I: Advanced Physics Practical I	5	4	40	60	100	3
	Non-credit						
18PLS101	Career Competency Skills I	1	-	-	-	-	-
	Total	**30**				**500**	**23**
Second Semester							
	Part A						
18PPHM201	Core V: Quantum Mechanics I	6	3	25	75	100	5
18PPHM202	Core VI : Electromagnetic Theory	6	3	25	75	100	5
	Elective I	5	3	25	75	100	4
18PPHMP201	Core Practical II: Advanced Physics Practical II	5	4	40	60	100	3
18PCSPHI201	IDC I: Computer Graphics and Multimedia	3	3	25	75	100	2
18PCSPHIP201	IDC Practical I: Multimedia Tools	2	3	40	60	100	2
	Part B						
18PVE201	Value Education: Human Rights	2	3	25	75	100	2
	Non-credit						
18PLS201	Career Competency Skills II	1	-	-	-	-	-
	Total	**30**				**700**	**23**

K.S. RANGASAMY COLLEGE OF ARTS & SCIENCE (AUTONOMOUS) CONTROLLER OF EXAMINATIONS TIRUCHENGODE

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Tiruchengode - 637 215. Namakkal. India.

Subject code	Subject	Hrs of Instruction	Exam Duration (Hrs)	Max Marks			Credit Points
				CA	CE	Total	
Third Semester							
Part A							
18PPHM301	Core VII: Quantum Mechanics II	6	3	25	75	100	5
18PPHM302	Core VIII: Advanced Electronics	6	3	25	75	100	4
18PPHM303	Core IX: Microprocessor and Microcontroller	5	3	25	75	100	4
	Elective II	5	3	25	75	100	4
18PPHMP301	Core Practical III: Advanced Electronics Practical	4	3	40	60	100	3
Optional Papers							
18PECPHI301	IDC II: Modern Biomedical Instrumentation	4	3	25	75	100	4
18PBCPHI301	IDC II: Molecular Biophysics						
	Total	**30**				**600**	**24**
Fourth Semester							
Part A							
18PPHM401	Core X: Spectroscopy	6	3	25	75	100	4
18PPHM402	Core XI: Nuclear and Particle Physics	6	3	25	75	100	4
18PPHM403	Core XII : Computational Physics	6	3	25	75	100	4
18PPHMP401	Core practical IV: Computation using MATLAB	3	3	40	60	100	2
18PPHPR401	Project & Viva-Voce	5	-	50	150	200	6
	Total	**26**				**600**	**20**
			Grand total			**2400**	**90**

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18PPHEL201	ELECTIVE I: MODERN OPTICS	SEMESTER – II

COURSE OBJECTIVES

The course aims

- To impart knowledge on polarization, double refraction and lasers
- To provide knowledge on fibre optics, non-linear optics, electro-optical and magneto-optical effects.

Credits: 4 **Total Hours: 50**

UNIT	CONTENTS	Hrs	CO
I	**Polarization and double refraction:** Linearly and circularly polarized waves-Transverse character of light waves - Polarizer and analyser - Production of polarized light - The wire grid polarizer and the polaroid- Polarization by reflection - Polarization by scattering – Malu's law - The phenomenon of double refraction - Normal and oblique incidence - Interference of polarized light - Quarter and half-wave plates - Analysis of polarized light - Optical activity.	10	CO1
II	**Laser Physics:** Basic principles - Spontaneous and stimulated emissions, components of a laser, optical amplification - Resonator and lasing action - Types of lasers - Solid state lasers - Ruby laser - Nd:YAG laser - Gas lasers - He-Ne laser - CO_2 laser - Semiconductor lasers - Liquid laser - Dye laser and Chemical lasers – Applications of various laser.	10	CO2
III	**Fiber optics:** Total internal reflection - Optical Fiber - Glass fibers - Coherent bundle - Numerical aperture – Attenuation in optical fibers - Attenuation limit - Single mode and multi-mode fibers – Pulse dispersion in multimode optical fibers - Ray dispersion in multimode step index fibers – Parabolic-index fibers – Material dispersion - Dispersion and maximum bit rates - Fiber-optic sensors.	10	CO3
IV	**Non-linear optics:** Basic principles - Harmonic generation - Second harmonic generation - Phase matching - Third harmonic generation - Optical mixing - Parametric amplification – Self focusing of light.	10	CO4
V	**Magneto-optics and electro-optics:** Magneto-optical effects - Zeeman effect - Faraday effect - Voigt effect or magnetic double refraction - Cotton-Mouton effect - Kerr magneto optic effect - Electro-optical effects - Stark effect - Electric double refraction - Kerr electro-optic effect - Pockels electro-optic effect.	10	CO5

