Indian Institute of Space Science and Technology (IIST)

Valiamala, Thiruvananthapuram, Kerala

Department of Aerospace Engineering

M.Tech in MANUFACTURING TECHNOLOGY

Curriculum and Syllabus

(Effective from 2024 Admission)

VISION

To be the state-of-the-art centre for manufacturing, continuously expanding the scope of education, research and technological development in the subject domain, with special focus on aerospace applications.

MISSION

Value added education in applied and advanced Manufacturing Science, Engineering and Technology, to nurture quality manpower for building the capabilities of nation in various domains of materials processing.

OBJECTIVE

To impart knowledge and promote research on the basic, applied & advanced manufacturing processes and develop the skill set of the students, to attain the industry aligned competencies and to complement the needs of society, with boundless collaborations of Indian Space Research Organization.

CORE VALUES AND SPECIALITIES OF THE PROPOSED PROGRAM

- Boundless support from state-of-the-art facilities of ISRO
- Opportunities to work with challenging manufacturing projects in space sector
- Inter/multi-disciplinary learning experience through innovative case studies in ISRO entities.

OUTCOMES

- Development of creative and technologically competent human resources to serve the nation
- Research and Development activities to crack the challenges/ cater the needs of manufacturing sector, with specific thrust on Aerospace/Space manufacturing.

CURRICULUM

SEMESTER 1

CODE	COURSE TITLE	L	T	P	C
AE601	Mathematical Methods in Aerospace Engineering	3	0	0	3
AE641	Advanced Engineering Materials	3	0	0	3
AE642	Subtractive and Computer Aided Manufacturing	3	0	0	3
AE643	Manufacturing Planning and control	3	0	0	3
	Elective -1	3	0	0	3
	Elective-2	3	0	0	3
AE804	Machine Tools and Metrology Practice (Lab)	0	0	3	1
	TOTAL	18	0	3	19

SEMESTER 2

CODE	COURSE TITLE	L	T	P	C
AE644	Plasticity and Advanced Deformation Processes	2	1	0	3
AE645	Additive Manufacturing and smart practices	3	0	0	3
AE646	Composite Manufacturing Technology	3	0	0	3
AE647	Advanced Welding Technology	3	0	0	3
	Elective-3	3	0	0	3
	Elective-4	3	0	0	3
AE805	Materials Processing and Characterization Practice (Lab)	0	0	3	1
	TOTAL	17	1	3	19

SEMESTER 3

CODE	COURSE TITLE	L	T	P	C
AE853	Summer Internship	0	0	0	2
AE852	Project Phase I	0	0	0	14

SEMESTER -4

CODE	COURSE TITLE	L	T	P	C
AE852	Project Phase II	0	0	0	16

List of Electives

CODE	COURSE TITLE	L	T	P	C
AE631	Advanced Solid Mechanics	3	0	0	3
AE632	Finite Element Method	3	0	0	3
MA618	Foundations of Machine Learning	3	0	0	3
AE791	Optimization Techniques	3	0	0	3
AE781	Mechanical Behaviour of Materials	3	0	0	3
AE782	Materials Characterization Techniques	3	0	0	3
AE758	Fracture Mechanics and Fatigue	3	0	0	3
AE757	Molecular Dynamics and Materials Failure	3	0	0	3
AE783	Advanced Machining Processes	3	0	0	3
AE784	Design for Manufacturing	3	0	0	3
AE785	Digital Manufacturing and Automation	3	0	0	3
AE786	Metrology and Computer Aided Inspection	3	0	0	3
AE797	Non-Traditional Machining	3	0	0	3
AE796	Micro/Nano Manufacturing	3	0	0	3
AE787	Solidification Processing	3	0	0	3
AE788	Heat Treatment Techniques	3	0	0	3
AE789	Powder Metallurgy	3	0	0	3
AE790	Thermodynamics and Phase Transformation of Materials	3	0	0	3
AE792	Advanced Operations Research	3	0	0	3
AE793	Quality Engineering	3	0	0	3
AE794	Industrial Engineering	3	0	0	3
AE795	Total Quality Management	3	0	0	3
AE766	Robot Mechanisms and Technology	3	0	0	3
AE762	Smart Materials and Structures	3	0	0	3
AE633	Structural Dynamics	3	0	0	3

AE625	Computational Fluid Dynamics	3	0	0	3
AE756	Advanced Finite Element Method	3	0	0	3
MA624	Advanced Machine Learning	3	0	0	3
AE603	Elements of Aerospace Engineering	3	0	0	3
AVM865	Sensors and Actuators	3	0	0	3
AVM612	Introduction to Micro Electro Mechanical Systems	3	0	0	3
AVM622	Micro/Nano Fabrication Technology	3	0	0	3
AVD887	Internet of Things	3	0	0	3
MA613	Data Mining	3	0	0	3
AVD864	Computer Vision	3	0	0	3

SYLLABUS

CORE COURSES

AE 601: MATHEMATICAL METHODS IN AEROSPACE ENGINEERING

Syllabus

Review of Ordinary Differential Equations: analytical methods, stability – Fourier series, orthogonal functions, Fourier integrals, Fourier transform – Partial Differential Equations: first-order PDEs, method of characteristics, linear advection equation, Burgers' equation, shock formation, Rankine-Hogoniot jump condition; classification, canonical forms; Laplace equation, min- max principle, cylindrical coordinates; heat equation, method of separation of variables, similar- ity transformation method; wave equation, d'Alembert solution – Calculus of Variations: standard variational problems, Euler-Lagrange equation and its applications, isoperimetric problems, Rayleigh-Ritz method, Hamilton's principle of least action.

References

1. *Brown, J. W. and Churchill, R. V., Fourier Series and Boundary Value Problems, 8th ed., McGraw-Hill, (2012).*
2. *Bleecker, D. D. and Csordas, G., Basic Partial Differential Equations, Chapman & Hall (1995).*
3. *Myint-U, T. and Debnath, L., Linear Partial Differential Equations for Scientists and Engineers, 4th ed., Birkhauser (2006).*
4. *Strauss, W. A., Partial Differential Equations: An Introduction, 2nd ed., John Wiley (2007).*
5. *Kot, M., A First Course in the Calculus of Variations, American Math Society (2014).*
6. *Gelfand, I. M. and Fomin, S. V., Calculus of Variations, Prentice Hall (1963).*
7. *Arfken, G. B., Weber, H. J., and Harris, F. E., Mathematical Methods for Physicists, 7th ed., Academic Press (2012).*
8. *Greenberg, M. D., Advanced Engineering Mathematics, 2nd ed., Pearson (1998).*

Course Outcomes

CO1: Develop a general understanding of linear algebra in terms of vector spaces and its application to differential equations and Fourier analysis.
CO2: Ability to use Fourier analysis techniques for solving PDE and for signal analysis.
CO3: Formulate physical problems in terms of ODE/PDE and obtain analytical solutions.
CO4: Use commercial/open-source math packages for solving ODE and performing signal analysis.

AE 641: ADVANCED ENGINEERING MATERIALS

Course Objectives

This course will provide a broad overview of materials used in strategic sectors like aerospace and defense. The rudiments of materials science, light metals and alloys used in aerospace sector, advanced steels, titanium alloys, super alloys & composites, their processing and structure property correlation will be discussed. In addition to the above, materials developed off late such as high entropy alloys and their applications will be discussed.

Syllabus

Review of crystal structures and miller indices & planes, crystal defects, formation of grains and grain boundaries from melt.
Light metals and its alloys – Aluminium and its alloys – Temper designation, strengthening mechanisms, precipitation hardening, Al-Li alloys, Applications, Magnesium and its alloys, Titanium and its alloys - α, β, α - β alloys, processing & applications
Certification of materials in relevance to aerospace and special processes.
Metals for high temperature service - Ni, Fe and Co based super alloys – Processing and properties, Environmental degradation and protective coatings, Maraging steels, stainless steels, Copper alloys, composites –carbon epoxy and ablative composites, High entropy alloys, Materials for launch vehicles and space applications.

Text book

1. *I.J Polmear, David Stjohn, Jian-feng Nie, Ma Qian, Light Alloys: Metallurgy of the Light Metals, Butterworth-Heinemann Ltd, 5th edition (2016)*
2. *Roger C. Reed, The Superalloys- Fundamentals and Applications. Cambridge University Press (2008)*

Reference books

1. *Adrian P Mouritz, Introduction to Aerospace Materials, Woodhead publishing (2012)*
2. *ASM Speciality Handbook, Heat Resistant Materials*
3. *B.S.Murty, Jien-Wei Yeh, S. Ranganathan, P. P. Bhattacharjee High entropy alloys, 2nd ed. Elsevier (2019).*
4. *PP Sinha, Maraging steels, ISRO publications (2012)*

Course Outcomes

CO1: Interpret the various microstructures of metallic alloys and correlate with the properties
CO2: Devise a proper heat treatment technique for obtaining the required microstructure in various metallic materials
CO3: Upon understanding the requirements, select a proper material for a given application

AE 642: SUBTRACTIVE AND COMPUTER AIDED MANUFACTURING

Couse Objectives

This course aims to cover the fundamental theory of subtractive manufacturing processes used in precision engineering applications, with special focus on aerospace/ space applications.

Syllabus

Material Removal Processes –Tool based and Non-traditional techniques- Mechanics and thermo-mechanical aspects of Machining- Modelling aspects to understand the role of process variables in subtractive manufacturing - Abrasive processing for surface finishing and surface integrity control- Machinability of Engineering Materials- Selection of subtractive manufacturing processes and strategies- Cutting Tools, Machine tools and their selection- Computer Numerical Control (CNC) machining technology- Basics of CNC programming- Machining for Aerospace/ Space applications

Text Books

1. *Ghosh, A. and Mallik, A. K., Manufacturing Science, Affiliated East West Press (2010).*
2. *Winston A. Knight, Geoffrey Boothroyd, Fundamentals of Metal Machining and Machine Tools, CRC Press (2006)*

References

1. *ASM Handbook Volume 16: Machining*
2. *B.L. Juneja, G.S.Sekhon, Nitin Seth, Fundamentals of Metal cutting and Machine Tools, New age (2017)*
3. *Paulo Davim, Machining Fundamentals and Machining: Fundamentals and Recent Advances, Springer (2008)*
4. *Serope Kalpakjian, Steven R. Schmid, Manufacturing Engineering and Technology, 8th ed., Pearson Education (2023).*
5. *Milton C. Shaw, Metal Cutting Principles, Oxford University Press (2012)*
6. *Peter Smid, CNC Programming Handbook, Industrial Press (2007)*
7. *Research articles/ Case Studies in Machining*

Course Outcomes

CO1: Discuss the theoretical aspects (thermo-mechanical aspects) of subtractive manufacturing (traditional and non-traditional machining), which find critical role in various mechanical/aerospace applications

CO2: Discuss various aspects related to cutting tools, machine tools, process parameters and the basics of computer numerical control for subtractive manufacturing

CO3: Understand various terminologies/ methodologies /practices associated with subtractive manufacturing techniques, to have an assessment on their suitability/selection in industrial /R&D related end-use applications.

