TRIPURA UNIVERSITY

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Department of Material Science and Engineering

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The Department of Material Science and Engineering is one of the new teaching and research departments of Tripura University (A Central University), started its journey in 2016, included under the XII Five Years Plan sanctioned by UGC. This department offers four-semester 'M. Tech' programme in 'Material Science and Engineering'. This unique stream in engineering helps students to gain technical knowledge of various kinds of materials like metals, semiconductors, ceramics, polymers and composites through material characterization and its structure – property relationships. This unique stream in engineering helps students to gain technical knowledge on various kinds of materials for engineering applications in critical industrial sectors, energy and electronics.

List of programmes offered by the Department

I. **M.Tech: Material Science and Engineering**

II. **Ph.D.: Material Science and Engineering**

I. M.Tech: Material Science and Engineering

Programme Specific Objectives:

PSO-1	**Develop core competency in fundamental understanding of materials and their properties.**
PSO-2	**Analyze, design and evaluate materials for engineering applications.**
PSO-3	**Solving engineering problems using the domain knowledge of materials.**
PSO-4	**Enabling student to work individually or in a group and under supervision for research and development activities with high professional and ethical standards.**

Programme Outcomes:

PSO-1	**Identify different materials and their properties for engineering applications.**
PSO-2	**Carryout a systematic research work on materials and analyze the results.**
PSO-3	**Write substantial scientific/technical reports and present the same.**
PSO-4	**Develop knowledge in the science of materials for the benefit of the society**

M.Tech. (Material Science and Engineering) – Course Structure

	1ST SEMESTER					
		L	**T**	**P**	**Credits**	**Marks**
Theory Papers	**Name**					
MS 903C	Techniques of Materials Characterization	4	0	0	4	100
MS 908C	Fundamentals of Materials Science and Engineering	4	0	0	4	100
MS 909C	Materials Processing Technology	4	0	0	4	100
MS 910E	Surface Engineering (Will be offered as an elective to other departments)	4	0	0	4	100
Elective from other department	Elective from other departments (Student will have to choose elective offered by other departments)	-	-	-	4	100
Sessional Papers	**Name**					
MS911P	Materials Characterization Laboratory			8	4	100
MS 912P	Mini Project-01 (Submission of Report/Presentation and Viva Voce)	0	2	0	2	100
Subtotal					**26**	**700**
	2ND SEMESTER					
		L	**T**	**P**	**Credits**	**Marks**
Theory Papers	**Name**					
MS 1001C	Electronic and Opto-electronic Materials	4	0	0	4	100
MS 1002C	Science and Technology of Ceramics	4	0	0	4	100
MS 1003E	Nanomaterials	2	0	0	2	100
MS 1008E	Advanced Engineering Materials	2	0	0	2	100
CFC	Compulsory Computer Foundation Course (Skill-3) (Will be offered by Department of IT or CSC)	4	0	0	4	100
Sessional	**Name**				**Credits**	**Marks**

Papers						
MS 1009P	Materials Processing Laboratory	0	0	8	4	100
MS 1010P	Mini Project-02 (Submission of Report/Presentation and Viva Voce)	0	2	0	2	100
Subtotal					22	700
	3RD SEMESTER					
		L	**T**	**P**	**Credits**	**Marks**
Paper	**Name**					
MS 1101	Progress Report on Thesis				10	100
MS 1102	Seminar Presentation and Viva-Voce				6	50
Subtotal					**16**	**150**
	4TH SEMESTER					
		L	**T**	**P**	**Credits**	**Marks**
Paper	**Name**					
MS 1201	Project Thesis Report				10	150
MS 1202	Project Presentation and Viva-Voce				6	100
Subtotal					**16**	**250**

	Total Credits	**Total Marks**
M.Tech. Material Science and Engineering	**26+22+16+16 = 80 Credits**	**700+700+150+250 = 1800**

Detailed Course Syllabus

1st Semester

		L	T	P	Credits	Marks
Theory Papers	**Name**					
MS 903C	Techniques of Materials Characterization	4	0	0	4	100

Course Objectives:
1. To develop an in-depth understanding of the various techniques/instruments used for different characterization of materials

Course Outcomes:
1. Knowledge about the principles of the different instruments used for materials characterization, Analysis of experimental results and interpretation of results