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TEXT BOOKS:	
1	*Ajoy Ghatak,* 2005. **Optics,** [Third Edition], Tata McGraw-Hill Publishing, New Delhi [Unit-I, III, V].
2	*Laud, B.B.* 2011. **Laser and Non-Linear Optics**. [Third Edition]. New Age International Publishers, New Delhi. [Unit: II, IV]
REFERENCE BOOKS:	
1	*Silfvast.T, W. 2004.* **Laser Fundamentals,** [Second Edition]. Cambridge University Press, New York.
2	*Jenkins. F.A and White. H.E.,* **Fundamentals of Optics,** [Fourth Edition]. McGraw-Hill International Edition, London, 2001.
3	*Lipson, S.G., Lipson. H., and Tannhauser. D.S.,* 1996. **Optical Physics** [Third Edition]. Cambridge University Press, London.
WEB REFERENCES:	
1	https://ocw.mit.edu/courses/physics/
2	http://nptel.ac.in/syllabus/115104041/
3	https://www.khanacademy.org/
4	http://nptel.ac.in/downloads/115101008/

COURSE OUTCOMES (CO)

After completion of the course, the students will be able to

CO 1	Describe the phenomena of polarization and double refraction.
CO 2	Explain the principle, construction and working of various lasers.
CO 3	Explain the fundamentals of optical fibers and related concepts.
CO 4	Analyze the various optical non-linear phenomena.
CO 5	Analyze the various electro-optical and magneto-optical effects.

MAPPING

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	H	H	H	H	L
CO 2	H	M	M	M	H
CO 3	H	M	M	M	M
CO 4	H	H	H	H	M
CO 5	H	H	H	H	M

H-High; M-Medium; L-Low;

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18PPHEL202	ELECTIVE I: NONLINEAR DYNAMICS	SEMESTER – II

COURSE OBJECTIVES

The course aims

- To impart knowledge on nonlinear dynamical systems.
- To provide the concept of solitons, chaos and its related phenomena
- To impart knowledge on applications of nonlinear dynamical systems.

Credits: 4 **Total Hours: 50**

UNIT	CONTENTS	Hrs	CO
I	Introduction to nonlinear dynamical systems - The notion of nonlinearity- Superposition principle and its validity - Linear and nonlinear oscillators- Autonomous and nonautonomous systems - Equilibrium points - Phase space - Classification of equilibrium points - Stability of fixed points.	10	CO1
II	Chaos- simple bifurcations - Saddle node, pitchfork, transcritical bifurcation- The logistic map - Onset of chaos- Other routes to chaos- Period doubling phenomenon - Quasi periodic route to chaos- Intermittency route to chaos- Bifurcation scenario in Duffing oscillator - Chaos in conservative systems.	10	CO2
III	Solitons - Birth of soliton - Nonlinear dispersive systems- Cnoidal and solitary waves- Scott Russel phenomenon and KdV equation- Fermi-Pasta-Ulam (FPU) lattice problem - FPU recurrence phenomenon- Asymptotic analysis- Numerical experiment of Zabusky and Kruskal.	10	CO3
IV	Integrability and methods to soliton equations- The notion of integrability - Painleve analysis and its application to KdV equation, nonlinear Schrödinger equation- Lax pair for KdV equations- Inverse Scattering Method and its application to KdV equation- Hirota's bilinearization method- Examples: KdV and nonlinear Schrödinger equation.	10	CO4
V	Applications- Chaos and secure communications - Nonlinear optics and biological systems - Role of soliton in condensed matter systems.	10	CO5

TEXT BOOKS:

1 *Lakshmanan, M and Rajasekar,* S. 2003. **Nonlinear Dynamics, Integrability, Chaos and Patterns.** Springer-Verlag, Berlin.