AE 643: MANUFACTURING PLANNING AND CONTROL

Couse Objectives

1. To understand the various types of manufacturing systems and their typical characteristics in terms of the layout, the level of automation and volume/variety of products manufactured.
2. To understand classical manufacturing planning and control (MPC) functions and the role of quantitative approaches to enhance industrial productivity and competitiveness.
3. To learn contemporary topics in MPC, including JIT and lean systems, Industry 4.0 and the use of Artificial Intelligence in manufacturing management.
4. To develop knowledge and skills in solving problems using real-life case studies in MPC.

Syllabus

Introduction to manufacturing planning and control (MPC)- Types and characteristics of manufacturing systems – Operations planning and productivity–– Product development and design - Forecasting - Process planning - Capacity planning – Facility location and layout - Aggregate planning -Master production schedule - materials requirement planning (MRP) and MRP-II –Scheduling in manufacturing systems - Assembly line balancing - Inventory planning and control - Quality management and control – Enterprise resource planning - JIT and lean systems – Introduction to industry 4.0 –Role of Artificial intelligence in MPC - case studies.

References

1. *T. E. Vollmann, W. L. Berry, D. C. Whybark and F. R. Jacobs, Manufacturing planning and control, Tata McGraw Hill, 5th Edition 2011.*
2. *E. S. Buffa and R.K. Sarin, Modern Production/Operations Management, Wiley, 8th Edition, 2010.*
3. *W. J. Stevenson, Operations Management, McGraw Hill, 14th Edition, 2021.*
4. *O. Perez, S, Sauceda and J. Cruz, Manufacturing 4.0: The use of emergent technologies in manufacturing, Palibrio, 2018.*
5. *K.N. Krishnaswamy and M. Mathirajan, Cases in Operations Management, PHI learning, 2010.*

Course Outcomes

CO1: Identify the elements of MPC and the various transformation processes to enhance industrial productivity and competitiveness.

CO2: Prepare demand forecasts, aggregate production plans, master production schedules and materials requirement plans.

CO3: Analyze and solve facility planning problems, sequencing and scheduling problems in various manufacturing environments, balancing of production lines in a flow manufacturing environment, inventory planning problems and quality control problems.

CO4: Demonstrate an understanding of contemporary topics like JIT and lean systems, Industry 4.0 and the role of artificial intelligence in MPC.

AE 644: PLASTICITY AND ADVANCED DEFORMATION PROCESSES

Couse Objectives

This course introduces the concepts of plasticity including the plastic stress- strain relations, leading to an understanding of deformation processes. The influence of state of stress during various plastic deformation processes will be covered. Advanced metal forming processes will be highlighted.

Syllabus

Concepts of stress and strain, state of stress in two and three dimensions, Hydrostatic and deviatoric stress, flow curves, yielding criteria, octahedral shear stress and shear strain, stress invariants, Plastic stress - strain relations, Friction in metal forming, Fundamentals of metal working - Extrusion, rolling, wire drawing, Forging, Solutions to metal forming problems Advanced deformation processes- Single point incremental forming, ring rolling, Roll bending, High energy rate forming processes etc. Deformation processes for launch vehicle and space applications

Text books

1. *George E.Dieter, Mechanical Metallurgy, 3rd ed. McGraw Hill Education (2017)*
2. *Chakrabarty, Theory of plasticity, 3rd ed. Elsevier (2007)*

Reference books

1. *Andrzej Sluzalec, Theory of Metal Forming Plasticity: Classical and Advanced Topics, Springer, (2004)*
2. *Sadhu Singh, Theory of Plasticity and Metal Forming Processes, Khanna Publishers (2003)*
3. *R. Ganesh Narayanan, Uday Shanker Dixit, Advances in material forming and joining – 5th International and 26th All India Manufacturing technology, design and research conference (2014)*
4. *Taylor Altan and Erman Tekkaya, Sheet metal forming fundamentals, ASM international (2012)*
5. *Taylor Altan and Erman Tekkaya, Sheet metal forming processes and applications, ASM international (2012).*

Course Outcomes

CO1: Solve problems related to plastic working of metals

CO2: Understand the various metal forming processes and its applicability in industries

CO3: Analyze the stress states in various forming processes and trouble shoot the defects that arise in the components

AE 645: ADDITIVE MANUFACTURING AND SMART PRACTICES

Couse Objectives

This course aims to cover the fundamentals and recent research trends of additive manufacturing processes. Various processes, principles, metallurgical aspects etc., will be discussed with an introduction to smart practices in additive manufacturing; with special focus on aerospace/ space applications.

Syllabus

Introduction to additive manufacturing – Classification, Methodology and process flow - Input for AM –Metal/ Non-metallic 3D printing – Powder, liquid, sheet and wire based processes- recent research trends/practices – Material science, process physics and Metallurgy of Additive manufacturing- Discussions on transport phenomena and hydrodynamics of metal additive manufacturing - Defects in AM- Processes selection, planning and control-Smart practices in Additive Manufacturing- 3D printing of Smart Materials and Structures- Multi-material/ Functionally graded / Lattice based 3D printing - Multi Dimensional (4D/5D/6D) 3D printing – Use of advanced tools (AI, ML and IoT etc.) in Additive Manufacturing- Additive manufacturing for Aerospace/ Space applications

Text Book

1. *Ian Gibson, David W. Rosen, Brent Stucker, Additive Manufacturing Technologies: 3D printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer (2015)*
2. *C. P. Paul, A. N. Jinoop, Additive Manufacturing: Principles, Technologies and Application, McGraw Hill (2021)*

References

1. *Richard Leach, Simone Carmignato, Precision Metal Additive Manufacturing, CRC Press (2021)*
2. *Martin Leary, Design for Additive Manufacturing: Additive Manufacturing Materials and Technologies, Elsevier (2020)*
3. *Andreas Gebhardt and Jan-Steffen Hötter, Additive Manufacturing: 3D printing for Prototyping and Manufacturing, Carl Hanser Verlag (2016)*
4. *Andreas Gebhardt, Understanding Additive Manufacturing: Rapid prototyping, Rapid Tooling, Rapid manufacturing, Hanser Pub Inc (2012)*
5. *Research articles / Case Studies in Additive Manufacturing and Smart Practices*

Course Outcomes

CO1: Introduce various additive manufacturing techniques

CO2: Discuss the theoretical and practical aspects (terminologies, process physics, materials, metallurgy and performance aspects) of additive manufacturing processes

CO3: Understand various methodologies and smart practices associated with additive manufacturing techniques, to have an assessment on their industrial /R&D end-uses.

AE 646: COMPOSITE MANUFACTURING TECHNOLOGY

Couse Objectives

The course will acquaint the students to the basics of composite materials, the various types in use, its constituents, fabrication and processing techniques employed, mechanics and its applications. It also introduces the various characterization techniques, advanced manufacturing technologies employed in space, aerospace and defence sectors. On completion of the course, the students will be equipped with skills to understand and relate to practical world applications of composite materials and apply the knowledge to simplify the currently used concepts.

Syllabus

Introduction to composites, Types & classification, Polymer matrix, Metal matrix, Ceramic matrix, Fibre – Matrix – interfaces, Fibre reinforced plastics, Processing & applications. Hybrid composites – GLARE, Ablatives, Carbon-Carbon, Fibres and fabrics, Resin system, Nano-composites, nano-reinforcements, Laminates.

Fabrication techniques, salvage & disposal of composites, Micro / Micromechanics of composites, Mechanisms of failure, Testing and characterization, 3D printing and other recent advances in composite technology, Composites for space & defence applications.

Text book

1. *Balasubramanian, M. Composite Materials and Processing, CRC press (2017)*
2. *H.K. Shivanand, B.V. Bapu Kiran, Composite Materials, Asian Books Pvt. Ltd (2010)*
3. *P.K. Mallick, Fiber reinforced composites, Materials, Manufacturing and Design, CRC Press (2008)*

Reference books

1. *K. Chawla, Composite Materials Science and Engineering, Springer (2006)*
2. *TW clyne and Hull, An introduction to composite materials, 3rd ed. Cambridge (2019)*
3. *Autar K. Kaw, Mechanics of Composite Materials, CRC Press (1994).*
4. *Rober M Jones, Mechanics of Composite materials, CRC Press (1998)*
5. *Madhujit Mukhopadhyay, Mechanics of Composite Materials and Structures, Universities press (2004)*

Course Outcomes

CO1: Knowledge on fundamentals of composite materials

CO2: Practical understanding of processing of composites and fabrication of composite structures

CO3: Understanding on various composite products in rocketry

CO4: Will be able to appreciate the advantages of composite materials

CO5: Knowledge about the different fibre-resin systems in use

CO6: Understanding on limitations and advantages of various manufacturing techniques involved

CO7: Will know the different characterisation techniques of composites including non-destructive methods

CO8: Novel thoughts on disposal of composites

AE 647: ADVANCED WELDING TECHNOLOGY

Couse Objectives

This course will familiarise the students with various welding processes that are used to manufacture structures and components needed for engineering applications. By understanding the concepts of welding processes, students can select the process based on the requirements and apply their knowledge in producing the components. This course focuses on both traditional and unconventional processes to gain knowledge in a wide spectrum of processes. In addition to various welding processes, allied topics such as filler wire selection, shield gases, the effect of various welding parameters, residual stress, distortion, welding defects, and their control will also be covered to address the practical challenges.

