Indian Institute of Space Science and Technology (IIST)

Department of Space., Govt. of India

Thiruvananthapuram

Curriculum and Syllabus for
B.Tech Aerospace Engineering
[*from Academic Year 2024-2025*]

Semester 1

Course Code	NEP Category	Subject Title	L	T	P	C
MA111C	MC	Calculus	3	0	0	3
PH113 C	MC	Engineering Physics	3	0	0	3
CH111 C	MC	Engineering Chemistry	3	0	0	3
AE111 C	MC	Thermodynamics	3	0	0	3
MA112 V	VC	Computer Programming and Applications	2	0	2	3
HS111 H	HEC	Communication skills-I	1	0	2	2
AE131 H	HEC	Basic Engineering Lab (Aerospace)	1	0	2	2

Semester 2

Course Code	NEP Category	Subject Title	L	T	P	C
MA121C	MC	Vector Calculus, ODE & Special Functions, and Fourier Series	3	0	0	3
AE121C	MC	Mechanics of Solids	3	0	0	3
AE122C	MC	Fluid Mechanics	3	0	0	3
AE123C	MC	Atmospheric Flight Mechanics	3	0	0	3
AE124C	MC	Engineering Materials	3	0	0	3
CH121H	HEC	Environmental science and engineering	2	0	0	2
HS141H	HEC	Communication skills-II	1	0	0	1

Semester 3

Course Code	NEP Category	Subject Title	L	T	P	C
MA211C	MC	Complex Analysis and PDE	3	0	0	3
AE 211C	MC	Aerodynamics	3	0	0	3
AE212C	MC	Aerospace Structures	3	0	0	3
AE213C	MC	Manufacturing Techniques	3	0	0	3
AV211H	HEC	Electrical and Electronics Engineering	3	0	0	3
HS211H	HEC	Basics of Economics	2	0	0	2
AE231V	VC	Strength of Materials Lab	0	0	2	1
AE232H	MC	Fluid mechanics and aerodynamics Lab	0	0	2	1

Semester 4

Course Code	NEP Category	Subject Title	L	T	P	C
MA221C	MC	Linear Algebra, Integral transform and Calculus Variation	3	0	0	3

AE 221C	MC	Compressible Flow	3	0	0	3
AE222C	MC	Aerospace Propulsion 1	3	0	0	3
AE223C	MC	Applied Dynamics and Vibration	3	0	0	3
AV221H	MC	Control systems Engineering	3	0	0	3
HS221H	HEC	Social sciences and Engineering Ethics	2	0	0	2
AE241C	MC	Aerospace Structures Lab	0	0	2	1
AE242V	VC	Manufacturing and Metrology Lab	0	0	4	2

Semester 5

Course Code	NEP Category	Subject Title	L	T	P	C
MA311H	HEC	Probability and Statistics	3	0	0	3
AE 311C	MC	Spaceflight Mechanics	3	0	0	3
AE 312H	HEC	Computational methods in Engineering	3	0	0	3
AE 313H	HEC	Industrial Engineering and Management	3	0	0	3
E01 (C)	ME	Program Elective (Slot 1)	3	0	0	3
E02 (M)	MSE	Minor stream Elective (Slot 1)	3	0	0	3
AE 331C	MC	Flight Mechanics and Propulsion lab	0	0	4	2
AV 332C	MC	Instrumentation and control lab	0	0	2	1

Semester 6

Course Code	NEP Category	Subject Title	L	T	P	C
AE 321 C	MC	Flight dynamics and control	3	0	0	3
AE 322C	MC	Optimization Techniques in Engineering	3	0	0	3
AE 323H	MC	Aerospace Propulsion 2	3	0	0	3
E03 (C)	ME	Program Elective (Slot 2)	3	0	0	3
E04 (C)	ME	Program Elective (Slot 3)	3	0	0	3
E05 (M)	MSE	Minor stream Elective (Slot 2)	3	0	0	3
AE 341H	HEC	Modeling and Analysis Lab	1	0	2	2

Semester 7

Course Code	NEP Category	Subject Title		L	T	P	C
AE 411 C	MC	Aerospace Vehicle Design		3	0	0	3
E06 C/ H	MC or HEC	Program Elective (Slot 4)		3	0	0	3
E07 (M)	ME	Minor stream Elective (Slot 3)		3	0	0	3
E08 (M)	MSE	Minor stream Elective (Slot 4)		3	0	0	3
E09 (M/H)	MSE /HECE (Optional open elective)	Minor stream Elective (Slot 5)	HEC Elective (Slot 1)	3	0	0	3

E10 (M/H)	MSE/HECE (Optional open elective)	Minor stream Elective (Slot 6)	HEC Elective (Slot 2)	3	0	0	3
AE 431 I	SI	Internship		0	0	0	3

Semester 8

Course Code	**NEP Category**	**Subject Title**	**L**	**T**	**P**	**C**
AE 441 R	RP	Research Project	0	0	0	15

Extra-Curricular (ECA) and Co-curricular (CCA) activities and credit requirement

Category	Course Code	Credit format (L-T-P-C)	Total credits to be acquired
ECA	ECYS*#	0-0-2-1	5
CCA	CCYS*#	0-0-2-1	4

Allocation of ECA/ CCA Credits:

- The required credits points for ECA shall be acquired within 6 semesters and the same will be added (upon successful completion) to the total credit points of the respective semester in which the student is registering for the activity.
- CCA activities can be registered by the student from third semester as per the credit format provided above. The completion of activities will be recorded appropriately and the total credit points (4 Nos) will be added to the score sheet of 8th Semester.

Overall Credit allocation per Semester

Semester	S1	S2	S3	S4	S5	S6	S7	S8
Credits	19 + (1)	18+(1)	19+(1)	20+(1)	21+(1)*	20+(1)*	21	15+[4]
Total	20	19	20	21	21-22	20-21	21	19
Total : 153 + (5)+ [4] = 162								

* option to choose either in 5th or 6th semester ( ) - ECA Credit [ ] – CCA Credit

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Indian Institute of Space Science and Technology (IIST)
B.Tech Aerospace Engineering

SYLLABUS DOCUMENT FOR CORE SUBJECTS

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SEMESTER-I

CALCULUS [3-0-0-3]

Syllabus

Sequence and Series of Real Numbers: sequence – convergence – limit of sequence – non decreasing sequence theorem – sandwich theorem (applications) – L'Hopital's rule – infinite series – convergence –geometric series – tests of convergence (nth term test, integral test, comparison test, ratio and root test) –alternating series and conditional convergence – power series.