REFERENCE BOOKS:	
1	*Drazin, P.G.* 1992. **Nonlinear systems**, Cambridge University Press, Cambridge.
2	*Leon, G and Kaplan, D. 1995.* **Understanding Nonlinear Dynamics.** Springer, New York.
3	*Ablowitz, M.J. and Clarkson, P.A.* 1991. **Solitons, Nonlinear Evolution Equations and Inverse Scattering**, Cambridge University Press, Cambridge.
4	*Dodd, R. Eilbeck, J. Gibbson J. and Morris, H.* 1982. **Solitons and Nonlinear Wave Equations**, Academic, New York.
WEB REFERENCES:	
1	http://nptel.ac.in/courses/108101002/
2	https://ocw.mit.edu/courses/physics/

COURSE OUTCOMES (CO)

After completion of the course, the students will be able to

CO 1	Explain the fundamentals of nonlinear dynamical systems.
CO 2	Apply the concept of chaos and related theories.
CO 3	Analyze the solitons and related phenomena.
CO 4	Create the different equations to describe non-linear systems.
CO 5	Apply solitons and chaos for various real time applications.

MAPPING

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	H	H	H	H	L
CO 2	H	H	H	H	M
CO 3	H	H	H	H	M
CO 4	M	H	H	H	H
CO 5	L	H	H	M	H

H-High; M-Medium; L-Low;

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18PPHEL203	ELECTIVE I: BIOMATERIALS	SEMESTER – II

COURSE OBJECTIVES

The course aims

- To impart knowledge on materials used for clinical applications.
- To provide knowledge on various biomedical implants.

Credits: 4 **Total Hours: 50**

UNIT	CONTENTS	Hrs	CO
I	Introduction to biomaterials - Classification- Impact of biomaterials- Tissue response to various biomaterials - Mechanical properties of biomaterials and its importance - Surface properties: Surface energy, Contact angles and critical surface tension - Surface improvements - Thermal treatments – Sterilization - Safety and efficacy testing of biomaterials.	10	CO1
II	Metals and alloys - Stainless steel - Cobalt-chromium alloys - Titanium based alloys- Nitinol - Metallic corrosion – Biological tolerance of metal implants – Polymers - Polyurethanes – Hydrogels - Polyamides - Silicone – Collagens – Cellulose – Chitin - Alginates - Polymers in biomedical use.	10	CO2
III	Ceramics - Bioinert ceramics – Carbon - Alumina- Yatria stabilized zirconia - Surface reactive ceramics - Bioglass - Resorbable ceramics – Hydroxyapatite: Properties and applications - Tricalcium phosphate: Properties and applications - Composites.	10	CO3
IV	Tissue graft – Tissue engineering –Bulk space fillers – Maxillofacial implants – biomaterials in urological practice - Vascular implants – Synthetic blood vessel – Cardiac valve replacement – Blood substitutes – Artificial kidney – Biomaterials in ophthalmology – Contact lenses – Optical implants - Eye shields – Artificial tears –Biosensors – Drug delivery systems.	10	CO4
V	Biomaterials in orthopedics – Bone: Composition, Structure and Mechanical properties – Osteoblasts – Osteoclasts – Bioelectric effect – Bone healing – Osteoporosis – Bone regeneration with resorbable materials – Teeth: Structure, Composition and Mechanical properties – Biomaterials in dentistry.	10	CO5

TEXT BOOKS:	
1	*Sujata V. Bhat. 2010.* **Biomaterials** [Second Edition]. Narosa Publishing House, New Delhi.
REFERENCE BOOKS:	
1	*Park. J, Lakes. R. S.* 2007. **Biomaterials: An Introduction** [Third Edition]. Springer Publication.
2	*Reema Shukla,* 2014. **Biomaterials** [First Edition]. Nandu Printers & Publishers Pvt. Ltd. Chennai.
WEB REFERENCES:	
1	http://nptel.ac.in/courses/113104009/
2	https://ocw.mit.edu/index.htm

COURSE OUTCOMES (CO)

After completion of the course, the students will be able to

CO 1	Explain the basics of biomaterials, their classification, properties and efficacy testing.
CO 2	Know about properties and applications of metallic and polymeric materials.
CO 3	Describe the properties and applications of various ceramics biomaterials
CO 4	Create various implants for biomedical applications.
CO 5	Analyze the structure of bone and teeth and apply the various materials for orthopedics and dentistry.