Module	Paper/Course content	Time (Hours)
1	Importance of different characterization techniques of materials, Classification of characterization techniques for materials depending upon the dimensions of the materials: macro, micro and nano-characterization; Microscopy techniques: Optical microscopy, Necessity to introduce electron microscope for materials characterization, Electron microscopy: Scanning electron microscopy and Transmission electron microscopy: working principles, data analysis and interpretation of results, advantages and limitations. Scanning probe microscopy: Scanning tunneling microscopy and Atomic force microscopy: analysis of data and interpretation of results.	20
2	X-ray: generation of x-rays, basic science, Braggs law, X-ray diffraction techniques for amorphous, single crystal and polycrystalline materials: analysis of data and interpretation of results.	6
3	Spectroscopy: Atomic absorption spectroscopy, UV-Vis-NIR spectroscopy, Energy dispersive X-ray spectroscopy, Infrared spectroscopy, Raman spectroscopy, Photoluminescence spectroscopy, X ray fluorescence spectroscopy and X-ray photoelectron spectroscopy: working principles, analysis of data and interpretation of results.	16
4	Electrical characterization: two-probe and four-probe methods; Magnetic characterization: magnetic measurements: VSM, Hall measurements; Thermal characterization: DTA, DSC, TGA, Mechanical testing and NDT.	6

Reference books:

1. L.Yang. Materials Characterization, Wiley-VCH, 2nd Edition, 2015.
2. S. Amelinckx, D. van Dyck, J. van Landuyt, and G. van Tendeloo, Electron Microscopy: Principles and Fundamentals, Wiley, 2008.
3. P.J. Goodhew, and F.J. Humphreys, Electron Microscopy and Analysis, 2nd Edition, Taylor and Francis, 1997.
4. R. Wiesendanger, Scanning Probe Microscopy and Spectroscopy-Methods and Applications, Cambridge University Press, 2010.
5. B. Voigtländer, Scanning Probe Microscopy, Springer, 2012.
6. B. D. Cullity, Elements of X-ray Diffraction, Addison-Wesley Publishing Co, 1979.
7. R. Jenkins and R. Snyder, Introduction to X-ray Powder Diffractometry, Wiley, 1996.
8. N. Colin, Fundamentals of Molecular spectroscopy, Tata McGraw-Hill Publishing Co. Ltd., 4th edition, 1994.
9. G. Gauglitz, and D. S. Moore, Handbook of Spectroscopy, 2nd Edition, Wiley, 2014
10. E.N. Kaufman, Characterization of Materials (Vol I, II and III), 2nd Edition, Wiley, 2003.
11. P.E.J. Flewitt, and R.K Wild, Physical Methods for Material Characterization, Institute of Physics Publishing, 1994.
12. D. B. Williams, and C. B. Carter, Transmission Electron Microscopy,Springer, 2009.
13. Y. Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd Edition, Wiley VCH, 2013.

		L	T	P	Credits	Marks
Theory Paper	**Name**					
MS 908C	**Fundamental of Materials Science and Engineering**	4	0	0	4	100

Course Objectives:

1. This course will introduce basic concepts of structure, and imperfection, phase transformations, and heat treatments in engineering materials.
2. To understand the fundamentals (structure, properties and processing) of materials and to apply those fundamentals for selecting and developing new materials for various engineering applications.

Course Outcomes:

After the completion of this course, the student will be able to:

1. Know the structure and properties of different materials.
2. Understand the phase diagrams and comprehend the phase transformations in materials.
3. Understand the mechanical, electrical, magnetic and optical properties etc. of engineering materials.

Module	Course content/ Lecture	Time (Hours)
1	Historical evolution of engineering materials Selection, Classification, properties and application of engineering materials, Significance of structure- property relationship, Few examples of structure-properties relationship in Engineering Materials,	06
2	Bonding and crystal Structure in Engineering materials, Amorphous Materials, Imperfections in solids, Diffusion phenomenon, Principles of solidification, Nucleation and Growth process, allotropy and polymorphism Solid solution and Hume-Rothery rules for forming a solid solution, interstitial solid solutions, ordering in solids, Order-Disorder transition	14
3	Phase diagrams and phase transformations, Fe- Fe_3C phase diagram, Concepts of Heat treatments, TTT diagram of steel, Diffusionless transformation: Martensitic transformation. Various strengthening mechanism, Cold working, Recovery, Recrystalization, Grain growth; Change in microstructure of materials caused by hot working and cold working etc.	14
4	Introduction to metallic, semiconductor, ceramic, polymer, superconductor, composite materials, nanomaterials and smart materials. Various Properties of Engineering materials: Electrical, Optical, Mechanical and Magnetic properties. Performance of engineering materials in service condition, A few case study	14

Reference books:

1. D.R. Askeland, P.P. Phule, W.J. Wright, The Science and Engineering ofMaterials, 6th ed., Cengage Learning, 2010.
2. W.D. Callister, D.G. Rethwisch, Materials science and Engineering: AnIntroduction, 8th Ed., Wiley, 2010.
3. V. Raghavan, Materials Science & Engineering: A first course, 5th ed., PHIlearning, 2004
4. R. Abbaschian, R.E. Reed-Hill, Physical Metallurgy Principles, 4th ed.,Cengage Learning, 2009.
5. S.H. Avener, Introduction to Physical Metallurgy, 2nd ed., Tata McGraw-HillEducation, 2011.