Differential Calculus: functions of one variable – limits, continuity and derivatives – Taylor's theorem– applications of derivatives– curvature and asymptotes– functions of two variables– limits and continuity–partial derivatives– differentiability, linearization and differentials– extremum of functions – Lagrange multipliers.

Integral Calculus: lower and upper integral – Riemann integral and its properties – the fundamental theorem of integral calculus – mean value theorems – differentiation under integral sign - double and triple integrals – change of variable in double integrals – polar and spherical transforms – Jacobian of transformations.

Text Books:

- Stewart, J., Calculus: Early Transcendentals, 8th ed., Brooks/ Cole (2015).
- Jain, R.K. and Iyengar, S.R.K., Advanced Engineering Mathematics, 4th ed., Alpha science international Ltd (2014).

References:

- Greenberg, M.D., Advanced Engineering Mathematics, Pearson Education (2021).
- James, G., Advanced Modern Engineering Mathematics, 4th ed., Prentice Hall (2010).
- Kreyszig, E., Advanced Engineering Mathematics, 9th ed., John Wiley (2005).
- Thomas, G.B. and Finney, R.L., Calculus and Analytic Geometry, 9th ed., Pearson Education (2010).
- Bartle, R.G. and Sherbert, D.R., Introduction to Real Analysis, 4th ed., Wiley (2011).

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ENGINEERING PHYSICS [3-0-0-3]

Syllabus

Vectors, Statics, and Kinematics: introduction to vectors (linear independence, completeness, basis, dimensionality), inner products, orthogonality – principles of statics, system of forces in plane and space, conditions of equilibrium – displacement, derivatives of a vector, velocity, acceleration – kinematic equations – motion in plane polar coordinates.

Angular momentum: angular momentum and torque on a single particle – angular momentum and torque on a system of particles – moment of inertia – angular momentum of a rigid body

Modern Physics: relativity– introduction to quantum physics –atom model hydrogen atom. Photoelectric effect - blackbody radiation - wave matter duality - uncertainty principle - Compton scattering

Optics: nature of light – ray approximation in geometrical optics – reflection – refraction, Fermat's principle – dispersion – mirrors and lenses – aberrations – interference – diffraction – polarization –lasers.

Harmonic Oscillator: 1-D harmonic oscillator – damped and forced harmonic oscillators.

Textbooks/References

1. Daniel Kleppner and Robert J. Kolenkow, Introduction to Mechanics, Cambridge University Press, 2010
2. David Halliday, Jearl Walker, and Robert Resnick, Fundamentals of Physics, Wiley, 2010.
3. Arthur Beiser, Concepts of Modern Physics, McGraw-Hill, 2009
4. Ajoy Ghatak, Optics, McGraw-Hill, 2020.
5. Tom M Apostol, Calculus Vol. 1, Wiley, 2017
6. Tom M Apostol, Calculus Vol. 2, Wiley, 2017

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ENGINEERING CHEMISTRY [3-0-0-3]

Syllabus

Kinetic theory of gases; Chemical Kinetics: basic concepts, complex reactions, effects of temperature, catalysis; Spectroscopy: fundamentals, electronic and vibrational spectroscopy; Polymers: Polymerization mechanisms, techniques, kinetics, properties; Propellants: classification and properties

- Kinetic theory of gases: Introduction, collision theory, estimation of gas properties, Chemical Kinetics: Introduction, elementary and complex reactions, rate law expressions, effect of temperature on reaction rates, catalysis
- UV-Visible Spectroscopy-fundamentals, Beer Lambert's law, electronic transitions, empirical rules for prediction of λmax. IR Spectroscopy-Fundamentals, identification of functional groups.

- Polymers: Introduction, molecular weights of polymers, polymerization mechanisms-radical, ionic and condensation, structure property relations and applications.
- Propellants: classification of propellants, performance of propellants and thermochemistry, liquid propellants, oxidizers and fuels, solid propellants, composite solid propellants, burning ignition, and rate of burning, factors affecting rate of burning

Text Books

- Atkins P, Paula J and Keeler J, Atkins' Physical Chemistry, 11th ed., Oxford Univ. Press (2018).
- Young R J and Lovell P A, Introduction to Polymers, CRC Press, (2011)
- Kemp, W., Organic Spectroscopy, Palgrave Foundations (1991).
- Laidler, K. J., Chemical Kinetics, 3rd ed., Pearson Education (2005).

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THERMODYNAMICS [3-0-0-3]

Syllabus

Introduction - - energy and the first law of thermodynamics - -energy balance for systems and cycles- -properties of pure, simple compressible substance -- Ideal gas model, use of generalized compressibility charts– conservation laws for a control volume – second law of thermodynamics, notion of entropy change—Introduction to non-reacting gas mixtures and its application–exergy, exergy analysis for system and control volume –thermodynamic property relation– thermodynamic power and refrigeration cycles – introduction to statistical thermodynamics.

Textbook:

- Cengel, Y. A. and Boles, M. A., Kanoglu M, Thermodynamics: An Engineering Approach, 10th ed., McGraw-Hill (2023).

References:

1. Moran, M. J., Shapiro, H. N., Boettner, D. D., and Bailey, M. B., Principles of Engineering
2. Thermodynamics (SI Version), 8th ed., Wiley (2015).
3. Robert T. Balmer, Modern Engineering Thermodynamics, Elsevier (2011)
4. Nag, P. K., Engineering Thermodynamics, 6th ed., Tata McGraw-Hill (2017).
5. Jones, J. B. and Dugan, R. E., Engineering Thermodynamics, Prentice Hall (1996).
6. Borgnakke, C. and Sonntag, R. E., Bhattacharya S, Soni M K, Fundamentals of Thermodynamics, 10th ed., Wiley(2022).
7. Zemansky M, Dittman R, Heat and Thermodynamics, 8th ed., McGraw-Hill (2017).

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COMPUTER PROGRAMMING AND APPLICATIONS [2-0-2-3]

Syllabus

Introduction to Computers and programming: Computers-Hardware and software; Program and Programming languages; Input processing, and output; Procedural and object oriented programming.

Introduction to C++ : Components of a C++ program; cout object; #include directive; Variables and literals; Identifiers; Integer data types; char data type; Floating-point data types; bool data type; Variables, assignment and initialization; Scope; Arithmetic, Relational, Logical Operators; comments

Expressions, Statements: cin object; Mathematical expressions; Type conversion; Overflow and underflow; Type casting; Compound assignments; Formatting output; Char and string objects; Mathematical library functions; Debugging.