Syllabus

Fusion welding processes: GTAW-concepts, physics of arc, flux assisted processes, forces, pulsed and continuous current modes, GMAW-concepts, types of metal transfer, pulsed and synergic MIG welding, shielding gases in arc welding processes, Selection of filler wire in welding, EBW: Concepts, types and applications. LBW: Physics of lasers, types of lasers, operation of laser welding setup, advantages and limitations, applications, hybrid welding.

Solid state welding processes: Friction welding: Concepts, types and applications. Friction stir welding: Metal flow phenomena, tools, process variables and applications, Explosive bonding, diffusion bonding and ultrasonic welding, principles of operation, process characteristics and applications- Brazing and soldering- Welding residual stresses - causes, occurrence, effects, and measurements - types of distortion - factors affecting distortion - distortion control methods - prediction – Defects: Origin - types - process induced defects, - significance - remedial measures, Welding and welding metallurgy of aerospace materials.

Text book

1. *J Norrish, Advanced welding process, woodhead publishing (2006)*
2. *Nadkarni S.V., Modern Arc Welding Technology, Oxford IBH Publishers (1996)*

Reference books

1. *Cary, Howard, Modern Welding Technology, prentice Hall (1993)*
2. *Kenneth Easterling, 'Introduction to Physical Metallurgy of Welding', Elsevier (1992)*
3. *Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM,*
4. *Christopher Davis, 'Laser Welding - A Practical Guide', Jaico Publishing House (1994)*
5. *H. Schultz, Electron Beam Welding, Woodhead Publishing Series in Welding and Other Joining Technologies (1994)*
6. *Larry Jeffus, welding: principles and applications, 8th ed. Cengage learning (2016).*
7. *AWS handbook*

Course Outcomes

CO1: Understand the basic concepts of various welding processes, including fusion welding and solid-state welding process

CO2: To analyse the various defects associated with welding processes and correlate with the process parameters

CO3: To decide on the type of metal transfer required for various applications

CO4: Understand the effect of process parameters in various welding processes on the quality and performance of weld joints

CO5: Gain knowledge on weld residual stresses, distortion, welding process defects, their causes, and remedies

CO6: To select the right choice of filler materials.

AE 804: MACHINE TOOLS AND METROLOGY PRACTICE (LAB)

Couse Objectives

This course aims to provide hands-on practical training on various machine tools and metrology systems used in shop floor, with special sessions on virtual processing, CNC programming, manufacturing simulations and computer aided, to get educated to industrial scenarios.

Syllabus

Exercises in Traditional/Non-traditional machining and Abrasive processes - CNC /CAM Practice – Familiarization of FMS - Manufacturing Simulation practices / Virtual manufacturing

Basics of shop floor metrology practices and instruments – Surface metrology- Discussions on dimensional/geometric tolerances, fits and Design for manufacturing /assembly

Demonstrations/ Practical sessions at ISRO centres

References

1. *ASM handbooks*
2. *Winston A. Knight, Geoffrey Boothroyd, Fundamentals of Metal Machining and Machine Tools, CRC Press*
3. *Krishnadas Nair, C. G. and Srinivasan, R., Materials and Fabrication Technology for Satellite and Launch Vehicle, Navbharath Enterprises*
4. *Geoffrey Boothryod, Peter Dewhurst, Winston A knight, Product design for Manufacture and Assembly, CRC Press.*
5. *Smith, G. T., Industrial Metrology: Surfaces and Roundness, Springer-Verlag*
6. *Shotbolt, C. S. and Galyer, J., Metrology for Engineers, Cassell Pub.*
7. *Corrado Poli, Design for Manufacturing – A structured Approach, Butterworth-Heinemann*
8. *Meadows, Geometric Dimensioning and Tolerancing: Application, analysis, gauging and measurements, James D. Meadows & Associates*
9. *Lab Manuals/ Study Materials*

Course Outcomes

CO1: Familiarization of traditional, non-traditional and CNC machining practices in shop floor.

CO2: Familiarization of virtual manufacturing and manufacturing simulation.

CO3: Familiarization of dimensional and geometric tolerances, measurement systems and practices in Industrial Metrology.

CO4: Implementation of above knowledge for solving typical tasks in manufacturing /metrology; and to have an assessment of suitable manufacturing /measurement techniques for end-use applications.

AE 805: MATERIALS PROCESSING AND CHARACTERIZATION PRACTICE (LAB)

Couse Objectives

The objective of the course is to augment the theoretical component learned in the class room through various systematic experiments that will help students understand the physical characteristics of materials and the processes and gain skill & hands-on experiences in handling the machinery and other equipments

Syllabus

Lab practices on applied and advanced techniques of metal forming, welding, heat-treatment. Material characterization / metallography practice.

Discussions on the manufacturing practices for polymers, composites and ceramics (including 3D printing options)- Demonstrations/ Practical sessions at ISRO centres

References

1. *ASM handbooks*
2. *Cary, Howard, "Modern Welding Technology', prentice Hall,*
3. *Krishnadas Nair, C. G. and Srinivasan, R., Materials and Fabrication Technology for Satellite and Launch Vehicle, Navbharath Enterprises*
4. *Campbell, F. C., Manufacturing Technology for Aerospace Structural Materials, Elsevier*
5. *Lab Manuals / Study Materials*

Course Outcomes

CO1: Familiarization and hands-on practices on metal forming and welding techniques

CO2: Practical understanding of heat treatment and metallography procedures

CO3: Basic understanding on the processing of polymers, composites and ceramics

CO4: Implementation of above knowledge for solving typical material processing tasks and to have an assessment of technique for end-use applications.

ELECTIVES

AE 631: ADVANCED SOLID MECHANICS

Syllabus

Review of basic equations of elasticity – state of stress at a point – analysis of strain, constitutive relations – generalized Hook's law – formulation of boundary value problems – solution of 2D problems – energy methods in elasticity – bending, shear and torsion – thin walled beams – applications.

Text Book

- Sadd, M. H., Elasticity: Theory, Applications, and Numerics, 3rd ed., Academic Press (2014).

References

1. *Srinath, L. S., Advanced Mechanics of Solids, 3rd ed., Tata McGraw-Hill (2010).*
2. *Mase, G. T., Smelser, R. E., and Mase, G. E., Continuum Mechanics for Engineers, 3rd ed., CRC Press (2009).*
3. *Timoshenko, S. P. and Goodier, J. N., Theory of Elasticity, 3rd ed., McGraw-Hill (1970).*

Course Outcomes

CO1: Develop advanced concepts of deformation, stress and strain with ability to represent and transform these quantities in different coordinate systems.

CO2: Develop constitutive relationships between stress and strain for linearly elastic solid.

CO3: Formulate boundary value problems in elasticity and grasp the various solution methodologies.

CO4: Apply techniques to determine shear centre and stress in thin-walled beams subjected to bending and torsion

AE 632: FINITE ELEMENT METHOD

Syllabus

Introduction – approximate solutions to governing differential equations (GDE) – finite element formulations starting from GDE – finite element formulations based on stationarity of a functional – one-dimensional finite element analysis; shape functions, types of elements and applications – two and three-dimensional finite elements – numerical integration – applications to structural mechanics and fluid flow.

References

1. Reddy, J. N., Introduction to the Finite Element Method, 3rd ed., McGraw-Hill (2006).
2. Seshu, P., Textbook of Finite Element Analysis, Prentice Hall of India (2009).
3. Chandrupatla, T. R. and Belegundu, A. D., Introduction to Finite Elements in Engineering, 2 nd ed., Prentice Hall of India (2000).
4. Segerlind, L. J., Applied Finite Element Analysis, 2nd ed., John Wiley (1984). (1992).

Course Outcomes

CO1: Students should have an understanding of the theory and procedures of Finite Element

CO2: Develop 1D & 2D elements for structural mechanics problems. Solve problems related to element formulation both from GDE and Potential, and those related to numerical integration.

CO3: Should be able to develop a code for simple 1D & 2D FE problems so that proper element selection, convergence, input and output are understood by the students. Should be able to implement the various procedures of FE to create the code.

CO4: Use a commercial FE program to solve a 2D sufficiently complex problem wherein modelling, element selection, and post-processing issues are understood. Should be able to differentiate and compare between some of the elements available for the solution of a problem. Analyse the issues that could occur due to improper selection of elements.

AE 618: FOUNDATIONS OF MACHINE LEARNING

Syllabus

Machine learning basics: capacity, overfitting and under fitting, hyper parameters and validation sets, bias & variance; PAC model; Rademacher complexity; growth function; VC-dimension; fundamental concepts of artificial neural networks; single layer perceptron classifier; multi-layer feed forward networks; single layer feed-back networks; associative memories; introductory concepts of reinforcement learning, Markhov decision process.

References

1. *Mohri, M., Rostamizadedh, A., and Talwalkar, A., Foundations of Machine Learning, The MIT Press (2012).*
2. *Jordon, M. I. and Mitchell, T. M., Machine Learning: Trends, perspectives, and prospects, Vol. 349, Issue 6245, pp. 255-260, Science 2015.*
3. *Shawe-Taylor, J. and Cristianini, N., Kernel Methods for Pattern Analysis, Cambridge Univ. Press (2004).*
4. *Haykin, S., Neural Networks: A Comprehensive Foundation, 2nd ed., Prentice Hall (1998).*

5. *Hassoun, M. H., Fundamentals of Artificial Neural Networks, PHI Learning (2010).*
6. *Ripley, B. D., Pattern Recognition and Neural Networks, Cambridge Univ. Press (2008).*
7. *Sutton R. S. and Barto, A. G., Reinforcement Learning: An Introduction, The MIT Press (2017).*

Course Outcomes

CO1: Ensure students grasp fundamental concepts in machine learning, including neural networks, ensemble learning, overfitting, under fitting, bias-variance trade-off, and reinforcement learning.
CO2: Enable students to apply machine learning techniques practically.
CO3: Equip students with the ability to evaluate and interpret the performance of machine learning models, emphasizing techniques for assessing generalization capabilities and managing bias-variance trade off.