		L	T	P	Credits	Marks
Theory Papers	**Name**					
MS 909C	**Materials Processing Technology**	4	0	0	4	100

Course Objective:
1. To gain in-depth knowledge of various materials processing techniques.

Course Outcomes
1. Identify various manufacturing processes for materials joining.
2. Identify appropriate manufacturing process to develop composites.
3. Understand the additive manufacturing process for fabricating a part or product.
4. Understand the need for high purity materials and their manufacturing process.

Module	Course content/ Lecture	Time (Hours)
1	Joining Processes: Introduction to welding, different techniques such as TIG, MIG, plasma welding, friction stir welding, electron beam welding, laser beam welding, applications	12
2	Fabrication of composites: Introduction to composites, manufacturing methods for fiber reinforced composites – Resin impregnation, prepeg production process, injection molding, hot press molding, metal matrix composites – powder processing, reactive processing, ceramic matrix composites-powder sintering, powder slurry processing, hot isostatic pressing, laminates and sandwich panels	12
3	Additive Manufacturing: Introduction to additive manufacturing, different additive manufacturing processes, classification of additive manufacturing processes, rapid prototyping and 3D printing techniques, applications	12
4	Special processing techniques: Arc melting, vacuum induction melting, melt spinning, zone melting and refining, processing for high purity materials, manufacturing processes of single crystals - semiconductor and aerospace applications	12

Reference books:

1. R.S.Mishra, Friction stir welding and processing, ASM International, 2007.
2. Nadkarni S.V., Modern Arc Welding Technology, Oxford IBH Publishers, 1996.
3. Surender Kumar, Technology of Metal Forming Processes, Prentice- Hall, Inc., 2008.
4. Y. Waseda, A. Muramatsu, Yoshio Waseda, Morphology Control of Materials and

Nanoparticles: Advanced Materials Processing and Characterization, Springer, 2004
5. Ian Gibson, David W Rosen, Brent Stucker., Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, 2nd Edition, Springer, 2015.
6. Chua Chee Kai, Leong Kah Fai, 3D Printing and Additive Manufacturing: Principles & Applications, 4th Edition, World Scientific, 2015.
7. T.W. Clyne and D.Hull, An introduction to composite materials, 3rd Edition, Cambridge University Press.

Theory Papers	Name	L	T	P	Credits	Marks
MS 910E	**Surface Engineering**	4	0	0	4	100

Course Objectives:

1. To develop an in-depth understanding of the various methods used for surface engineering.

Course Outcomes

1. Identification of appropriate surface engineering process for different engineering applications.
2. Structural and mechanical characterization of the engineered surfaces.

Module	Course Content / Lectures	Time (Hours)
1	Basics of surface engineering, surfaces and interfaces, broad classification, surface dependent properties	6
2	Surface engineering Techniques: Diffusion methodologies - Boriding, carburizing, nitriding, cyaniding, and applications. Thin films and coatings - Thin film deposition processes -PVD, CVD, Thermal spray coatings – Flame spray, HVOF, Plasma spray, applications	14
3	Advanced Surface Engineering Techniques – Surface engineering laser beams, Surface engineering by electron beams, laser cladding, ion implantation, electroless plating, electroplating, ion implantation, microstructural modification of surfaces, optical lithography, applications to automobile, aerospace industries and biomedical implants	14
4	Characterization and evaluation of engineered surfaces: Techniques for coating thickness measurement, optical and electron microscopy techniques for topography, surface profilometry, spectrographic techniques for compositional analysis of surfaces, bond strength evaluation, microhardness, nanoindentation	14

Reference Books

1. M.Ohring, Material Science of Thin Films, Academic Press, 2002.
2. P. A. Dearnley, Introduction to Surface Engineering by, Cambridge University Press, 2017
3. H. Dimigen, Surface Engineering, Wiley-VCH, 2000.
4. J. B. Hudson, Surface Engineering: An Introduction, Butterworth Heinemann, 2000.
5. S. Grainger and J. Blunt, Engineering Coatings, Woodhead Publishing, 1998.
6. ASM Handbook, Surface Engineering, 1994.
7. J.R. Davis, Surface Engineering for Corrosion and Wear Resistance, ASM International, 2001
8. Chi Tat Kwok , Laser surface modification of alloys for corrosion and wear resistance, Woodhead Publishing Limited, 2012.

		L	T	P	Credits	Marks
Sessional Paper	**Name**					
MS911P	Materials Characterization Laboratory		0	8	4	100

Course Objectives:
1. Hands on experience on the different techniques/instruments used for materials characterization

Course Outcomes:
1. Knowledge about the experimental techniques, generation of data and interpretation of results

Syllabus:
1. Quantitative and qualitative analysis of microstructure using optical microscope.
2. Scanning electron microscope: sample preparation, imaging and interpretation of results.
3. Energy dispersive x-ray spectroscopy (EDS) characterization of materials
4. Atomic force microscope: sample preparation, imaging and interpretation of results.
5. X-ray Diffraction: Interpretation of results, study of XRD pattern, crystallite size and residual stress calculation, Simulation of XRD pattern.
6. UV-Vis-IR spectroscopic characterization of materials.
7. Differential Scanning Calorimetry: study of thermodynamic parameters of materials.
8. FTIR: experiments, results and data interpretation.