Making Decisions and loops: Assignment statements; Compound assignment; Increments and decrements; Conditional statements-if/else; Nested if/else; Conditional operator; switch statement; while loop; do-while loop; for loop

Functions and Arrays: Defining and calling functions; function prototypes; Passing data by value; return statement; local and global variables; static local variables; Default arguments; Reference variables as parameters; Overloading functions; exit() function; Array initialization; Processing array contents; Arrays as function arguments; Two dimensional arrays.

Pointers and Strings: Getting the address of a variable; Pointer variables; Pointer arithmetic; Initializing pointers; Comparing pointers; Pointers as function parameters; Dynamic memory allocation; Character case conversion; C-Strings; Library functions for working with C-Strings; C++ string class.

Classes and File stream: Introduction to classes; Private members; member functions; constructors; destructors; Overloading constructors; Private member functions; Array of objects; Friends of classes; copy constructors; Operator overloading; File operations; Passing file stream objects to functions; Member functions for reading and writing files; Opening a file for input and output.

Text Books

- Stanley B. Lipmann, Josee Lajoie, Barbara E. Moo, C++ Primer, Addison-Wesley.
- Ulla Kirch-Prinz, Peter Prinz, A Complete Guide to Programming in C++, Jones and Barlett publishers.

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COMMUNICATION SKILLS- I [1-0-2-2]

Syllabus

Module 1- Functional English: Conversation Skills-Asking questions, requests, doubts, engage in conversation, Different types of Communication-verbal and non-verbal, body language

Module 2-Teaching Grammar: Grammar Games, Exercise

Module 3-Teaching Vocabulary: Language Games, Exercise

Module 4- Presentation Skills

Module 5: Role Plays, debates, extempores, group presentations

Thrust areas of focus: Listening drills, Pronunciation drills, Practice special communication situations, Vocabulary exercises, Functional grammar exercises, Technical writing tips (engineering and scientific papers), Neuro-linguistic programming, Passage comprehension, Metronome practice with the help of mnemonics, Group discussions and debates, Technical guide lines for seminar presentation

Audio Visual Lab and Language Lab employs multimedia teaching materials to enhance speaking, listening, reading, and writing skills. This course also includes neuro-linguistic programming to develop language competency

References

- Alan Garner. Conversationally Speaking: Tested New Ways to Increase Your Personal and Social Effectiveness.
- Mike Bechtle. Confident Conversation: How to Communicate Successfully in Any Situation
- Ronald carter, Rebecca Hughes. Exploring Grammar in Context
- Baker, Ann and S. Goldstein, Pronunciation Pairs, Cambridge Univ Press, Cmbridge.2002.
- S. Brown and D. Smith, Active Listening. Cambridge, CUP. 2004

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BASIC ENGINEERING LAB (AEROSPACE) [1-0-2-2]

Syllabus

Introduction to sketching- Introduction to Computer-Aided Drawing and 3D Modelling- Orthographic/ Isometric / sectional views- Development of surfaces

Familiarization of Machine Elements and Mechanical Assemblies- Assembly and Disassembly Practices/ demonstrations.

Text Books/ References

- Bhatt, N. D., Engineering Drawing: Plane and Solid Geometry, 50th ed., Charotar Publishing House (2010).
- Varghese, P. I., Engineering Graphics with AutoCAD, 26th ed., VIP Publishers (2012).
- Bethune, J. D., Engineering Graphics with AutoCAD 2014, Pearson Education (2014).
- John, K. C., Textbook of Machine Drawing, PHI Learning (2009).
- Sidheswar, N., Kanniah, P., and Sastry, V. V. S., Machine Drawing, Tata McGraw Hill (2001).

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SEMESTER-II

VECTOR CALCULUS, ODE & SPECIAL FUNCTIONS, AND FOURIER SERIES [3-0-0-3]

Syllabus

Vector Calculus: scalar and vector fields – level surfaces – directional derivatives, gradient, curl, divergence – Laplacian – line and surface integrals – theorems of Green, Gauss, and Stokes.

Ordinary Differential Equations & Special Functions: first order ordinary differential equations – classification of differential equations – Picard's existence and uniqueness of solution of initial value problem – higher order linear differential equations with constant coefficients – method of variation of parameters and method of undetermined coefficients – power series solutions – regular and irregular singular point – Frobenius method to solve variable coefficient

homogeneous differential equation –Legendre polynomials, Bessel's function – Sturm-Liouville boundary-value-problem.

Fourier Series and Integral: Fourier series of periodic functions with period "2pi" – Fourier series of even and odd functions – half-range series – Fourier series of functions with arbitrary period "T" – point-wise convergence of Fourier series – Fourier integral– pointwise convergence of Fourier integrals.

Text Books:

- Stewart, J., Calculus: Early Transcendentals, 5th ed., Brooks/Cole (2007).
- Ross, S. L., Differential Equations, 3d ed., Wiley India Pvt. Ltd. (2007).
- Jain, R.K. and Iyengar, S.R.K., Advanced Engineering Mathematics, 4th ed., Alpha science international Ltd. (2014).

References:

- E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India (1995).
- Kreyszig, E., Advanced Engineering Mathematics, 9th ed., John Wiley (2005).
- Greenberg, M.D., Advanced Engineering Mathematics, Pearson Education (2007).
- Alan Jeffrey, Advanced Engineering Mathematics, Academic Press Inc. (2001).
- James Ward Brown and Ruel V. Churchill, Fourier Series and Boundary Value Problems, 8th ed., McGraw-Hill (2011).
- George Bachmann, Lawrence Narici, Edward Beckenstein, Fourier and Wavelet Analysis, 1st ed., Springer-Verlag New York Inc. (2000).

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MECHANICS OF SOLIDS [3-0-0-3]

Syllabus

Analysis of stress, strain – torsion – axial force, shear, and bending moment – pure bending – shear stress in beams – transformation of stresses and strains – deflection of beams columns; Buckling of Columns, Euler loads, beam-columns, eccentrically loaded columns – energy methods, virtual displacement method, virtual force method.

Text Books

- Popov, E. P., Engineering Mechanics of Solids, 2nd ed., Pearson Education (2015).

References

- Hibbeler, R. C., Mechanics of Materials, 9th ed., Prentice Hall (2013).
- Beer, F. P., Johnston, E. R., and DeWolf, J. T., Mechanics of Materials, 7th ed., McGraw-Hill (2014).
- Srinath, L. S., Advanced Mechanics of Solids, 2nd ed., Tata McGraw-Hill (2003).