AE 791: OPTIMIZATION TECHNIQUES

Course Objectives

1. To develop mathematical modelling skills to formulate optimization problems for various engineering applications.
2. To understand the theory of optimization and optimality conditions for constrained and unconstrained optimization problems.
3. To understand the principles and procedural steps involved in various mathematical and heuristic techniques to solve linear and non-linear optimization problems.
4. To learn the use of optimization solvers and non-traditional optimization techniques to solve various optimization problems in engineering.

Syllabus

Introduction – Formulation of optimization problems – Linear programming – duality - Non-linear programming – unconstrained optimization: optimality conditions, range elimination methods, gradient method, quasi-newton method, conjugate gradient method – Constrained optimization: Lagrange multiplier theorem, Kuhn Tucker condition, penalty function methods, projected gradient methods, Quadratic programming, sequential quadratic programming – Non-traditional optimization techniques for single and multi-objective optimization – Applications in Engineering.

References

1. *S.S. Rao, Engineering Optimization: Theory and Practice, John Wiley and sons, 4th edition 2009.*
2. *E. K. P. Chong and S. H. Zak, An introduction to optimization, Wiley publishers, 2017.*

3. *H.A. Taha, Operations Research: An Introduction", Pearson, 10th edition, 2016.*
4. *K. Deb, Optimization for Engineering Design: Algorithms and Examples, Prentice-Hall of India 2012.*
5. *K. Deb, Multi-objective optimization using Evolutionary Algorithms, Wiley, 2010.*

Course Outcomes

CO1: Apply fundamental concepts of mathematics to formulate an optimization problem.
CO2: Analyze and solve general linear programming problems.
CO3: Analyze and solve constrained and unconstrained non-linear programming problems in single-variable as well as multi-variable.
CO3: Implement computer codes for mathematical as well as non-traditional techniques for various optimization problems and analyze the results.

AE 781: MECHANICAL BEHAVIOUR OF MATERIALS

Course Objectives

To impart knowledge on the response of the materials (polymers, metals and ceramics) to mechanical loading in particular to static & dynamic loading at room temperature and higher temperatures. The underlying mechanisms of the deformation (elastic and plastic) ranging till fracture will be discussed in detail.

Syllabus

Introduction to mechanical response of materials: Bonding and young's modulus, anelasticity, Theoretical estimates of yield strength in metals and ceramics.
Mechanical behaviour of polymers: structure of polymers, elastic and plastic response, deformation mechanisms, time dependent deformation, visco elastic models.
Dislocation theory and strain hardening in metals and ceramics: Burgers vector, stress field, forces on dislocations, dislocation jogs and kinks, frank reed source, Lomer-cottrell lock, strain hardening behaviour, twining, yield point elongation, strain ageing, serrated flow.
Fatigue: characteristics of fatigue fracture, Influence of residual stresses, fatigue terminology, strain life equation, cumulative damage, stages of crack growth, crack growth rate, factors affecting fatigue life.
Creep: High temperature materials, creep curve, structural changes during creep, creep mechanisms, deformation mechanism map, creep fracture, creep in polymers and ceramics, Larsen miller parameter.
Fracture: Griffith's theory, fracture toughness, strain energy release rate, crack growth in ductile and brittle materials, types of fracture (mechanisms of ductile and brittle fracture), notch effect, fracture in ceramics and composites.
Testing of materials: tensile testing and hardness testing, influence of strain rate in testing

Text book

- *M.A. Meyers, K.K. Chawla, Mechanical Behavior of Materials, 2nd ed., Cambridge University Press (2009).*

Reference books

1. *G.E. Dieter, Mechanical Metallurgy, 2nd ed., 3rd ed., McGraw-Hill (2017).*
2. *R.W. Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, 5th Ed. John Wiley & Sons (2012).*
3. *J. Roesler, H. Harders, M. Baeker, Mechanical Behaviour of Engineering Materials: Metals, Ceramics, Polymers, and Composites, Springer-Verlag (2007).*
4. *William F. Hosford, Mechanical Behavior of Materials, 2nd ed., Cambridge university press (2009)*

Course Outcomes

CO1: To understand the various response of materials such as polymers, metals and ceramics under mechanical loading and to interpret the various types of fracture in the materials

CO2: To differentiate different types of fractures occurring in the materials

CO3: To analyse the properties exhibited by materials and its correlation with microstructure

AE 782: MATERIALS CHARACTERIZATION TECHNIQUES

Course Objectives

This course is intended to expose the various characterization techniques to students, for analyzing the microstructure, different phases available in the materials and the details phase transformations and stability of phases in various metallic materials. The sample preparation techniques, various modes of imaging for better contrast and diffraction techniques will be covered.

Syllabus

Structural characterization – Symmetry operations, crystals systems and lattice, Optical Microscopy - Introduction, Optical principles, Instrumentation, Imaging Modes, Applications, Limitations; Scanning Electron Microscopy (SEM) - Introduction, Instrumentation, Contrast formation, Operational variables, Specimen preparation, imaging modes, Applications, EBSD, Transmission Electron Microscopy (TEM) - Introduction, Instrumentation, Specimen preparation-pre thinning, final thinning, Image modes- mass density contrast, diffraction contrast, phase contrast, Applications, Limitations, X- Ray Diffraction (XRD) - Introduction, Basic principles of diffraction, X - ray generation, Instrumentation, Types of analysis, Data collection for analysis, Applications, Limitations, Thermal Analysis - Instrumentation, experimental parameters, Different types used for analysis, Differential thermal analysis, Differential Scanning Calorimetry, Thermogravimetry, Dilatometry, Dynamic mechanical analysis- Basic principles, Instrumentation, working principles, Applications, Limitations. ; X-Ray Spectroscopy for Elemental Analysis

Text book

- *Materials Characterization Techniques by Sam Zhang, Lin Li and Ashok Kumar, CRC Press.*
- *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods by Yang Leng, Wiley & Sons*

Reference books

1. *Characterization of Materials by Elton N. Kaufmann, Wiley & Sons.*
2. *David Brandon, Wayne D. Kaplan, Microstructural Characterization of Materials, Wiley, 2008*
3. *B.D. Cullity, Elements of X-Ray Diffraction*
4. *David B. Williams and C. Barry Carter, Transmission Electron Microscopy: A Textbook for Materials Science, springer, 2009*
5. *Dale E. Newbury, David C. Joy, Charles E. Lyman, Patrick Echlin, Eric Lifshin, Linda Sawyer, J.R. Michael, Scanning Electron Microscopy and X-Ray Microanalysis, springer*
6. *Joseph I. Goldstein, Dale E. Newbury, Joseph R. Michael, Nicholas W.M. Ritchie, John Henry J. Scott, David C. Joy., scanning electron microscope and X-Ray Analysis, 4th ed. Springer (2018)*

Course Outcomes

CO1: Appreciate the various microstructures leading to variation in the properties
CO2: Analyze the different phases present in the material
CO3: Identify a characterization technique for a given material

AE 758: FRACTURE MECHANICS AND FATIGUE

Syllabus

Linear elastic fracture mechanics; energy release rate, stress intensity factor (SIF), relation between SIF and energy release rate, anelastic deformation at the crack tip – J-integral, CTOD, test methods for fracture toughness – crack growth and fracture mechanisms, mixed-mode fracture, fracture at nanoscale – numerical methods for analysing fracture, applications – fatigue and design against fatigue failure – prediction of fatigue life.

Reference books

1. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw-Hill (2009).
2. Anderson, T. L., Fracture Mechanics: Fundamentals and Applications, 3rd ed., CRC Press (2004).
3. Buehler, M. J., Atomistic Modelling of Materials, Springer (2008).

AE 757: MOLECULAR DYNAMICS AND MATERIALS FAILURE

Syllabus

Introduction – materials deformation and fracture phenomena – strength of materials: flaws, defects, and a perfect material, brittle vs. ductile material behaviour, the need for atomistic simulations – applications basic atomistic modelling – classical molecular dynamics – interatomic potential-numerical implementation – visualisation – atomistic elasticity, the virial stress and strain – multiscale modelling and simulation methods – deformation and dynamical failure of brittle and ductile materials – applications.

Reference books

1. Buehler, M. J., Atomistic Modeling of Materials Failure, Springer (2008).
2. Doeblin, E. O., Understanding Molecular Simulation: from Algorithms to Applications, Academic Press (2001).
3. Rapaport, D. C., The Art of Molecular Dynamics Simulation, 2nd ed., Cambridge Univ. Press (2004)

AE 783: ADVANCED MACHINING PROCESSES

Course Objectives

This course aims to discuss the advancements in tool based and unconventional material removal techniques and their hybrid versions for various precision engineering applications including aerospace, space and bio-medical applications.

Syllabus

High performance machining strategies for difficult-to-cut materials (super alloys, ceramics, composites and other emerging materials etc.)- Ductile Regime Machining of brittle materials – Advances in non-traditional material removal techniques- Hybrid and energy assisted machining strategies- Tool based and Unconventional Micro/ Nano Machining –Advanced Abrasive Processing -Micro/ Nano Finishing techniques and hybrid surface generation strategies – Machining of free-form surfaces – Post-processing (Machining and Finishing) of additively manufactured components

Reference books

1. Helmi Youssef, Hassan El-Hofy, Non-Traditional and Advanced Machining Technologies, CRC Press (2020)
2. V. K. Jain, Nanofinishing Science and Technology: Basic and Advanced Finishing and Polishing Processes, CRC Press (2017)
3. Paulo Davim, Machining: Fundamentals and Recent Advances, Springer (2008)
4. Hassan El-Hofy, Advanced Machining Processes: Non-traditional and Hybrid Machining Processes, McGraw-Hill Professional (2005).
5. ASM Handbook Volume 16: Machining
6. Recent research articles in Advanced Machining and Finishing Technologies

Course Outcomes

CO1: Discuss the challenges and advancements in machining and finishing techniques for difficult-to-cut materials such as super alloys, ceramics, composites etc., which find critical role in various mechanical/aerospace/bio-medical applications

CO2: Discuss the advancements in non-traditional energy based material removal techniques and their hybrid strategies at macro to micro/nano scale.

CO3: Understand various terminologies, methodologies and practices associated with advanced traditional, non-traditional and hybrid manufacturing techniques to have an assessment on their suitability/selection in industrial /R&D related end-use applications.