		L	T	P	Credits	Marks
Sessional Paper	**Name**					
MS 912P	**Mini Project-01 (Submission of report/Seminar Presentation)**	**4**	**0**	**0**	**4**	**100**

Course Objectives:

1. The students have to write a report on a given topic, which will be related to recent advances in material science for engineering applications. The report should be submitted along with a seminar presentation.

Course outcomes:

1. The student will gain knowledge on advance areas of material science and engineering along with applications.
2. The student will know how to write a scientific / technical report.
3. Read the concerned books and scientific literature on the chosen topic.
4. Improve the communication and presentation skills.

2nd Semester

		L	T	P	Credits	Marks
Theory Papers	**Name**					
MS 1001C	**Electronic and Opto-electronic Materials**	**4**	**0**	**0**	**4**	**100**

Course Objectives

1. To gain in-depth knowledge of semiconductor materials devices.

Course Outcomes

1. Explain different properties of semiconductors based on band theory.
2. Use different semiconductor materials for optoelectronic devices and energy harvesting.

Module	Course Content / Lectures	Time (Hours)
1	Energy band diagram and band theory; band gap energy, conduction band, valance band, Fermi level; metal, semiconductor and insulators based on band diagram	12
2	Bloch's theorem and periodic potential; Kronig-Penney model; effective mass; concept of holes; density of states; carrier density; carrier mobility; Hall effect; intrinsic and extrinsic semiconductors; doping in semiconductors; semiconductor junction	12
3	Optical properties of materials: absorption and emission; radiative and non-radiative transition; photo-conducting material	12
4	Semiconductor light interaction; electronic devices: photodiode, LED, photovoltic cell, photoelectrochemical cell; LASER material.	12

Text/ Reference books:

1. Donald A. Neamen, Semiconductor Physics And Devices: Basic Principles, 4th edition (McGraw-Hill; 1 March 2011).
2. W. Gao, Z. Li, N. Sammes, An Introduction to Electronic Materials for Engineers, 2nd Edition, (World Scientific Publishing Co Inc, 16th May, 2011)
3. B. G. Streetman and S. K. Banerjee, Solid State Electronic Devices, 7th edition (PHI, 2014).
4. P. Horowitz, and W. Hill, The Art of Electronics, 2nd Edition (Cambridge University Press, 1995).
5. J. Milliman, & C. C. Halkias, Integrated Electronics, (Tata McGraw-Hill, 1995).
6. U. Woggon, Optical properties of Semiconductors, (Springer-Verlag, 2000).
7. C. Harper, Electronic Materials and Processes Handbook (Handbook), 3rd Edition (McGraw-Hill Professional; August 7, 2003)
8. S. O. Kasap, Principles of Electronic Materials and Devices, 3rd Edition, (McGraw-Hill, 2006).

		L	T	P	Credits	Marks
Theory Papers	**Name**					
MS 1002C	**Science and Technology of Ceramics**	**4**	**0**	**0**	**4**	**100**

Course objectives:

1. The course is aimed to enable the students to have a thorough knowledge on the advanced processing techniques in ceramics.

2. **Course outcomes:**
Develop an understanding and knowledge about various advanced processing techniques for ceramics.

Module	Course content/ Lecture	Time (Hours)
1	Physical ceramics: Bonding, Crystal structure and Imperfection in ceramics, Classification – Traditional and advanced ceramics, Oxide and Non oxide ceramics, Spectrum of applications, Phase diagram and Phase transition in ceramic. polymorphic modifications, stabilization in ceramics.	8
2	Process Ceramics: Ceramic raw materials (synthesis and characterization) Conventional and novel powder processing techniques, Shaping and forming of dense and porous ceramics. Synthesis of nano-structured ceramics, thin and thick film synthesis, growing ceramic single crystals.	12
3	Driving force of sintering, various sintering additives. A few case studies of sintering process. Advanced Sintering techniques: (Spark plasma sintering, microwave sintering and Reactive sintering, Liquid phase sintering, Sintering with an externally applied pressure), Problems in sintering process. A few case studies of sintering process. Effect of green microstructure on sintered microstructural features of the ceramic products.	12
4	Properties and Application Area of Ceramics: Mechanical, thermal, electrical, optical and magnetic properties of ceramics. Ceramics in biology and bio-medical applications, traditional ceramics (glass, glass-ceramics, white-ware, glass, cement, refractory, abrasive, Advanced ceramic (cellular ceramics, Ceramics in Energy Sectors, ceramic matrix composite, toughened ceramic etc.), Electro-ceramics, (insulating, ionic, semi-conducting, and conducting ceramics, Superconducting ceramics), Ferrites, Energy materials (rechargeable battery, supercapacitor, and fuel cell).	14