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FLUID MECHANICS [3-0-0-3]

Syllabus

Fluid properties -- fluid statics -- integral control volume formulation -- applications of Bernoulli equation -- fluid kinematics -- differential formulation, continuity and momentum equations -- exact solutions of Navier-Stokes equation-- dimensional analysis -- pipe flow -- potential flow -- boundary layer theory.

Textbook

- Fox, R. W., McDonald, A. T., Pritchard, P. J., and Mitchell, J. W., Fluid Mechanics, John Wiley (2018).

Reference Books

- Munson, B. R., Okiishi, T. H., Huebsch, W. W., and Rothmayer, A. P., Fundamentals of Fluid Mechanics, 7th ed., Wiley (2017).
- White, F. M. and Xue, H., Fluid Mechanics, 9th ed., McGraw-Hill (2022).
- Cengel, Y. A. and Cimbala, J. M., Fluid Mechanics: Fundamentals and Applications, 4th ed., McGraw-Hill (2019).
- Massey, B. S. and J. Ward-Smith, Mechanics of Fluids, 7th ed., Nelson Thornes (1998).
- Potter, M. C., Wiggert, D. C., and Ramadan, B. H., Mechanics of Fluids, 5th ed., Cengage (2017).
- Wilcox, D. C., Basic Fluid Mechanics, 5th ed., DCW Industries (2013).

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ATMOSPHERIC FLIGHT MECHANICS [3-0-0-3]

Syllabus

Introduction to aerodynamics, propulsion, atmosphere and aircraft instrumentation- Equations of motion - Steady performance: gliding, cruise and climbing flight, optimal trajectories, accelerate performance: turn, pull up and pull down, take-off and landing, V-n diagrams, Introduction to aircraft stability.

Textbook

- Anderson, J.D. Jr., Introduction to Flight, 9th ed., McGraw Hill, (2021).
- Mohammad H. Sadraey, Aircraft Performance: An Engineering Approach, CRC Press (2017)

Reference Books

- Anderson, J.D. Jr., Aircraft Performance and Design, McGraw Hill, (2017).
- McCormick, B. W., Aerodynamics, Aeronautics, and Flight Dynamics, 2nd ed., Wiley (1994).
- Pamadi, B. N., Performance, Stability, Dynamics, and Control of Airplanes, 2nd ed.,
- AIAA Edu. Series (2004).
- Smetana, F. O., Flight Vehicle Performance and Aerodynamic Control, AIAA Edu.

- Series (2001).
- Phillips, W. F., Mechanics of Flight, 2nd ed., John Wiley (2010).
- S. K. Ojha, Flight Performance of Aircraft, AIAA (1995)
- Angelo Miele, Flight Mechanics, Dover Publications, (1990)

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ENGINEERING MATERIALS [3-0-0-3]

Syllabus

Classification of materials based on atomic structure and Bonding, Concept of crystal structure based on symmetry, Miller indices and planes, Atomic imperfections.
Principles of solidification – nucleation and growth, structure property relationships, Binary phase diagrams, Iron carbon diagram and steels.
Concepts of diffusion and Heat treatment.
Strengthening mechanisms: solid solution strengthening, strain hardening and grain boundary strengthening
Bonding and structure in ceramics, processing and applications of ceramics
Structure, processing and applications of polymers
Testing of materials: Tensile test, bend test and hardness

Text book

- Donlad R Askeland, Peadeep P Fulay, Wendelin J Right, The science and engineering of materials, Cengage learning (2011), 6th edition.

References

- Reza Abbaschian, Physical metallurgy principles, Cengage learning, 2009
- Vijendra singh, Physical metallurgy, Standard publishers (2020)
- William D Callister, David G Rethwisch, Materials science and engineering, An introduction, Wiley (2017), 10th Edition
- V. Raghavan, Physical metallurgy: Principles and practice, PHI (2015)
- Ashok Rajan, TV Sharma, CP Sharma, Heat treatment: Principles and techniques, PHI (2010)

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ENVIRONMENTAL SCIENCE AND ENGINEERING [2-0-0-2]

Syllabus

Introduction to environment, Biogeochemical cycles, environmental issues, environmental and drinking water quality, and treatment processes, Pollutants-Types, Sources and consequences and technological solutions/innovations, Engineering Interventions for better environment, Waste Management-Technological aspects, Protocols and norms in Environment.

Detailed syllabus

Awareness of the impact of environment on quality of life – natural resources – biological

systems – bio-geo chemical cycles – chemical processes; water treatment operations, water sampling, storage, quality measurement – oxygen demand – detection of pollutants – current environmental issues; pollutants, global warming, causes and consequences, air pollution, organic and inorganic air pollutants, smog-acid mine drainage, accumulation of salts in water–soil formation; micro and macro nutrients in soil, pollutants in soil – green chemistry: an alternative tool for reducing pollution – engineering interventions; flow sheets, waste minimization, e-waste management, ASP, reverse osmosis, trickling filter – environmental management; solid, liquid waste management, hazardous wastes, ISO standards – Kyoto protocol, Montreal protocol, Euro norms.

Text Books

- Rao, V., Textbook of Environmental Engineering, Prentice Hall of India (2002).

References

- Baird, C. and Cann, M., Environmental Chemistry, 3rd ed., W. H. Freeman and Company (2005).
- Manual on Water Supply and Treatment, CPHEEO, Ministry of Urban Development, GOI (1999).
- Manual on Sewerage and Sewage Development, CPHEEO, Ministry of Urban Development, GOI (1993).
- Hauser, B. A., Practical Hydraulics Hand Book, Lewis Publishers (1991).
- Hammer, M. J., Water and Wastewater Technology, Regents/Prentice Hall (1991).
- Sharma, J. P., Comprehensive Environmental Studies, Laxmi Publications (2004).
- Garg, S. K., Environmental Engineering (vol. 1 and 2), Khanna Publishers (2004).
- Kiely, G., Environmental Engineering, McGraw-Hill (1997).
- Bharucha, E., Textbook of Environmental Studies, University Grants Commission (2004).
- Vanloon, G. W. and Duffy, S. J., Environmental Chemistry: A Global Perspective, Oxford Univ. Press (2000).

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COMMUNICATION SKILLS -II [1-0-0-1]

Syllabus

Module 1: Audience analysis and adaptation

Module 2: Technical writing formats and styles (e.g., reports, minutes, posters, proposals, manuals, instructions), Writing style and tone, Clarity, conciseness, and coherence, Introduction to Technical Writing: Document planning and organization

Module 3: Reading and appreciating stories, poems, essays, Comprehensive questions and answers, Listening and note taking video lectures

Module 4: Short plays, individual presentations, group discussions, debates

References:

- Buzan, Tony. Use Your Head, Guild Publishing, 1974.