AE 784: DESIGN FOR MANUFACTURING

Course Objectives

This course aims to discuss the design aspects and considerations (aspects related to design for manufacturing) for various manufacturing processes under the category of moving material, removing material, adding material (additive manufacturing) and joining/assembly techniques.

Syllabus

Selection of Manufacturing Processes for a part design- Selection of raw materials and shapes- Dimensional and Geometric Tolerances- Surface texture and topography characteristics- Familiarization of Manufacturing Drawings- Design for Manufacturing and Assembly (DfM / DfA/ DfMA)- DfM for Casting, Bulk Deformation, Sheet Metal Forming, Powder Metallurgy, Machining – Design for Joining/ Assembly –Selection of fasteners- Design for Additive Manufacturing (DfAM) –DfAM for various types of 3D printing and lattice based structures - Topology optimization and Generative Design- Design for quality, reliability and manufacturing optimization- Case studies on DfM and DfAM.

Reference books

1. Sherif D. El Wakil, Processes and Design for Manufacturing, CRC Press (2019)
2. Olaf Diegel, Axel Nordin, Damien Motte, A Practical Guide to Design for Additive Manufacturing, Springer (2020)
3. Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, Product Design for Manufacture and Assembly, CRC Press (2010)
4. Gene R. Cogorno, Geometric Dimensioning and Tolerancing for Mechanical Design, McGraw Hill (2020)
5. James Meadows, Tolerance Stack Up Analysis, James d Meadows (2011)
6. Martin Leary, Design for Additive Manufacturing: Additive Manufacturing Materials and Technologies, Elsevier (2020)
7. Recent research articles in Design for Manufacturing

Course Outcomes

CO1: Understanding the selection of manufacturing processes and raw material configuration for a part design, with familiarization of tolerances and drawing preparation

CO2: Discuss the fundamental aspects of Design for Manufacturing and Assembly (DfM / DfA/ DfMA)

CO3: Discuss the fundamental aspects of Design for Additive Manufacturing (DfAM)

CO4: Apply the above knowledge on various examples and case studies to get acquainted with industrial /R&D practices.

AE 785: DIGITAL MANUFACTURING AND AUTOMATION

Course Objectives

This course aims to discuss the elements of digital manufacturing, starting from computer aided design/virtual prototyping to computer aided manufacturing/ rapid prototyping via Numerical control systems. The basic aspects of automation for digital manufacturing and assembly is also planned as a part of discussions, aiming an exposure to modern industrial practices.

Syllabus

Digital Manufacturing via Computer Numerical Control - Overview and constructional features of CNC systems for Rapid Prototyping (3D printing, Multi axis Machining, Forming etc.) -Computer Aided Design and Modelling (Direct/ Parametric) for digital manufacturing– Generative Design and Topology Optimization- Design for Manufacturing and assignment of tolerances/ allowances- Data formats and interoperability- Familiarization and case trials in CAD software- Computer Aided Manufacturing and CNC tool path generation- Virtual prototyping/ manufacturing simulations- Simulations for 3D printing- Pre-processing steps for 3D printing- Concept of digital twin and its applications in manufacturing- Automation in Digital Manufacturing – Flexible Manufacturing Systems- Robotic systems for automation-

Assembly automation and product design- Some discussions on pneumatic circuits and PLC logics in automation- Sensors and feedback systems for process monitoring and adaptive control- AI, ML and IoT practices in digital manufacturing and their role in Industry 4.0.

Reference books

1. Zhuming Bi, Practical Guide to Digital Manufacturing: First-Time-Right for Design of Products, Machines, Processes and System Integration, Springer (2021)
2. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson Education (2016).
3. M. Groover, E. Zimmers, CAD/CAM Computer-Aided Design and Manufacturing, Pearson (2014)
4. Chandrakant D. Patel, Chun-Hsien Chen, Digital Manufacturing: The Industrialization of 'Art to Part'- 3D Additive Printing, Elsevier (2022)
5. Geoffrey Boothroyd, Assembly Automation and Product Design, CRC Press (2005).
6. Vytautas Ostaševičius, Digital Twins in Manufacturing, Springer (2022)
7. Tien-Chien Chang, Richard A Wysk, Hs-Pin Wang, Computer Aided Manufacturing, Pearson (2005)
8. Kaushik Kumar, Divya Zindani, J. Paulo Davim, Digital Manufacturing and Assembly Systems in Industry 4.0: Science, Technology, and Management, CRC Press (2019)
9. Recent research articles in Digital Manufacturing

Course Outcomes

CO1: Discuss the fundamental aspects of Computer Aided Design and Modelling for virtual prototyping and digital manufacturing

CO2: Familiarize CNC tool path generation and Computer aided Manufacturing

CO3: Familiarize the Pre-processing steps and simulations for 3D printing based digital manufacturing

CO4: Discuss the systems and practices of automation in digital manufacturing (via CNC) environment

AE 786: METROLOGY AND COMPUTER AIDED INSPECTION

Course Objectives

This course aims to discuss the theoretical and practical aspects of metrology and computer aided inspection techniques /strategies for precision engineering applications.

Syllabus

Selection of Instruments and Comparators (Contact/ Non-contact / Computer Aided) for Dimensional and Geometrical metrology- Design and Calibration of Instruments- Standards and Traceability- Sources of measurement errors and error propagation- Uncertainty and Statistical Concepts in Metrology- Limit, Fits and Tolerances- Design of limit gauges- Machine

Tool Metrology and practices on Geometrical Tolerances- On-Machine and In-Process Measurements –Planning and Practices in Computer Aided Inspection - Measurement using light and developments in Non-Contact Measuring systems- Coordinate and Surface (2D and 3D) Metrology- Gear and Thread Metrology – Non-destructive techniques and X-ray Computed Tomography- Micro/Nano Metrology and Instrumentation- Computational Metrology- Metrology for Additive Manufacturing –Measurement/Inspection Strategies and Standards for 3D printed Components and Assemblies.

Reference books

1. Graham T. Smith, Machine Tool Metrology: An Industrial Handbook, Springer (2016)
2. Graham T. Smith, Industrial Metrology: Surfaces and Roundness, Springer (2010).
3. Raghavendra, Krishnamurthy, Engineering Metrology And Measurements, Oxford University press (2013)
4. Alex Hebra, The Physics of Metrology: All about Instruments: From Trundle Wheels to Atomic Clocks, Springer (2009)
5. Semyon G. Rabinovich, Measurement Errors and Uncertainties: Theory and Practice, Springer (2010)
6. Abdulrahman Al-Ahmari, Emad Abouel Nasr, Osama Abdulhameed, Computer-Aided Inspection Planning: Theory and Practice, CRC Press (2016)
7. James Meadows, Geometric Dimensioning and Tolerancing-Applications, Analysis, Gauging & Measurement, Manetti Shrem Museum (2020)
8. Chee Kai Chua, Chee How Wong and Wai Yee Yeong, Standards, Quality Control, and Measurement Sciences in 3D Printing and Additive Manufacturing, Elsevier (2017)
9. Anand K. Bewoor, V. Kulkarni, Metrology and Measurement, McGraw Hill Education (2017)
10. 10.Richard Leach, Fundamental Principles of Engineering NanoMetrology, William Andrew (2014)

Course Outcomes

CO1: Familiarization of dimensional & geometrical metrology, and selection of instruments & comparators for typical end use requirements

CO2: Familiarization of measurement using light and advancements in non-contact computer aided measuring systems

CO3: Understand various terminologies, methodologies, statistical concepts and practices associated with metrology and computer aided inspection, to have an assessment on the suitability and selection of measuring strategy and instrumentation for various industrial /R&D applications.

AE 796: MICRO/ NANO MANUFACTURING

Syllabus

Need and relevance of micro manufacturing – Size effects- Tool based –mechanical micro Machining (Microscale turning, milling, drilling, grinding etc.). Non-traditional micro machining: micro EDM, Micro ECM, Electron beam, ion beam and laser based micro machining Abrasive micro/nano finishing techniques (AFM, MAF, MRF, EEM, EAM etc.) and other recent advancements. Micro forming techniques: laser micro-bending, micro-deep drawing and Extrusion-Micro welding / joining techniques. Micro-fabrication using deposition techniques such as sputtering, CVD, ALD, LIGA etc. Metrology for micro/nano manufacturing.

Reference books

1. V. K. Jain, Introduction to Micro Machining, Alpha Science International Ltd. (2010)
2. Yi Qin, Micro manufacturing Engineering and Technology, Elsevier Inc. (2015)
3. Irene Fassi, David Shipley, Micro-Manufacturing Technologies and Their Applications: A Theoretical and Practical Guide, Springer (2017)
4. V. K. Jain, Nanofinishing Science and Technology: Basic and Advanced Finishing and Polishing Processes, CRC Press (2017)
5. Golam Kibria, B. Bhattacharyya, J. Paulo Davim, Non-traditional Micro Machining Processes: Fundamentals and Applications, Springer (2017).
6. Recent research articles in Micro/ Nano Machining

AE 797: NON-TRADITIONAL MACHINING

Syllabus

Introduction- Classifications- Mechanical, Thermal, Electrical and Chemical based processes

(EDM, ECM, AJM, AWJM, CHM, USM, LBM, EBM etc.)

Mechanism of Material removal- Modelling aspects- Process selection and process variables

Hydrid methods and advanced practices

Reference books

1. ASM Handbook Volume 16: Machining
2. Helmi Youssef, Hassan El-Hofy, Non-Traditional and Advanced Machining Technologies, CRC Press (2020).
3. Hassan El-Hofy, Advanced Machining Processes: Non-traditional and Hybrid Machining Processes, McGraw-Hill Professional (2005).
4. Carl Sommer, Non Traditional Machining Handbook, Advanced Publishing (2009).
5. Recent research articles in Non-Traditional Machining

AE 787: SOLIDIFICATION PROCESSING

Course Objectives

The basic aspects on the principles of solidification will be covered in detail, along with the stability of phases. Various thermodynamic aspects governing the solidification process and growth process will be discussed. The fluid dynamics during mould filling for different casting processes will be covered. Casting of aerospace materials will be emphasized.