Text/Reference books:

Text/Reference books:
1. W. David Kingery, H. K. Bowen, Donald. R. Uhlmann, Introduction toCeramics, 2nd Edition, by, Wiley-Interscience; April 20, 1976.
2. M.N. Rahman, Ceramic Processing and Sintering by Marcel Dekker, Inc.
3. C. Barry Carter, M. Grant Norton, Ceramic Materials, Science and Engineering Springer-Verlag New York.
4. Yet-Ming Chiang, Dunbar P. Birnie, W. David Kingery, Physical Ceramics:Principles for Ceramic Science and Engineering, John Wiley, 1997.
5. L. H. Van Vlack, „Physical Ceramics for Engineers, Addison Wesley, 1964.
6. Mechanical properties of ceramics by Watchman J. B., John Wiley New York,1996.
7. J. Reed, Introduction to the Principles of Ceramic Processing, 2nd Ed.,John Wiley & Sons. 1995.
8. Fundamentals of Ceramic Powder Processing and Synthesis: Terry A Ring,Academic Press.
9. Fundamentals of Ceramics: M.W. Barsoum, CRC Press.

Theory Papers	Name	L	T	P	Credits	Marks
MS 1003E	**Nanomaterials**	**4**	**0**	**0**	**4**	**100**

Course Objectives:
1. To develop in-depth understanding on the science and technology of nanoscale materials

Course Outcomes:
1. Knowledge of science, properties, synthesis routes and applications of nanomaterials

Syllabus:

Module	Course content/ Lecture	Time (Hours)
1	Atomic world, bulk and nanomaterials: an introduction; History and development of nanoscience and nanotechnology; Fundamental of nanomaterials: definition, shape, dimension and classification; Morphology of Nanomaterials.	5
2	Physics and chemistry of nanomaterials: surface energy, surface reactivity, surface chemistry, de-Broglie wave-particle duality, exciton Bohr radius, quantum confinement, energy states, band diagram, electronic structure, density of states, blue shift, shape and dimension dependence of electronic structure.	10
3	Properties of nano-materials: electronic, optical, chemical, mechanical, thermal and magnetic properties; Synthesis of nano-materials: bottom-up synthesis: chemical, electrochemical, wet chemical, template synthesis, PVD, CVD, PLD, sol-gel etc., Top-down synthesis: ball milling, lithography: optical and electron beam lithography, etching.	10
4	Special nanomaterials: Inorganic nanostructures, porous nanostructures, carbon nano-materials, nano-biomaterials, nano-heterostructures, layered nanomaterials, 2D nanomaterials; Applications of nanomaterials: electronics, energy and healthcare.	5

Reference books:

1. M. Wilson, K. Kannagara, G. Smith, M. Simmons and B. Raguse, Nanotechnology: Basic science and emerging technologies, UNSW Press, 2002.
2. A. T. S. Wee, C. H. Sow, and C. W. Shong, Science at the Nanoscale: An Introductory Textbook, Pan Stanford Publishing, 2016.
3. T. Pradeep, Nano: The Essentials, McGraw Hill, 2008.
4. B. S. Murty, P. Shankar, B. Raj, B. B. Rath, and James Murday, Textbook of Nanoscience and Nanotechnology, Springer, 2013.

5. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, World Scientific, 2011.
6. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties, and Applications, 2nd edition, Wiley VCH, 2013.
7. S. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
8. A.S. Edelstein, and R.C. Cammaratra, Nanomaterials: Synthesis, Properties and Applications, 2nd Edition, CRC Press, 1998.
9. C. N. R. Rao, A. Müller, and A. K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications (Vol 1 and 2), Wiley, 2004.
10. B. Bhushan, Springer Handbook of Nanotechnology, Springer, 2010.
11. B. Zhang, Physical Fundamentals of Nanomaterials, Elsevier, 2018.
12. R. Tantra, Nanomaterial Characterization: Introduction, Wiley, 2016.

		L	T	P	Credits	Marks
Theory Papers	**Name**					
MS 1008E	Advanced Engineering Materials	2	0	0	2	100

Course Objectives:
1. To gain knowledge on engineering materials for advanced applications.

Course Outcomes:
1. Identify polymers, metals & alloys, biomaterials used for advanced engineering applications.