- G. Maugur, The English Language Laboratory Drills for Students of Science and Technology, Oxford, OUP. 2005.
- Mc Carthy, Carter. Cambridge Grammar of English. Cambridge, CUP.2006
- Yule, George. Oxford Practice Grammar. Oxford, OUP. 2006.
- Anderson, Kenneth. Et al. Study Speaking. CUP, Cambridge.2004.
- Freeman, Sarah. Written Communication in English. Orient Longman, Chennai. 2005.
- Hancock, Mark. English Pronunciation in Use. CUP, UK. 2003.
- Swales, J. M., & Feak, C. B. Academic writing for graduate students: Essential tasks and skills (Vol. 1). Ann Arbor, MI: University of Michigan Press. 2004.
- Belcher, W. L. Writing your journal article in twelve weeks: A guide to academic publishing success. University of Chicago Press.2019

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SEMESTER-III

COMPLEX ANALYSIS AND PDE [3-0-0-3]

Syllabus

Complex Analysis, and PDE (45 Lectures) Complex Analysis (22L): Complex numbers and elementary properties, Complex functions - limits, continuity and differentiation, Cauchy-Riemann equations, analytic and harmonic functions, elementary analytic functions – anti-derivatives and line (contour) integrals, Cauchy-Goursat theorem, Cauchy's integral formula – Morera's theorem, Liouville's theorem –Power series, Taylor series, zeros of analytic functions, singularities and Laurent series, residues, Cauchy's Residue theorem – applications of Cauchy's Residue theorem to evaluate improper integral– Bilinear Transformations and Conformal Mapping. Partial Differential Equations (23L): Introduction to PDEs and modelling –first order partial differential equations, solutions of linear and quasilinear first order PDEs, method of characteristics, transport equation, shocks and rarefactions waves, weak solution–Charpit method – classification of second-order PDEs, canonical form – solution of Initial and boundary value problems involving Laplace, heat and wave equations by the method of separation of variables and Fourier series

Text books:

- Mathews, J. H. and Howell, R., Complex Analysis for Mathematics and Engineering, Narosa (2005).
- Kreyszig, E., Advanced Engineering Mathematics, 9th ed., John Wiley (2005).
- Alan Jeffrey, Advanced Engineering Mathematics, Academic Press Inc.(2001).

References

- Brown, J. W. and Churchill, R. V., Complex Variables and Applications, 9th ed., McGrawHill (2013).
- Jain, R.K. and Iyengar, S.R.K., Advanced Engineering Mathematics, Narosa (2005).
- Greenberg, M.D., Advanced Engineering Mathematics, Pearson Education (2007).

- Sneddon, I.N., Elements of Partial Differential Equations, McGraw-Hill (1986).
- K. Sankara Rao, Introduction to Partial Differential Equations, 3rd Ed., Prentice Hall of India (2011).
- A.K. Nandakumaran and P. S. Datti, Partial Differential Equations: Classical Theory with a Modern Touch, Cambridge University Press; First Edition (2020).
- McOwen, R.C., Partial Differential Equations: Methods and Applications, 2nd ed., Pearson Education (2003)

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AERODYNAMICS [3-0-0-3]

Syllabus

Aerodynamic forces and moments – review of governing equations – potential flows – Kutta condition – vortex theorems – thin airfoil theory – finite wing theory – panel methods – flow over delta wings – boundary layer theory – effect of pressure gradient – flow separation and stall – high-lift devices

Textbook

- Anderson, J. D., Fundamentals of Aerodynamics, 5th ed., McGraw Hill (2010).

References

- Bertin, J. J. and Cummings, R. M., Aerodynamics for Engineers, 6th ed., Prentice Hall (2013).
- Houghton, E. L., Carpenter, P. W., Collicott, S. H., and Valentine, D. T., Aerodynamics for Engineering Students, 6th ed., Butterworth-Heinemann (2012).
- Kuethe, A. M. and Chow, C.-Y., Foundations of Aerodynamics, 5th ed., John Wiley (1997).
- Clancy, L. J., Aerodynamics, Reprint ed., Himalayan Books (2006).
- Drela, M., Flight Vehicle Aerodynamics, MIT Press (2014).

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AEROSPACE STRUCTURES [3-0-0-3]

Syllabus

Structural components of aircraft, loads and material selection – Introduction to elasticity, torsion, unsymmetric bending of beams – bending of open and closed thin walled beams: shear of and torsion of thin walled beams – combined open and closed section beams – introduction to composite materials.

Text Book

- Megson, T. H. G., Aircraft Structures for Engineering Students, 4th ed., Butterworth-Heinemann (2007).

Reference Books

- Sadd, M. H., Elasticity: Theory, Applications, and Numerics, 3rd ed., Academic Press (2014)
- Sun, C.T., Mechanics of Aircraft Structures, John Wiley and Sons, New York, (2006)
- Donaldson, B. K., Analysis of Aircraft Structures: An Introduction, 2nd ed., Cambridge Univ. Press (2008).
- Jones, R. M., Mechanics of Composite Materials, 2nd ed., CRC Press (1998).

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MANUFACTURING TECHNIQUES [3-0-0-3]

Syllabus

Manufacturing Techniques for aerospace applications: Metal Casting – Bulk metal and Sheet metal forming Processes- Machining, finishing and Precision manufacturing techniques- Fusion and solid state welding – Joining and assembly techniques- Additive Manufacturing Processes – Case studies and discussions on manufacturing techniques for aerospace / space grade materials

Text book

- Serope Kalpakjian, Steven R. Schmid, Manufacturing Engineering and Technology, 8th ed., Pearson Education (2023).

Reference books

- T. J Black, Ronald A. Kohser, DeGarmo's Materials and Processes in Manufacturing, Wiley (2017)
- Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes and Systems- 7th ed., Wiley (2020)
- Beddoes, J. and Bibby, M. J., Principles of Metal Manufacturing Processes, Butterworth-Heinemann (1999).
- Krishnadas Nair, C. G. and Srinivasan, R., Materials and Fabrication Technology for Satellite and Launch Vehicle, Navbharath Enterprises

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BASIC ELECTRICAL AND ELECTRONICS ENGINEERING [3-0-0-3]

Syllabus

Fundamentals of AC Power System: Introduction to Alternating Current – Basic concepts of AC circuits – Behaviour of resistor, capacitor and inductor in AC circuits – concepts of reactance and impedance - Sinusoidal steady state analysis - Power in AC circuits. Three-phase systems – Basic concepts of balanced three-phase systems– Power in three-phase systems.