Syllabus

Introduction and advances in metal casting processes; Thermodynamics and stability of phases, Classification of phase transformations, Order of transformation, Gibbs rule and application, Phase diagrams construction and interpretation. Liquid-solid transformation: homogeneous and heterogeneous nucleation, Growth aspects- plane front, cellular, columnar, dendritic and equiaxed. Growth of single crystals, Czochralski growth, Macro and micro segregation; Composition control; Constitutional supercooling; Solidification of pure materials, eutectic solidification, Fluid dynamics during mould filling and solidification, Interfaces, Rheocasting, thixocasting, electroslag casting, casting of composites. Rapid solidification. Design of various systems in casting processes. Solidification under microgravity conditions. Solidification in welding processes, solidification in Additive manufacturing processes.

Investment casting, die casting processes, continuous casting, centrifugal casting processes. Casting of aerospace materials – Aluminium alloys, Magnesium alloys, Titanium alloys. Defects in casting processes

Text book

- *Doru Michael Stefanescu, Science and Engineering of Casting Solidification, Kluwer Academic/ Plenum publishers (2016).*

Reference books

1. *M. C. Flemings, Solidification process–, McGraw-Hill (1974).*
2. *W. G. Winegard, An Introduction to the Solidification of Metals CRC press (1964).*
3. *G.J Davies, Solidification and casting, Elsevier (1973).*
4. *Hasse Fredriksson, Ulla Akerlind Solidification and Crystallization Processing in Metals and Alloys, Wiley (2012).*

Course Outcomes

CO1: To understand the principles of phase change during liquid to solid transformations

CO2: To troubleshoot the casting process for defect free components.

CO3: To design the gating systems of a casting process for a healthy product

CO4: To appreciate various advanced casting processes for various metals

AE 788: HEAT TREATMENT TECHNIQUES

Course Objectives

This course introduces the students to various heat treatment techniques applied to metals for causing a change in the microstructure and hence the properties. The mechanisms of atomic transport causing a change in the structure will be dealt. Heat treatment techniques applied to surface hardening and the various furnace atmospheres required to effect the heat treatment techniques will be covered.

Syllabus

Concepts of diffusion and Phase Transformations on heating, Kinetics of phase transformation, Phase stability and free energy of mixing; free energy-composition diagrams, principles of nucleation and growth, Importance of austenitic grain size, TTT diagrams, CCT Diagrams, Various heat treatment processes in steels and aluminium alloys, hardenability, thermomechanical treatments, characteristics of quenchants, Surface hardening: Laser hardening, Case carburizing (solid, liquid and gaseous), Cyaniding, Carbonitriding, Nitriding, Plasma nitriding. Defects and remedies in heat treatment, Heat treatment furnaces and atmospheres, Heat treatment of aerospace materials.

Text book

- *Rajan T.V., Sharma C.P, Sharma Heat Treatment Principles and Techniques, A., Prentice Hall of India (P) Ltd (2004).*

Reference books

1. *Porter & Easterling, Phase transformations in metals and alloys, Chapman and Hall, London (2015).*
2. *V. Raghavan Solid State Phase Transformations, , Prentice Hall of India (P) Ltd (1992).*
3. *Vijendra Singh, Heat Treatment of Metals, Standard Publishers Distributors (2020).*
4. *Karl-Erik Thelning, Steel and its Heat Treatment, Butterworths London (1984).*

Course Outcomes

CO1: Understand the mechanisms associated with various heat treatment processes

CO2: Execute various heat treatment processes applied to various metals for obtaining specific properties in metals

CO3: Troubleshoot and rectify the process for obtaining defect free components during heat treatment

AE 789: POWDER METALLURGY

Course Objectives

This course provides a basic understanding of the rudiments of traditional powder based manufacturing techniques that spans from characterizing the powder to qualifying the component in terms of the required properties. This course is expected to cover the science and methodologies involved in processing a component for industrial application using the starting material as powder.

Syllabus

Basic steps of powder metallurgy, powder fabrication techniques and Characterization, various Compaction techniques, Sintering techniques and mechanisms, Various compaction techniques -Injection molding, Powder forging/ rolling/ extrusion, Hot pressing/ Isostatic Pressing, Post Sintering process, Application of Powder Metallurgy Parts - Production of filters, self-lubricating bearings, gears, friction parts, electrical materials, sintering of carbide tools, Application of powder metallurgy in automobile and space industries.

Reference books

1. *Upadhyaya, Powder Metallurgy Technology, Cambridge International Science Publishing, 2002.*
2. *J. S. Hirschhorn: Introduction to Powder Metallurgy, American Powder Metallurgy Institute, Princeton, NJ, 1976.*
3. *P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.*
4. *R. M. German, Powder Metallurgy- Principles and Applications, MPIF, Priceton, 1994*
5. *C.R. Shakespeare Sands, R.L., Powder Metallurgy: Practice and Applications, George Newnes Limited*

Course Outcomes

CO1: Understand the manufacturing methodologies involved using metallic powder as the starting material

CO2: Interpret and analyze various mechanisms involved in sintering of Powder metallurgy parts.

AE 790: THERMODYNAMICS AND PHASE TRANSFORMATIONS IN MATERIALS

Course Objectives

This course is expected to introduce students the basic concepts of materials thermodynamics and construction of free energy diagrams for phase stability. The various phase transformations (liquid to solid, and solid to solid) occurring in a metallic system will be discussed in detail.

Syllabus

Thermodynamics basic concepts - the first law, (the enthalpy concept, heat capacity), the second law (reversible and irreversible processes, entropy, Gibbs energy, chemical potential, driving force), the third law, Clausius-Clapeyrons equations.

Basics of Phase diagrams: Gibbs free energy – composition diagrams, Gibbs phase rule. Ideal and regular solutions, Diffusion: steady vs non-steady states, driving force and mechanisms

Interfaces: solid-vapour, grain and phase boundaries. Nucleation (homogeneous and heterogeneous), growth, Eutectic solidification

Solid state transformations: Recovery, recrystallization and grain growth. Eutectoid transformations, Order-disorder transformations, spinodal, and massive transformations. Transformations in steels and aerospace alloys

Text book

1. *Porter, D.A., Easterling, K. E., and Sherif, M.Y., Phase Transformation in Metals and Alloys, 3rd edition, CRC Press (2009).*

Reference books

- *David R. Gaskell and David E. Laughlin, Introduction to the Thermodynamics of Materials, 6th ed., CRC Press, (2017).*
- *Raghavan, V., Solid State Phase Transformations, 1st edition, Prentice Hall India (1987).*
- *Abbaschian, R., Abbaschian, L., and Reed-Hill, R. E., Physical Metallurgy Principles, 4th edition, Cengate Learning (2009).*
- *Ghosh, Ahindra, Textbook of Materials and Metallurgical Thermodynamics, PHI (2002).*
- *Darken L.S., Physical chemistry of metals, CBS publishers (2002).*
- *Robert Dehoff, Thermodynamics in materials science, 2nd ed. CRC press (2006).*

Course Outcomes

CO1: To analyse the variation of properties associated with the microstructural evolution during phase transformations

CO2: To understand the rudiments of phase transformations through thermodynamics of materials for modelling of materials and alloy design

CO3: To understand the concepts on phase stability and to explore the use of phase diagram for understanding various types of phase transformations that are relevant to metals and alloys

AE 792: ADVANCED OPERATIONS RESEARCH

Course Objectives

1. To develop mathematical modelling skills to formulate operations management, logistics and supply chain management problems.
2. To understand the methodologies used to solve linear programming, integer programming, goal programming, and travelling salesman problems.
3. To understand the basics of formulating and solving operations research problems using network optimization models and Dantzig-Wolfe decomposition methods.
4. To learn the use of optimization solvers and implement evolutionary algorithms for solving operations research problems.

Syllabus

Introduction to Operations research – Formulation of optimization problems – Linear programming – Revised simplex method – Simplex method for bounded variables - – Karmarkar's method - Dual-simplex method – Goal programming - Integer programming – Dantzig-Wolfe decomposition – Network optimization models– Travelling salesman problem and its extensions – Evolutionary algorithms.

References

1. *A. Ravindran, D. T. Phillips and J. J. Solberg, Operations research: Principles and Practice, Wiley, 2nd edition, 2007.*
2. *H.A. Taha, Operations Research: An Introduction", Pearson, 10th edition, 2016.*
3. *F. S. Hillier, G. J. Lieberman, B. Nag and P. Basu, Introduction to Operations Research, 11th edition, 2021.*
4. *M. S. Bazaraa, J. J. Jarvis and H. D. Sherali, Linear programming and Network flows, Wiley, 4th Edition, 2010.*
5. *K. Deb, Optimization for Engineering Design: Algorithms and Examples, Prentice-Hall of India 2012.*

Course Outcomes

CO1: Formulate operations, logistics and supply chain management problems.

CO2: Solve linear programming, integer programming, goal programming problems and the travelling salesman problem using appropriate techniques and optimization solvers, and analyze the results.

CO3: Model and solve real-world problems using network optimization and Dantzig-Wolfe decomposition methods.

CO4: Implement computer codes for mathematical and evolutionary algorithms to solve operations research problems and analyze the results.

AE 793: QULAITY ENGINEERING

Course Objectives

1. To understand the basic statistical concepts and the concepts of process variability and process capability.
2. To understand how to plan, design and conduct experiments efficiently and effectively, and analyze the resulting data for quality improvement.
3. To learn statistical quality control methods, control charts and acceptable sampling plans.

Syllabus

Introduction – Basics of probability and statistics– process capability – Quality loss function– design of experiments– Orthogonal array selection and utilization – Analysis and interpretation methods- Parameter design – tolerance analysis– statistical quality control: Control charts, Sampling plans.

References

1. *G. Taguchi, E. A. Elsayed and T. Hsiang, Quality engineering in production systems, Mc Graw Hill, 1989.*
2. *P. J. Ross, Taguchi techniques for quality engineering, Tata McGraw Hill, 2nd Edition, 2005.*
3. *M. S. Phadke, Quality Engineering using robust design, Pearson education, 2008.*
4. *D. C. Montgomery, Introduction to statistical quality control, John Wiley and sons, 6th edition, 2009.*
5. *E. L. Grant and R. S. Leavenworth, Statistical Quality control, McGraw Hill, 6th Edition, 1998.*

Course Outcomes

CO1: Apply the basic statistical concepts and the concepts of process capability to solve quality control problems in industrial environments.