Module	Course content/ Lecture	Time
1	Synthesis, properties and application of specialty polymers such as aromatic polyethers, polyacetals, polyamides, inorganic polymer, polymeric liquid crystals, heat and fire-resistant polymers, conducting and photo-conducting polymers, polymers for biomedical applications, biodegradable polymers	7
2	Metals and alloys: Dual phase steels, Micro alloyed, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) steel, Maraging steel, Light metals and alloys - magnesium and its alloys, aluminum and its alloys, titanium and its alloys, shape memory alloys, magnetic alloys	7
3	Materials for energy applications: Novel solar cell materials, Materials for photo catalysis and photo-electrochemical cell, Materials for supercapacitor and battery devices, Hydrogen storage materials. Bio materials: Introduction to Nanobiotechnology, Materials for Biosensors, bio electronics and biomedical materials.	8
4	High temperature materials: Superalloys–Iron, Cobalt and Nickel based super alloys, strengthening mechanisms at high temperatures, temperature and time dependent transformation,structure property correlation in super alloys; Ultra high temperature ceramics; Carbon-Carbon composites applications	8

Text Books:
1. Callister et al., Material Science and EngineeringAn Introduction, 10th edition, Wiley, 2017
2. Ian Polmear, Light alloys, Elsevier, 2017.
3. Superalloys: Source Book, ASM International.
4. Fahrenholtz et al., Ultra-High Temperature Ceramics: Materials for Extreme Environment Applications, 2014.

		L	T	P	Credits	Marks
Sessional	**Name**					
MS 1009P	Materials Processing Laboratory	0	0	8	4	100

Syllabus:

1. Heat treatment (annealing, quenching) of steel specimens.
2. Ageing treatments in aluminium alloy specimens.
3. Fabrication of sintered ceramics by powder pressing and colloidal processing route.
4. Processing of polymer materials and determination of density and glass transition temperature.
5. Thin films / coatings by electrochemical techniques.
6. Synthesis of nano powder by sol-gel and co-precipitation techniques.
7. Fabrication of metal matrix / ceramic matrix composites
8. Oxidation behavior of metals / non oxide ceramics

		L	T	P	Credits	Marks
Theory Papers	**Name**					
MS 1010P	Mini Project-01 (Submission of Report/Seminar Presentation)	0	0	2	2	100

Course Objectives:

1. The students have to write a report on a given topic, which will be related to recent advances in material science for engineering applications. The report should be submitted along with a seminar presentation.

Course outcomes:

1.The student will gain knowledge on advanced areas of material science and engineering along with applications.

2.The student will know how to write a scientific / technical report.

3.Read the concerned books and scientific literature on the chosen topic.

4.Improve the communication and presentation skills.

3rd Semester

3rd Semester (150 Marks) (16 credits)			
Paper	**Name**	**Credits**	**Marks**
MS 1101	Progress Report on Thesis	10	100
MS 1102	Seminar Presentation and Viva-Voce	6	50

4th Semester

4th Semester (250 Marks) (16 credits)			
Paper	**Name**	**Credits**	**Marks**
MS 1201	Project Thesis Report	10	150
MS 1202	Project Presentation and Viva-Voce	6	100

***In 1st semester, the student has to take an elective offered by other departments for a total of 4 credits**

***MOOC/ SWAYAM PLATFORM**

- The student can take any course from MOOC/SWAYAM platform upto a maximum of 4 credits.
- The student can take MOOC/SWAYAM courses in lieu of MS 1003E or MS1008E or both.
- The student can to take MOOC/SWAYAM courses in addition to the syllabus up to a maximum of 4 credits.

Program: PhD

Program: PhD, Material Science and Engineering

Program Specific Objective:

PSO-1	**Enabling the student to design and conduct systematic research independently and critically analyze and interpret results/data.**
PSO-2	**Enabling the student to design materials/devices for specific application considering economic, environmental, social, and sustainable development.**
PSO-3	**Training and guiding next generation of researchers both in academics and research and development.**
PSO-4	**Develop skills to prepare a detailed scientific report on the knowledge created by research and publish in manuscript for knowledge dissemination.**

Program Outcome:

PO-1	**Ability to design and conduct experiments and critically analyze and interpret data.**
PO-2	**Ability to design a process and/or material system to achieve specific requirements.**
PO-3	**Ability to identify, formulate, and solve engineering problems.**
PO-4	**Write substantial scientific/technical reports and present the same.**
PO-5	**Apply the knowledge of science and engineering to material issues.**

PhD Syllabus

Paper code	Paper	Credits	Marks
PhD-9001	Research Methodology-I	04	100
PhD-9002	Research Methodology-II	04	100
PhD-9003	Advanced Area in Materials Science and Engineering	04	100
PhD-9004	Seminar & viva-voce /Practical/Projects & assignments on specific research topics	04	100

Research Methodology-I (Credits: 04)
1. Common for all science departments (as defined by Tripura University)

Research Methodology-II (Credits: 04)
1. Common for all under some group of science departments

		L	T	P	Credits	Marks
Theory Papers	**Name**					
PhD-9002	**Research Methodology-II**	4	0	0	4	100