MAPPING

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	H	M	M	M	H
CO 2	M	H	H	M	H
CO 3	M	H	H	L	H
CO 4	M	H	H	L	H
CO 5	M	M	M	L	H

H-High; M-Medium; L-Low;

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18PPHEL301	ELECTIVE II: PHYSICS OF NANOSCALE	SEMESTER – III

COURESE OBJECTIVES:

The course aims

- To impart knowledge on basics of nanoscience, preparation and properties, of nanomaterials
- To inculcate knowledge on various characterization methods and applications of nanomaterials.

Credits: 4 **Total Hours: 50**

UNIT	CONTENTS	Hrs	CO
I	**Introduction to the nanoworld:** History of nanoscience – Nano and nature – Classification of Nanomaterials – Nanorods, nanoparticles, nanotubes – Size and dimensionality effects. **Quantum mechanics of nanosystems:** Density of states and quantum confinement – Quantum wells – Quantum wires – Quantum dots – Superlattices.	10	CO1
II	**Basic aspects of synthesis of nanomaterials:** Bottom-Up approach: Sol-gel synthesis – Hydrothermal growth – Thin film growth: Physical vapor deposition – Chemical vapor deposition – Top-Down approach: Ball milling – Microfabrication – Lithography – Ion-beam lithography.	10	CO2
III	**Properties of nanostructured materials:** Nanoscale magnetism – Optoelectronic property of bulk and nanostructures – Electronic structure of nanomaterials and Fermi surface – Luminescence properties of nanomaterials - Specific heat of nanocrystalline materials – Melting points of nanomaterials – Mechanical properties of nanostructured materials.	10	CO3
IV	**Nanoscale characterization techniques:** X-ray diffraction and Scherrer method –Scanning electron microscopy – Transmission electron microscopy – Energy Dispersive X-ray analysis – Scanning probe microscopy – Atomic Force microscopy– X-ray photoelectron spectroscopy – Diffuse reflectance spectra - Photoluminescence spectroscopy – IR and Raman spectroscopy - DC magnetization measurements: SQUID – VSM.	10	CO4

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V	**Prime materials in nanoworld:** Carbon nanotubes – Graphene – Metal nanoparticles – Semiconducting nanoparticles. **Application of nanomaterials:** Impact of nanoscience in materials science – Nanoelectronics – Nanophotonics – Nanocatalyst – Applications of nanomaterials in textiles – Applications of nanomaterials in biology and medicine – Nanocosmetics – Nanosensors – Drug delivery – Cancer therapy – Tissue engineering – Impact of nanomaterials in energy and environment.	10	CO5

TEXT BOOKS:

1. *M.S. Ramachandra Rao and Shubra Singh.* 2013. **Nanoscience and Nanotechnology: Fundamentals to Frontiers.** [First Edition]. John-Wiley & Sons, USA.
2. *C.N.R. Rao.* 2013. **Nanoworld: Introduction to Nanotechnology and Nanotechnology.** [Third Edition]. Navakarnataka Publications Private Limited, Bangalore.

REFERENCE BOOKS:

1. *Charles P.Poole* and *Frank J. Owens.* 2009. **Introduction to Nanotechnology.** John-Wiley & Sons, USA.
2. *Guozhong Gao.* 2010. **Nanostructures and Nanomaterials Synthesis, Properties and Applications.** [Second Edition]. Cambridge University Press India Pvt Ltd.
3. *De Jongh, J.* 1994. **Physics and Chemistry of Metal Cluster Compounds.** Kluwer Academic Publishers, Dordrecht.
4. *Kenneth J. Klabunde.* 2001. **Nanoscale Materials in Chemistry.** John-Wiley & Sons, USA.