Introduction to Electrical Machines: Basic concepts of transformers and rotating electrical machines.

Diode – clipping, clamping circuits, applications in rectifiers and power supplies. Amplifiers: BJT-Characteristics- DC analysis and AC analysis of BJT. Application of BJT as amplifiers/switch.

Introduction to operational amplifiers – characteristics/specifications and application to various circuits.

Digital circuits – Boolean logic – basic gates – truth tables – logic minimization using K maps – combinatorial and sequential circuits.

Text Books:

1. Boylestad, R. L. and Nashelsky, L., Electronic Devices and Circuit Theory, Pearson Education (2003).
2. Mano, M. M., Digital Design, Prentice Hall (2002).
4. Same as Reference (Electrical Part)

References:

1. Vincent Del Toro : 'Electrical Engineering Fundamentals', Pearson Education
2. A.E.Fitzgerald, David E Higginbothom, Arvin Grabel: 'Basic Electrical Engineering', Tata McGraw-Hill
3. Hughes, E. : 'Electrical and Electronic Technology', Pearson Education.
4. Charles K Alexander, Mathew N O Sadiku: 'Electric Circuits'
5. Fitzgerald, Kingsley, Umans, 'Electric Machinery', TMH 6. M.G.Say, ' Performance and Design of AC Machines'

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BASICS OF ECONOMICS [2-0-0-2]

Syllabus

Module 1- Exploring the subject matter of Economics: Origin of Economics – Definitions – importance - The Economic Problem – Scarcity and Choice – Resource allocation - Economic Systems –Micro and Macro Economics

Module 2- Principles and Concepts of Micro Economics: Demand and Supply, How Prices allocate resources - Equilibrium - Elasticity – concepts of Marginal utility, Consumer surplus – Production and production function – Law of variable proportions – Costs – Concept of Market.

Module 3- Basics of Macro Economics: Macro economy - methodology of macroeconomics – Concepts of National Income – Limitations – Black Economy – Inflation and its calculations - Globalization – Global Financial Crisis – introduction to Stock Market – introduction to space economy

Module 4- Economic Problems and Policies: Problems of Growth – lessons and controversies, Indian situation - Development Vs Growth, Measuring development - Poverty and Inequality – vicious circle of poverty –Population and Development – Demographic transition theory – Agriculture, Industry and development – Trade structure – Closed and Open Economy – New Economic Policy – Planning and growth.

Text Books

- Samuelson, Paul A and William D Nordhaus "Economics" (17th Edition), Mc Graw Hill.
- Dewett K K "Modern Economic Theory" S Chand 3. Thirlwall, A P "Growth and Development with Special Reference to Developing Economies" Palgrave.

References

- Ackley, Gardner “Macroeconomic Theory” Surjeet Publications
- Koutsoyiannis, A “Modern Micro Economics” Palgrave Macmillan
- Black, John “Dictionary of Economics” Oxford University Press.
- Meir, Jerald M and James E Rauch, “Leading Issues in Economic Development” (7th Edition) Oxford University Press.
- Todaro, Michael P and Steven C Smith “Economic Development” Pearson Education Ltd.
- Govt. of India, “Economic Survey 2023” Ministry of Finance.
- The Hindu, Newspaper, Daily.
- Connor, David E “The Basics of Economics” Greenwood Press

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STRENGTH OF MATERIALS LAB [0-0-2-1]

Syllabus

Uniaxial tension test with loading/unloading of mild steel and aluminium alloy rods – Hardness tests: Brinell hardness – Vickers hardness and Rockwell hardness – Impact tests– Torsion test – Double shear test – Compression test – Spring test

Text Book/Reference

Popov, E. P., Engineering Mechanics of Solids, 2nd ed., Pearson Education (2015).

ASTM Handbooks/Standards

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FLUID MECHANICS AND AERODYNAMICS LAB [0-0-2-1]

Syllabus

Pipe flow measurements, Calibration of flow meters, Pump and turbine efficiencies Measurement of lift and drag on airfoil and cylinder using various methods (pressure measurements, wake survey, and force balance) – flow visualization (smoke, oil, and optical) – free jet characteristics.

References

- Lab Manual/ Study Materials

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SEMESTER-IV

LINEAR ALGEBRA, INTEGRAL TRANSFORM AND CALCULUS OF VARIATION [3-0-0-3]

Syllabus

Linear Algebra (20L): elementary row-operations, row-echelon form and reduced-rowechelon form of matrices, rank of matrices – solution of system of equations Ax=b by Gauss elimination method, and Gauss-Jordan method – eigenvalues and eigenvectors, Cayley-Hamilton theorem, similarity matrices, diagonalization, computation of n-th power of square matrices – vector

spaces over real field, subspaces, linear dependence, independence, basis, dimension – linear transformation, null space and nullity, range and rank of a linear transformation– inner product, Gram-Schmidt orthogonalization process. Integral Transforms (15L): The Fourier transform pair, inverse Fourier transforms – linearity property, modulation, translation of Fourier transform– Fourier Convolution theorem – Fourier transforms of derivatives and derivatives of transform– applications of Fourier transform in solving ordinary differential equations – Fourier Sine and Cosine transforms, Fourier Sine inverse and Fourier Cosine inverse, Sine and Cosine transforms of derivatives and derivatives of transform – applications of Fourier Sine and Cosine transforms in solving ordinary differential equations and integral equations– Laplace transforms of elementary functions, inverse Laplace transforms– linearity property– exponential order of a function and existence of Laplace transform– first and second shifting theorem– Laplace transforms of derivatives and integrals– Laplace Convolution theorem – Laplace transform of periodic functions – applications of Laplace transform in solving ordinary differential equations. Calculus of Variations (10L): optimization of functional– Euler- Lagrange equations– first variation– isoperimetric problems– Rayleigh- Ritz method.

Text books:

- Howard Anton, Elementary Linear Algebra, 10th ed., John Wiley & Sons Inc (2010).
- Jain, R.K. and Iyengar, S.R.K., Advanced Engineering Mathematics, 4th ed., Alpha science international Ltd (2014).
- B.S. Grewal, Higher Engineering Mathematics, 45th ed., Khanna Publishers (1965).

References:

- Gilbert Strang, Linear Algebra and its Applications, Cengage learning, 4th edition, 2006.
- Greenberg, M.D., Advanced Engineering Mathematics, Pearson Education (2007).
- Kreyszig, E., Advanced Engineering Mathematics, 9th ed., John Wiley (2005).