CO2: Implement factorial design of experiments and Taguchi's orthogonal arrays to optimize product and process parameters.

CO3: Prepare and analyze various control charts for quality control and improvement.

CO4: Prepare sampling plans using single and multiple sampling techniques.

AE 794: INDUSTRIAL ENGINEERING

Course Objectives

1. To understand the concept of productivity, its measurement and the methods that eliminates wastes and optimizes resource utilization in organizations.
2. To learn the concepts and tools used in method study and time study to improve productivity and reduce production costs.

3. To understand the basic concepts of ergonomics and value engineering.

Syllabus

Productivity – Work study – Method study – Principles of motion economy - Work measurement - – Work sampling - Time study – Standard time determination –Incentive plans - Introduction to Ergonomics - Value Engineering.

References

1. *ILO, Introduction to Work study, Oxford and IBH Publishing Co., 2010.*
2. *R. M. Barnes, Motion and Time Study – Design and Measurement of Work, John Wiley & sons, New York, 1990*
3. *M. S. Sanders and E. J. McCormick, Human Factors in Engineering and Design, McGraw Hill, 1993.*
4. *A. K. Mukhopadhyaya, Value Engineering: concepts, techniques and applications, Sage publications, 2014.*

Course Outcomes

CO1: Demonstrate an understanding of the concept of productivity and the use of work-study techniques to improve productivity in industrial settings

CO2: Apply the method study, work measurement and time study techniques in a workspace to improve productivity.

CO3: Apply the principles of ergonomics to improve human comfort at the workplace and demonstrate an understanding of the role of value engineering in providing the necessary functions for a product at the lowest cost.

AE 795: TOTAL QUALITY MANAGEMENT

Course Objectives

1. To understand the principles of total quality management (TQM) for continuous process improvement.
2. To learn the TQM tools and techniques used in managing quality in organizations.
3. To learn the modern tools like Six Sigma, DMADV and DMAIC to manage quality in organizations
4. To learn statistical quality control methods, control charts and acceptable sampling plans.

Syllabus

Introduction to Total quality management – Philosophies and frameworks - Quality and competitiveness - Customer focus and satisfaction – Employee involvement - Continuous process improvement – Kaizen – 5S – Quality circles - Quality control tools – Poka-yoke – Quality *function deployment - Failure mode effect analysis- Benchmarking - Quality costs– ISO 9000 standards – Quality audit – Statistical process control – control charts for variables and attributes – acceptance sampling – Sampling plan design – Six-Sigma: concept, DMAIC and DMADV, case studies.*

References

1. *D. H.Besterfiled, C. Besterfield-Michna, G. H. Besterfield, M. Besterfield-Sacre, H. Urdhwareshe, R. Urdhwareshe, Total Quality Management, Pearson Education, fifth Edition, 2018.*
2. *J. R. Evans and W. M. Lindsay, The Management and Control of Quality, 6th Edition, South-Western Cengage learning, 2010.*
3. *J. E. Ross, Total Quality Management, CRC Press, 1999.*
4. *E. L. Grant, Statistical Quality Control, McGraw Hill, seventh edition, 2017.*
5. *D. C. Montgomery, Statistical Quality Control, Wiley, sixth edition, 2010.*

Course Outcomes

CO1: Apply the basic principles, tools and techniques of TQM for continuous process improvement.

CO2: Prepare and analyze various control charts and acceptance sampling plans for quality control and improvement.

CO3: Demonstrate an understanding of the use of modern methods like Six Sigma and DMAIC for quality improvement.

AE 766: ROBOT MECHANISMS AND TECHNOLOGY

Syllabus

Mechanisms of robots: Regional and orientational mechanisms of serial chain manipulators, gripper mechanisms, parallel chain manipulator mechanisms, leg mechanisms of walking robots, suspension and drive mechanisms of wheeled rovers, bio-robots, UAV's and Underwater robots. Representation of spatial mechanisms, and rigid body transformations Actuators, drives, and sensors in robotics.

References

1. *Craig, J. J., Introduction to Robotics: Mechanics and Control, 4rd ed., (2017).*
2. *Siciliano, B. and Khatib, O. (Editors), Springer Handbook of Robotics, Springer (2008).*
3. *Nourbakhsh, I. R. and Siegwart, R., Introduction to Autonomous Mobile Robots, 2nd ed., (2011).*
4. *Sclater, N., Mechanisms and Mechanical Devices Sourcebook, 5rd ed., McGraw Hill (2011).*
5. *Vepa, R., Biomimetic Robotics: Mechanisms and Control, 5rd ed., Cambridge Univ. Press (2009).*
6. *Sandin, P. E., , Robot Mechanisms and Mechanical Devices Illustrated, McGraw Hill (2003).*

AE 762: SMART MATERIALS AND STRUCTURES

Syllabus

Overview of smart materials – piezoelectric ceramics – piezo-polymers – magnetostrictive materials – electroactive polymers – shape memory alloys – electro and magneto rheological fluids. Mechanics of Piezoelectric Materials and Systems: constitutive modelling – actuator and sensor – piezoelectric beams and plates. Shape Memory Alloys: constitutive modelling – actuation models. Electroactive polymer materials applications.

Textbook

1. *Leo, D. J., Engineering Analysis of Smart Material Systems, Wiley (2007).*

References

1. *Culshaw, B., Smart Structures and Materials, Artech House (1996).*
2. *Gaudenzi, P., Smart Structures: Physical Behaviour, Mathematical Modelling and Applications, Wiley (2009).*

Course Outcomes

CO1: Apply the knowledge of mathematics, science, and engineering by developing constitutive equations of piezoelectric materials and systems.

CO2: Use of Phenomenological models of Shape memory alloys for designing actuator systems.

CO3: Interpret the analysis results, use it for design of actuator and sensor systems for smart structures.

AE 633: STRUCTURAL DYNAMICS

Syllabus

Elements of analytical dynamics – discrete systems with multiple degrees of freedom – elastic and inertia coupling – natural frequencies and mode – free vibration response – uncoupling of equations of motion – modal analysis – forced vibration response – vibration isolation – vibration of continuous systems – differential equations and boundary conditions – longitudinal, flexural and torsional vibrations of one-dimensional structures – vibration analysis of simplified aircraft and launch vehicle structures – structural damping – free and forced response of continuous systems – introduction to concepts of nonlinear and random vibrations – elements of vibration testing and experimentation.

References

1. *Meirovitch, L., Elements of Vibration Analysis, 2nd ed., McGraw-Hill (1986).*

2. *Paz, M., Structural Dynamics: Theory and Computation, 2nd ed., CBS Publishers & Distributors (2004).*
3. *Weaver Jr., W., Timoshenko, S. P., and Young, D. H., Vibration Problems in Engineering, 5th ed., John Wiley (1990).*
4. *Meirovitch, L., Computational Methods in Structural Dynamics, Sijthoff & Noordhoff (1980).*
5. *Cough, R. W. and Penzien, J., Dynamics of Structure, 2nd ed., McGraw-Hill (1993)*

Course Outcomes

CO1: Apply the knowledge of mathematics, science, and engineering by developing the equations of motion for vibratory systems and solving for the free and forced response.

CO2: Create simple computational models for engineering structures using the knowledge of structural dynamics.

CO3: Interpret the dynamic analysis results for design, analysis and research purposes.

AE 625: COMPUTATIONAL FLUID DYNAMICS

Syllabus

Mathematical models for fluid dynamics – classification of partial differential equations – discretization methods – finite difference formulation – numerical solution of elliptic equations – linear system of algebraic equations – numerical solution of parabolic equations – stability analysis – numerical solution of hyperbolic equations – finite volume method – time integration schemes – isentropic flow through CD nozzle – simulation of shockwave formation – incompressible Navier–Stokes equations and their solution algorithms – basics of grid generation

References

1. *Hirsch, C., Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics, Vol. I, 2nd ed., Butterworth-Heinemann (2007).*
2. *Pletcher, R. H., Tannehill, J. C., and Anderson, D. A., Computational Fluid Mechanics and Heat Transfer, 3rd ed., Taylor & Francis (2011).*
3. *Hoffmann, K. A. and Chiang, S. T., Computational Fluid Dynamics for Engineers, 4th ed., Engineering Education Systems (2000).*
4. *Anderson, J. D., Computational Fluid Dynamics: The Basics with Applications, McGraw- Hill (1995).*
5. *Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Hemisphere Pub. Corporation (1980).*
6. *Ferziger, J. H. and Peri´c, M., Computational Methods for Fluid Dynamics, 3rd ed., Springer (2002).*
7. *Roache, P. J., Fundamentals of Computational Fluid Dynamics, Hermosa Publishers (1998).*

8. *Fletcher, C. A. J., Computational Techniques for Fluid Dynamics 1: Fundamental and General Techniques, 2nd ed., Springer (1996).*

AE 756: ADVANCED FINITE ELEMENT METHOD

Syllabus

Finite element formulations for beam, plate, shell (Kirchhoff and Mindlin-Reissner), and solid elements – large deformation nonlinearity – nonlinear bending of beams and plates – stress and strain measures – total Lagrangian and updated Lagrangian formulations – material nonlinearity – ideal and strain hardening plasticity – elastoplastic analysis – boundary nonlinearity – general contact formulations – solution procedures for nonlinear analysis, Newton-Raphson iteration method.

References

1. *Reddy, J. N., Introduction to Nonlinear Finite Element Analysis, Oxford Univ. Press (2010).*
2. *Bathe, K. J., Finite Element Procedures, 2nd ed., Klaus-Jurgen Bathe (2014).*

MA624: ADVANCED MACHINE LEARNING

Syllabus

Kernel Methods: reproducing kernel Hilbert space concepts, kernel algorithms, multiple kernels, graph kernels; multitasking, deep learning architectures; spectral clustering ; model based clustering, independent component analysis; sequential data: Hidden Markhov models; factor analysis; graphical models; reinforcement learning; Gaussian processes; motiff discovery; graph-based semisupervised learning; natural language processing algorithms.