WEB REFERENCES:

1. https://epgp.inflibnet.ac.in/ahl.php?csrno=831
2. https://nptel.ac.in/courses/118102003/
3. https://nptel.ac.in/courses/118104008/
4. https://www.sciencedaily.com/news/matter_energy/nanotechnology/
5. http://www.understandingnano.com/index.htm

COURSE OUTCOMES (CO)

After completion of the course, the students will be able to

CO 1	Explain the fundamentals of nanoscience.
CO 2	Describe the various methods for synthesis of nanoparticles.
CO 3	Analyze the various properties of nanomaterials.
CO 4	Apply the different analytical method for the characterization of nanoparticles
CO 5	Utilize the nanostructured materials for various applications

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MAPPING

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	H	M	M	M	H
CO 2	H	L	M	M	H
CO 3	H	M	H	H	H
CO 4	H	H	H	H	H
CO 5	L	L	M	H	H

H-High; M-Medium; L-Low;

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18PPHEL302	ELECTIVE II: CRYSTAL GROWTH AND THIN FILM PHYSICS	SEMESTER – III

COURESE OBJECTIVES:

The course aims

- To impart knowledge on crystal growth theory and techniques
- To provide knowledge on thin films deposition and characterization methods.

Credits: 4 **Total Hours: 50**

UNIT	CONTENTS	Hrs	CO
I	**Nucleation theory:** Nucleation – Homogenous and heterogeneous nucleation - Concept of formation of critical nucleus – Theory of nucleation. **Solution Growth Technique**: Low temperature solution growth: Solution - Solubility and super solubility – Expression of super saturation – Miers T-C diagram - Crystallizer – Seed preparation and mounting - Slow cooling and solvent evaporation methods.	10	CO1
II	**Gel Growth Technique:** Principle – Various types – Structure of gel – Importance of gel – Experimental procedure – Chemical reaction method – Single and double diffusion method – Chemical reduction method – Complex and decomplexion method – Solubility reduction method – Advantages of gel method.	10	CO2
III	**Melt technique:** Bridgman technique - Basic process – Various crucibles design - Thermal consideration –Vertical Bridgman technique - Czochralski technique – Experimental arrangement – Growth process. **Vapour technique:** Physical vapour deposition – Chemical vapour deposition (CVD) – Chemical Vapour Transport.	10	CO3
IV	**Thin Film Deposition Techniques :** Thin Films – Deposition Techniques - Physical Methods – Resistive Heating, Electron Beam Gun, Laser Gun Evaporation and Flash Evaporations, Sputtering - Reactive Sputtering, Radio-Frequency Sputtering - Chemical Methods – Spray Pyrolysis – Spin coating method.	10	CO4
V	**Characterization Technique:** Powder and single crystal X-ray diffraction – Fourier transform infrared analysis – EDX analysis - Scanning electron microscopy (SEM) – Atomic force microscopy (AFM) – UV-Vis NIR spectrometer – Photoluminescene (PL) spectrometer – Microhardness.	10	CO5

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TEXT BOOKS:	
1.	*Santhana Ragavan, P. Ramasamy, P.* 2001. **Crystal Growth Processes and Methods,** KRU Publications, Kumbakonam. [Unit- I to III]
2.	A. *Goswami, A.* 1996. **Thin Film Fundamentals,** [First Edition]. New Age International (P) Limited, New Delhi [Unit-I, IV, V].

REFERENCE BOOKS:	
1	*Brice, J.C.* 1986. **Crystal Growth Processes,** John Wiley and Sons, New York.
2	*Sangawal, K.*1994. **Elementary crystal growth,** Shan Publisher, UK.
3	*Maissel. L.I. and clang, R.* 1970. **Hand Book of Thin Films Technology,** McGraw-Hill, New York.
4	*William, M. and Steve, D.* 1986. **Instrumental Methods of analysis,** CBS Publishers, New Delhi.