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COMPRESSIBLE FLOW [3-0-0-3]

Syllabus

Governing equations – quasi-one-dimensional flows – acoustic waves and waves of finite amplitude – normal shocks – R-H equations – shock tube problem – oblique shocks – Prandtl-Meyer expansion – wave drag – reflection and interaction of waves – conical flows – flows with friction and heat transfer – linearized potential flow and its applications – transonic flows.

Textbook

- Anderson, J. D., Modern Compressible Flow with Historical Perspective, 3rd ed., McGraw Hill (2004).

References

- Liepmann, H. W. and Roshko, A., Elements of Gas Dynamics, Dover (2001).
- John, J. E. A. and Keith, T., Gas Dynamics, 3rd ed., Prentice Hall (2006).
- Zucker, R. D. and Biblarz, O., Fundamentals of Gas Dynamics, 2nd ed., Wiley (2002).
- Saad, M. A., Compressible Fluid Flow, 2nd ed., Prentice Hall (1992).

- Shapiro, A. H., The Dynamics and Thermodynamics of Compressible Fluid Flow, Vol. 1 & 2 Wiley (1953).

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AEROSPACE PROPULSION -I [3-0-0-3]

Syllabus

Introduction -- Air Breathing Jet Engine Types -- Air Breathing Jet Engine Thrust and Performance Parameters -- Air Breathing Jet Engine Thermodynamic Cycle Analysis -- Aerothermodynamics of Inlets, Combustors/Afterburners and Nozzles -- Basic Turbomachinery Concepts of Axial Compressors and Axial Flow Turbines -- Aircraft Gas Turbine Engine Off-Design Analysis -- Introduction to Hypersonic Air Breathing Propulsion -- Overview of UAV Propulsion Systems.

Textbooks

- Saeed Farokhi, Aircraft Propulsion (Cleaner, Leaner and Greener), 3rd ed., John Wiley (2022).
- Mattingly J.D., Elements of Propulsion: Gas Turbines and Rockets, AIAA Education Series (2006).

References

- Flack R., Fundamentals of Jet Propulsion with Power Generation Applications, Cambridge Aerospace Series (2023).
- Hill P.G. and Peterson C.R., Mechanics and Thermodynamics of Propulsion, 2nd ed., Pearson (2010).
- Cohen H., Saravanamutoo H.I.H., Rogers G.F.C., Straznicky, Nix A.C., Gas Turbine Theory, 7th ed., Pearson (2019).
- Kerrebrock J.L., Aircraft Engines and Gas Turbines, 2nd ed., MIT Press (1992).
- Heiser W., Pratt D., Daley D., Mehta U., Hypersonic Air Breathing Propulsion, AIAA Education Series (1994).
- Dixon S.L. and Hall C.A., Fluid Mechanics and Thermodynamics of Turbomachinery, 7th ed., Butterworth-Heinemann Inc. (2013).
- Fahlstrom P.G., Gleason T.J., Sadraey M.H., Introduction to UAV Systems, 5th ed., John Wiley (2022).

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APPLIED DYNAMICS AND VIBRATION [3-0-0-3]

Syllabus

Review of kinematics and dynamics of particles – kinematics and dynamics of rigid bodies – constraint dynamics applied to mechanisms – conservation laws for rigid bodies.

Vibration of single dof systems – response of single Dof system to transient loadings – multi Dof systems and mode superposition.

Text Books

- Uicker, J. J., Pennock, G. R., and Shigley, J. E., Theory of Machines and Mechanisms, 4th ed., Oxford Univ. Press (2010).
- William, J. H. Jr., Fundamentals of applied dynamics, John Wiley and Sons (1996).

References

- Norton, R. L., Kinematics and Dynamics of Machinery, 1st SI Edition, Tata McGraw Hill (2009).
- Ghosh, A. and Mallik, A. K., Theory of Mechanisms and Machines, 3rd ed., Affiliated East-West Press (2011).
- Thomson, W. T. and Dahleh, M. D., Theory of Vibrations with Applications, 5th ed., Pearson Education (2008).
- Dresig, H. and Holzweisig, F., Dynamics of Machinery: Theory and Applications, Springer (2010).
- Tenenbaum, R. A., Fundamentals of Applied Dynamics, Springer (2004).

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CONTROL SYSTEMS ENGINEERING [3-0-0-3]

Syllabus

Examples of controlled systems, open loop and feedback control, control system components-modeling of physical systems, block diagrams – review of Laplace transform, transfer function – time domain and frequency domain responses – stability, poles and zeros, Routh-Hurwitz criterion – root locus – Bode plot, Nyquist criterion – PID controller, lead and lag compensators – examples from aerospace and mechanical systems – introductions to state-space representation – stability criterion – concepts of controllability and observabilty.

Text Book

- D'Azzo, H., Feedback Control System Analaysis and Synthesis, CRC Press (2007).
- Norman S Nise, Control Systems Engineering, Wiley India (2024)

References

- Ogata, K., Modern Control Engineering, 5th ed., Pearson Education (2009).
- Gopal, M., Control Systems: Principles and Design, 3rd ed., Tata McGraw Hill (2008).
- Xue, D., Chen, YQ., and Atherton, D. P., Linear Feedback Control Analysis and Design with MATLAB, SIAM (2007).
- F Golnaraghi, BC Kuo, Automatic Control Systems, MC Graw Hill Education

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SOCIAL SCIENCE AND ENGINEERING ETHICS [2-0-0-2]

Syllabus

Module 1- Introduction to Social Sciences: Social Science Perspective: Characteristics, Common Sense Knowledge and Social Science Knowledge -Emergence of Social Science - Theoretical Perspectives- Functionalism, Structuralism, Conflict, Post Modern - Subdivisions of Social

Sciences - Philosophy of Science and Social Science - Social Science, Science, Technology and Space Technology

Module 2 – Methodology to Study Society: Statement of the Problem - Literature Review - Universe, Unit and Sampling - Qualitative and Quantitative Methods - Analysis

Module 3 - Macrocosms: Social Structure, Society : Society - Different Types of Societies - Family, Kinship and Marriage - Changes - Culture, Socialization, Agencies of Socialization - Race, Ethnicity, Nation States - Caste and Tribe - Transparency, Civil Society and Good governance - Femininities, Masculinities and Gender relations, Sexuality and Gender

Module 4 Microcosm: Problems of the Marginalized: Tribal Society- Development Induced Displacement, Poverty - Women in India– Sex Ratio, Increasing Violence - Children – Foeticide & Infanticide, Unequal sex ratio, Child marriage, Child labour and Trafficking - Elderly in India - People with Disabilities - Sexual Minorities