Syllabus:

Research in Materials Science: introduction, a history, importance, outlook and future; How to define a research problem in Materials Science and Engineering; Computational methods in Materials Science research.
Experimental Materials Science research: laboratory formalities, instruments handling and maintenance, laboratory safety and troubleshooting; Materials Science research: development of a research idea, methods to perform experiments, data collections, errors in data collections, interpretation of results and related discussions, reproducibility of data.
Preparation of research reports/manuscript: authorship, graphical abstract, introduction, experimental/computational methods, results and discussion, conclusions.
Few reacted sections in materials research: acknowledgement, conflict of interest, copyright, ethics of research and publications; Patents; Post publication: citation of an article, profile of a researcher, communication with scientist and collaboration.

(Following courses will be offered according to the research area of the scholar)

Advanced Area in Materials Science and Engineering (Credits: 04)

		L	T	P	Credits	Marks
Theory Papers	**Name**					
PhD-9003	**Advanced Area in Materials Science and Engineering**	4	0	0	4	100

Advanced Characterization of Materials (Credits: 04)

Syllabus:

Microscopy techniques: Optical microscopy, Electron microscopy: Scanning electron microscopy and Transmission electron microscopy, Scanning probe microscopy: Scanning tunnelling microscopy, Atomic force microscopy, Magnetic force microscopy (MFM), and piezoelectric force microscopy (PFM): analysis of data and interpretation of results; X-ray: basic physics, X-ray diffraction techniques: analysis of data and interpretation of results; Spectroscopy: Atomic absorption spectroscopy, UV-Vis spectroscopy, Energy dispersive X-ray spectroscopy, Infrared spectroscopy, Raman spectroscopy, Photoluminescence spectroscopy, X-ray fluorescence spectroscopy (XRF), Time-resolved fluorescence spectroscopy and X-ray photoelectron spectroscopy: working principles, analysis of data and interpretation of results; Thermal characterization: DTA, DSC, TGA, Mechanical testing and NDT. Electrical characterization of materials and Electrochemical characterization of materials.

14. L.Yang. Materials Characterization, Wiley-VCH, 2nd Edition, 2015
15. S. Amelinckx, D. van Dyck, J. van Landuyt, and G. van Tendeloo, Electron Microscopy: Principles and Fundamentals, Wiley, 2008
16. P.J. Goodhew, and F.J. Humphreys, Electron Microscopy and Analysis, 2nd Edition, Taylor and Francis, 1997
17. R. Wiesendanger, Scanning Probe Microscopy and Spectroscopy-Methods and Applications, Cambridge University Press, 2010
18. B. Voigtländer, Scanning Probe Microscopy, Springer, 2012
19. B. D. Cullity, Elements of X-ray Diffraction, Addison-Wesley Publishing Co, 1979
20. R. Jenkins and R. Snyder, Introduction to X-ray Powder Diffractometry, Wiley, 1996
21. N. Colin, Fundamentals of Molecular spectroscopy, Tata McGraw-Hill Publishing Co. Ltd., 4th edition, 1994
22. G. Gauglitz, and D. S. Moore, Handbook of Spectroscopy, 2nd Edition, Wiley, 2014
23. E.N. Kaufman, Characterization of Materials (Vol I, II and III), 2nd Edition, Wiley, 2003
24. P.E.J. Flewitt, and R.K Wild, Physical Methods for Material Characterization, Institute of Physics Publishing, 1994
25. D. B. Williams, and C. B. Carter, Transmission Electron Microscopy,Springer, 2009
26. Y. Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd Edition, Wiley VCH, 2013

Advanced Nanomaterials (Credits: 04)

Syllabus:

Atomic, nano and bulk world; Bulk, amorphous and nanostructure materials; Fundamental of nanomaterials: definition, basics, history, morphology of Nanomaterials ; Physics and chemistry of nanomaterials: surface energy, surface reactivity, de-Broglie wave-particle duality, exciton Bohr radius, quantum confinement, energy states, band diagram and density of states; Properties of nano-materials: electronic, optical, chemical, mechanical, thermal and magnetic properties; Synthesis of nano-materials: bottom-up synthesis: chemical, electrochemical, wet chemical template synthesis, PVD, CVD, PLD, sol-gel etc., Top-down synthesis: ball milling and lithography; Special nanomaterials: Inorganic nanostructures, porous nanostructures, carbon nano-materials, nano-biomaterials, nano-heterostructures, Energy nanomaterials, 2D nanomaterials, layered nanomaterials; Applications of nanomaterials: electronics, energy and healthcare.

Reference Books:

1. M. Wilson, K. Kannagara, G. Smith, M. Simmons and B. Raguse, Nanotechnology: Basic science and emerging technologies, UNSW Press, 2002.
2. A. T. S. Wee, C. H. Sow, and C. W. Shong, Science at the Nanoscale: An Introductory Textbook, Pan Stanford Publishing, 2016.
3. T. Pradeep, Nano: The Essentials, McGraw Hill, 2008.