WEB REFERENCES:	
1	https://epgp.inflibnet.ac.in/ahl.php?csrno=831
2	https://nptel.ac.in/courses/113104004/

COURSE OUTCOMES (CO)

After completion of the course, the students will be able to

CO 1	Explain the fundamentals of crystal and thin film growth.
CO 2	Describe the various solution growth and gel growth techniques for grow single crystals.
CO 3	Demonstrate the various melt and vapour growth techniques for grow single crystals.
CO 4	Apply the different deposition techniques to prepare thin films.
CO 5	Utilize the various analytical methods for characterizing the crystalline materials.

MAPPING

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	H	H	M	M	M
CO 2	H	M	H	H	M
CO 3	H	M	H	H	M
CO 4	H	M	H	H	H
CO 5	H	M	H	H	H

H-High; M-Medium; L-Low;

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18PPHEL303	ELECTIVE II: INSTRUMENTAL METHODS OF ANALYSIS	SEMESTER – III

COURESE OBJECTIVES:

The course aims

- To impart knowledge on different errors, analysis of experimental data and concept of stress analysis.
- To impart knowledge on the basic theories, construction and working of various analytical instruments for analyze the materials.

Credits: 4 **Total Hours: 50**

UNIT	CONTENTS	Hrs	CO
I	**Errors and analysis of experimental data:** Types of errors – Mean, variance and standard deviation - Sampling techniques – Chi square test. **Experimental stress analysis:** Stress analysis by strain gauging - high temperature strain gauge techniques – Photoelasticity and holography.	10	CO1
II	**Thermal analysis:** Thermogravimetric analysis - Instrumentation and applications – Differential scanning calorimetric – Instrumentation – Specific heat capacity measurements – Determination of thermochemical parameters – Differential thermal analysis – Basic principles – Melting point determination and analysis.	10	CO2
III	**X-ray analysis:** Single crystal and powder X-ray diffraction – Interpretation of diffraction patterns – Indexing – Unknown and phase identification – Thin film characterization – Energy dispersive X-ray analysis – X- ray fluorescence method and its applications.	10	CO3
IV	**Optical methods and electron microscopy:** IR and Raman spectroscopy - X-ray photoelectron spectroscopy – Diffuse reflectance spectra - Photoluminescence spectroscopy – Near field scanning optical microscopy – Transmission electron microscopy – Scanning probe microscopy – Atomic force microscopy.	10	CO4
V	**Electrical methods :** Hall Effect – Carrier density – Resistivity - Two probe and four probe methods – CV characteristics – Schottky barrier capacitance – Impurity concentration – Electrochemical CV profiling – Limitations. **Magnetic methods:** SQUID – VSM.	10	CO5

TEXT BOOKS:	
1	*Sivasankar, B.* 2012. **Instrumental Methods of Analysis,** Oxford University Press, Oxford.
2	*Belk, J.A.* 1979. **Electron microscopy and Microanalysis of Crystalline Materials,** Applied Science Publishers, London.
REFERENCE BOOKS:	
1	*Willard, Merritt, Dean and Settle.* 2012. **Instrumental Methods of Analysis,** CBS Publishers, New Delhi.
2	*Philips, V.A.* 1971. **Modern Metallographic Techniques and their Applications,** Wiley Interscience, USA.
WEB REFERENCES:	
1	https://nptel.ac.in/syllabus/103108100/
2	https://epgp.inflibnet.ac.in/ahl.php?csrno=831
3	https://nptel.ac.in/courses/113104004/

COURSE OUTCOMES (CO)

After completion of the course, the students will be able to

CO 1	Explain the different errors, analysis of experimental data and concept of stress analysis.
CO 2	Describe the principle and working of different analytical methods for thermal analysis.
CO 3	Utilize the X-ray diffraction technique for characterizing the crystals and thin films.
CO 4	Explain the fundamentals of various optical and electron microscopic techniques.
CO 5	Apply the various analytical methods for measuring the electrical properties of materials.

MAPPING

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	M	H	H	H	M
CO 2	H	H	H	H	L
CO 3	H	H	H	H	M
CO 4	H	H	H	H	H
CO 5	H	M	H	H	M

H-High; M-Medium; L-Low;

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