References

1. Bishop, C. M., Pattern Recognition and Machine Learning, Springer (2006).
2. Hastie, T., Tibshirani, R., and Friedman, J., The Elements of Statistical Learning: DataMining, Inference, and Prediction, Springer (2002).
3. Cristianini, N. and Shawe-Taylor, J., An Introduction to Support Vector Machines and otherkernel- based methods, Cambridge Univ. Press (2000).
4. Scholkopf, B. and Smola, A.J., Learning with Kernels: Support Vector Machines, Regularization, Optimization, and Beyond, The MIT Press (2001).
5. Sutton R. S. and Barto, A. G., Reinforcement Learning: An Introduction, The MIT Press (2017).
6. Goodfellow, I., Bengio, Y., and Courville, A., Deep Learning, The MIT Press (2016).
7. Koller D. and Friedman, N., Probabilistic Graphical Models: Principles and Techniques, The MIT Press (2009).

Course Outcomes

CO1: Provide students with an in-depth knowledge of advanced machine learning concepts.

CO2: Introduce the mathematical and statistical concepts that form the basis of advanced machine learning models.

CO3: Foster critical thinking and problem-solving skills by challenging students to analyze and critique the strengths and limitations of advanced machine learning models in various applications and contexts.

AE603: ELEMENTS OF AEROSPACE ENGINEERING

Syllabus

History of aviation – types of flying machines – anatomy of an aircraft; fundamental aerodynamic variables – aerodynamic forces – lift generation – airfoils and wings – aerodynamic moments –concept of static stability – control surfaces; mechanism of thrust production – propellers – jet engines and their operation – elements of rocket propulsion; loads acting on an aircraft – load factor for simple maneuvers – Vn diagrams; aerospace materials; introduction to aerospace structures; basic orbital mechanics – satellite orbits; launch vehicles and reentry bodies.

References

1. Anderson, J. D., Introduction to Flight, 7th ed., McGraw-Hill (2011).
2. Anderson, D. F. and Eberhardt, S., Understanding Flight, 2nd ed., McGraw-Hill (2009).
3. Szebehely, V. G. and Mark, H., Adventures in Celestial Mechanics, 2nd ed., Wiley (1998).
4. Turner, M. J. L., Rocket and Spacecraft Propulsion: Principles, Practice and New Developments,3rd ed., Springer (2009).

AVM865: SENSORS AND ACTUATORS

Syllabus

Introduction and historical background, Micro sensors : Sensors and characteristics, Integrated Smart sensors, Sensor Principles/classification-Physical sensors (Thermal sensors, Electrical Sensors, tactile sensors, accelerometers, gyroscopes , Proximity sensors, Angular displacement sensors, Rotational measurement sensors, pressure sensors, Flow sensors, MEMS microphones etc.), Chemical and Biological sensors (chemical sensors, molecule-based biosensors, cell-based biosensors), transduction methods(Optical, Electrostatic, Electromagnetic, Capacitive, Piezoelectric, piezo resistive etc.), Micro actuators : Electromagnetic and Thermal micro actuation, Mechanical design of micro actuators, Micro actuator examples,-micro valves, micro pumps, micro motors- Micro actuator systems : eg. Ink-Jet printer heads, Micro-mirror TV Projector. Introduction to interfacing methods: bridge circuits, Programmable gain instrumentation amplifiers, A/D and D/A converters, microcontrollers Applications and case studies: Micro sensors and actuators in environmental sensing, RF/Electronics devices, Optical/Photonic devices, micro sensors for space applications, MEMS sensors in navigation systems, radiation sensors, Medical devices, Bio-MEMS

References

1. M.H. Bao , Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes Elsevier, New York, 2000
2. Richard S. Muller, Roger T. Howe, Stephen D. Senturia, Rosemary L. Smith, and Richard M. White, Micro sensors, IEEE Press, IEEE Number PC 0257-6, ISBN 0-87942-254-9, New York, 1991.
3. William Trimmer, Micromechanics and MEMS: Classic and Seminal Papers to 1990, IEEE Press, IEEE Number PC4390, ISBN 0-7803-1085-3, New York.
4. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, and V. K. Aatre, Micro and Smart Systems, Wiley-India, 2010.

AVM612: INTRODUCTION TO MICRO ELECTRO MECHANICAL SYSTEMS

Syllabus

History of Microsystem Technology with overview on commercial products, Scaling laws, Microelectronic technologies for MEMS ,Materials and processing for MEMS, Micromachining Technology: Surface and Bulk Micromachining, Microsystem modelling: Mechanics of microsystems, Transduction Mechanisms (optical, piezoelectric, piezo resistive etc.), MEMS Micro sensors, and applications.

References

1. S. D. Senturia, Microsystem Design, 2005
2. Chang Liu, Foundations of MEMS Pearson
3. Minhang Bao, Analysis and Design Principles of MEMS Devices.
4. Marc Madau, Fundamentals of Microfabrication Science of Miniaturization, CRC Press

AVM622: MICRO/NANO FABRICATION TECHNOLOGY

Syllabus

Classical scaling in CMOS, Moore's Law, Clean room concept, Material properties, crystal structure, lattice, Growth of single crystal Si, Cleaning and etching, Thermal oxidation, Dopant diffusion in silicon, Deposition & Growth (PVD, CVD, ALD, epitaxy, MBE, ALCVD etc.),Ion-implantation, Lithography (Photolithography, EUV lithography, X-ray lithography, e-beam lithography etc.), Etch and Cleaning, CMOS

Process integration, Back end of line processes (Copper damascene process, Metal interconnects; Multi-level metallization schemes), Advanced technologies(SOI MOSFETs, Strained Si, Silicon-Germanium MOS, metal semiconductor source / drain junctions, High K, metal gate electrodes and work function engineering, Double gate MOSFETs, FinFETs, TunnelFETsetc..) , emerging research devices and architectures (Nanowire FETs, CNT FETs, Graphene transistors, Organic FETs etc..)

References

1. James Plummer, M. Deal and P.Griffin, Silicon VLSI Technology, Prentice Hall Electronics
2. Stephen Campbell, The Science and Engineering of Microelectronics, Oxford University Press, 1996
3. S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill, 1988
4. C.Y. Chang and S.M. Sze (Ed), ULSI Technology, McGraw Hill Companies Inc, 1996.
5. Peer reviewed international journals such as IEEE Electronic Device Letters, Transactions on Electron Devices, Journal o Microelectronics, etc., and conference proceedings such as International Electron Device Meeting (IEDM), IRPS etc.

AVD887: INTERNET OF THINGS

Syllabus

Evolution of the Internet and Big Data. Introduction to the Internet of Things (IoT). The Internet protocol stack. IPv4 and IPv6. TCP and UDP. DNS and the IoT Protocol stack, Layers in the Internet of Things. Sensing and Actuator Layer, Network Layer, and Application Layer. Wireless Sensor Networks. Communication Technologies for the Internet of Things. CoAP, MQTT, and HTTP Protocols for IoT. Data aggregation and fusion. Operating Systems for IoT. Contiki OS, Tiny OS, and other IoT OSs. Databases for the Internet of things. Data mining for the Internet of Things. Blockchain design for the Internet of Things. Approaches of Big data analytics for IoT. Security issues and solutions in IoT. Applications of the Internet of Things. IoT for assisted living. Case studies of IoT. Internet of Medical Things. Introduction to the Digital Twins.

References

1. Soldatos, John –Editor, Building blocks for IoT analytics internet-of-things analytics, River publishers, 2017.
2. Perry Lea, Internet of Things for Architects: Architecting IoT solutions by implementing, Packt Publishing Limited, 2018.
3. Raj Kamal, Internet of Things, McGraw Hill Education, 2017

MA613: DATA MINING

Syllabus

Introduction to data mining concepts; linear methods for regression; classification methods: k- nearest neighbour classifiers, decision tree, logistic regression, naive Bayes, Gaussian discriminant analysis; model evaluation & selection; unsupervised learning: association rules; apriori algorithm, FP tree, cluster analysis, self-organizing maps, google page ranking; dimensionality reduction methods: supervised feature selection, principal component analysis; ensemble learning: bagging, boosting, AdaBoost; outlier mining; imbalance problem; multi class classification; evolutionary computation; introduction to semi supervised learning, transfer learning, active learning, data warehousing.

References

1. Bishop, C.M., Pattern Recognition and Machine Learning, Springer (2006).
2. Hastie, T., Tibshirani, R., and Friedman, J., The Elements of Statistical Learning: Data Mining, Inference,and Prediction, Springer(2002).
3. Han, J., Kamber, M., and Pei, J., Data Mining: Concepts and Techniques, 3rd ed., Morgan Kaufmann (2012).
4. Mitchell, T. M., Machine Learning, McGraw-Hill (1997).

Course Outcomes

CO1: Develop a solid understanding of the fundamental concepts and principles of both machine learning and data mining.

CO2: Explore how machine learning and data mining contribute to knowledge discovery.

CO3: Cultivate critical thinking skills by analyzing and interpreting the results of machine learning and data mining algorithms in various contexts.

AVD864: COMPUTER VISION

Syllabus

Basics of computer vision, and introduce some fundamental approaches for computer vision research: Image Filtering, Edge Detection, Interest Point Detectors, Motion and Optical Flow, Object Detection and Tracking, Region/Boundary Segmentation, Shape Analysis, and Statistical Shape Models, Deep Learning for Computer Vision, Imaging Geometry, Camera Modeling, and Calibration. Recent Advances in Computer vision.

References

1. Simon Prince, Computer Vision: Models, Learning, and Interface, Cambridge University Press
2. Mubarak Shah, Fundamentals of Computer Vision
3. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010
4. Forsyth and Ponce, Computer Vision: A Modern Approach, Prentice-Hall, 2002

5. Palmer, Vision Science, MIT Press, 1999,
6. Duda, Hart and Stork, Pattern Classification (2nd Edition), Wiley, 2000,
7. Koller and Friedman, Probabilistic Graphical Models: Principles and Techniques, MIT Press, 2009,
8. Strang, Gilbert. Linear Algebra and Its Applications 2/e, Academic Press, 1980.

Prerequisites: Basic Probability/Statistics, a good working knowledge of any programming language (Python, Matlab, C/C++, or Java), Linear algebra, and vector calculus.

Programming: Python will be the main programming environment for the assignments. For mini-projects, a processing programming language can also be used (strongly encouraged for android application development)