4. B. S. Murty, P. Shankar, B. Raj, B. B. Rath, and James Murday, Textbook of Nanoscience and Nanotechnology, Springer, 2013.
5. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, World Scientific, 2011.
6. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties, and Applications, 2nd edition, Wiley VCH, 2013.
7. S. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
8. A.S. Edelstein, and R.C. Cammaratra, Nanomaterials: Synthesis, Properties and Applications, 2nd Edition, CRC Press, 1998.
9. C. N. R. Rao, A. Müller, and A. K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications (Vol 1 and 2), Wiley, 2004.
10. B. Bhushan, Springer Handbook of Nanotechnology, Springer, 2010.
11. B. Zhang, Physical Fundamentals of Nanomaterials, Elsevier, 2018.
12. R. Tantra, Nanomaterial Characterization: Introduction, Wiley, 2016.

Advanced Polymer Materials (Credits: 04)

Syllabus:

Basic concepts; polymer raw materials ; polymerization principles and processes (step, chain and other polymerizations, polymer kinetics, polymerization techniques); polymer manufacture (unit operations, polymer reactors, polymer isolation, handling and storage); polymer structure and property; polymer characterization; polymer modification, multi-component polymeric materials (polymer miscibility, polymer blends and alloys, filled plastics, polymer composites); polymer compounding and fabrication (polymer additives, compounding processes, fabrication techniques, post fabrication operations); polymer testing (sample preparation, testing standards and methods, analysis of polymer and additives) ; polymer product design; polymer applications; frontiers of polymer materials (biogradable polymers, biomedical polymers, conducting polymers, magnetic polymers, polymers for space, nonlinear optical polymers); problems of polymer (thermoxidative degradation, fire hazards, toxicity, effluent disposal, feedstock scarcity).

Reference Books:

1. G. Odian, Principles of Polymerization, Wiley, London, 2004.
2. John Brydson, Plastics Materials, Elsevier.
3. P. Ghosh, Polymer Science and Technology of Plastics and Rubber, Tata
4. McGraw Hill, New Delhi, 2000.
5. V. R. Gowarikar, N. V. Viswanathan and J. Sreedhar, Polymer Science, John
6. Wiley and Sons 1986.

Advanced Processing of Ceramics (Credits: 04)

Syllabus:

Ceramic powder preparation by mechanical and chemical methods, solid-state reaction, directed metal oxidation, reaction bonding, polymer pyrolysis, spray dying, freeze drying, spray pyrolysis, particle size reduction and optimized particle size distribution by Crushing, grinding, milling by various techniques. Processing and fabrication of ceramics by dry and semi-dry pressing, cold isostatic compaction, Hot Pressing and Hot Isostatic Pressing, slip casting, pressure casting, gel casting, tape casting, extrusion, injection moulding. Colloidal Processing of ceramics: basic surface forces, Hamekar constant, DLVO theory, double-layer formation, Stern layer, zeta potential, debye length, stabilization phenomena of colloidal suspensions, electrostatic stabilization, electrical double layer theory, zeta potential, electrophoresis, steric stabilization, electrosteric stabilization, rheology of colloidal suspension and ceramic slurry, role of additive (plasticizers, binders, surfactants, foaming and antifoaming agents) in ceramic forming, Forming of Ceramics: particle packing in green ceramics, drying behaviour of ceramics: drying shrinkage drying defects, Various drying techniques. binder removal by solution de-binding and thermal de-binding, Advanced sintering techniques: Liquid phase sintering, mechanism, stages and microstructure of liquid phase sintering. Pressure assisted liquid phase sintering, activated sintering, microwave sintering and spark plasma sintering, Explosive Shock Consolidation,sintering with an externally applied pressure – Hot Pressing and Hot Isostatic Pressing, role of stress in densification factor Densification and coarsening, simultaneous densification and grain growth. Grain growth in ceramics due to sintering, Normal and exaggerated grain growth, mechanism, stages and microstructure evolution during sintering. Material examples of ceramic materials for various applications, Few case study on ceramic processing and fabrication, Various ceramic industries in India.

Reference Books:

1. M. N. Rahaman, *Ceramic Processing and Sintering*,, CRC Press, 2003
2. J.S. Reed, *Introduction to the Principles of Ceramic Processing*, *2nd Ed.*,, John Wiley & Sons. 1995.
3. Ceramic Processing before Firing Onada& Hench.
4. Advanced Ceramics Vol 9, Forming of Ceramics.

PhD-9004	Seminar & viva-voce /Practical/Projects & assignments on specific research topics	04	100

Seminar & viva-voce /Practical/Projects & assignments on specific research topics (Credits: 04)

(Seminar presentation related to the research works done by the research scholars)