Ethics: Introduction to Engineering Ethics - Professional ethics - Personal Ethics

Text Books/ References ·

- Perry and Perry, Contemporary Society: An Introduction to Social Science. London: Allyn & Bacon (2010).
- Strada. Through the Global Lens: An Introduction to Social Sciences. London: Prentice Hall,.(2008)
- Ahuja, Ram. Social Problems in India. Jaipur: Rawat Publications (2014)
- Peter Singer, A Companion to Ethics. Blackwell Publishers (2013).
- Mike W. Martin, Ethics in Engineering. Mc Grawhill (2010)

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AEROSPACE STRUCTURES LAB [0-0-2-1]

Syllabus

Buckling of struts – Experiments on thin-walled pressure vessel – Unsymmetrical bending and shear center measurements – Measurement of strain using strain gauges – Shear force in a beam – Deflection of beams and cantilevers – Continuous and indeterminate beams.

Text Book/References

- Megson, T. H. G., Aircraft Structures for Engineering Students, 4th ed., Butterworth-Heinemann (2007).
- Popov, E. P., Engineering Mechanics of Solids, 2nd ed., Pearson Education (2015).

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MANUFACTURING AND METROLOGY LAB [0-0-4-2]

Syllabus

Understanding manufacturing drawings- Discussions on dimensional and geometric tolerances - Familiarization of various shop floor manufacturing processes and machines- Hand on exercises on machining, metal forming and welding operations- Familiarization of 3D printing platforms- Raw material selection/ heat treatment- Selection of manufacturing processes – Discussions on Aerospace/ Space applications -Familiarization of shop floor metrology

practices and instruments –Assembly / Joining aspects- Characterization, Inspection and Quality Control aspects

Text Book/References

- Campbell, F. C., Manufacturing Technology for Aerospace Structural Materials, Elsevier
- Krishnadas Nair, C. G. and Srinivasan, R., Materials and Fabrication Technology for Satellite and Launch Vehicle, Navbharath Enterprises
- Winston A. Knight, Geoffrey Boothroyd, Fundamentals of Metal Machining and Machine Tools, CRC Press
- Smith, G. T., Industrial Metrology: Surfaces and Roundness, Springer-Verlag
- Geoffrey Boothryod, Peter Dewhurst, Winston A knight, Product design for Manufacture and Assembly, CRC Press.
- Meadows, Geometric Dimensioning and Tolerancing: Application, analysis, gauging and measurements, James D. Meadows & Associates
- ASM handbooks / Lab Manuals/ Study Materials

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SEMESTER-V

PROBABILITY & STATISTICS [3-0-0-3]

Syllabus

Probability: Elementary concepts on probability – axiomatic definition of probability – conditional probability – Bayes' theorem – random variables – standard discrete and continuous distributions – moments of random variables – moment generating functions – multivariate random variables – joint distributions of random variables – conditional and marginal distributions – conditional expectation – distributions of functions of random variables – t and $\chi 2$ distributions – Schwartz and Chebyshev inequalities – weak law of large numbers for finite variance case – central limit theorem for iid finite variance case.

Statistics: Elementary concepts on populations, samples, statistics – sampling distributions of sample mean and sample variance – point estimators and its important properties – point estimator for mean and variance and proportion – confidence interval for sample mean – tests of hypotheses – Chi-squared test of goodness of fit. Simple linear regression and correlation, curve fitting, inferences concerning regression coefficients, statistical quality control

Text Book:

- Walpole, W. E., Myers, R. H., Myers, S. L., and Ye, K., Probability & Statistics for Engineers & Scientists, 9th ed., Pearson Education (2012).

References

- Johnson, R. A., Miller & Freund's Probability and Statistics for Engineers, 6th ed., Prentice Hall (2000).
- Milton, J. S. and Arnold, J. C., Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, 4th ed., McGraw-Hill (2002).

- Ross, S. M., Introduction to Probability and Statistics for Engineers and Scientists, 3rd ed., Academic Press (2004).
- Hogg, R. V. and Tanis, E. A., Probability and Statistical Inference, 7th ed., Prentice Hall(2005).
- Larsen, R. J. and Marx, M. L., An Introduction to Mathematical Statistics and Its Applications, 4th ed., Prentice Hall (2005).

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SPACE FLIGHT MECHANICS [3-0-0-3]

Syllabus

Dynamics of point masses- Newton's inverse square law - n-body equation- Kepler's law- eqn of conic- types of conics- flight path angle- Vis-Viva eqn- orbital position as a function of time- Kepler's eqn- orbits in three dimensions-different coordinate frames- conversion of state vector to orbital elements-coordinate transformation between different frames- earth's oblateness- ground tracks- preliminary orbit determination- Julian date- topocentric coordinate frame- angle and range measurements- orbit maneuvers- impulse transfer-Hohmann- bielliptic-phasing maneuvers-non-Hohman transfers-chase maneuvers- plane change maneuvers- lunar transfer trajectories

Text Book

- Howard D.Curtis,'Orbital Mechanics for Engineering Students, ELSEVIER,

Reference Book

- Francis J Hale, 'Introduction to Space Flight', Prentice Hall
- Ashish Tewari, 'Atmospheric and Spaceflight Dynamics', Birkhauser,2007
- David A Vallado, 'Fundamentals of Astrodynamics and Applications, Kluwer Academic Publishers
- Richard H.Bartin, 'An introduction to the Mathematics and Methods of Astrodynamics, Revised Edition', AIAA Education Series
- V A Chobotov,'ORBITAL MECHANICS'. AIAA EDUCATION SERIES
- W E Weisel,' Spaceflight dynamics', The McGraw-Hill Companies
- Charles D.Brown , Spacecraft Mission Design, AIAA Education Series
- P.R. Escobal, 'Methods of Orbit determination', Krieger Publishing Company
- Michael D Griffin, James R French, 'Space Vehicle Design', AIAA Education Series

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COMPUTATIONAL METHODS IN ENGINEERING [3-0-0-3]

Syllabus

Approximation and Round-off errors, truncation error, roots of equations, algebraic equations, optimization, curve fitting, numerical differentiation and integration, Ordinary differential equation

Text Book

- Chapra, S.C., Canale, R.P., Numerical Methods for Engineers, McGraw-Hill.

References

- Cheney, W., Kincaid, D., Numerical Mathematics and Computing, Thompson Brooks/Cole.
- Analysis of Numerical Methods, Issacson, E., Keller, H.B., Dover Publications.
- Hamming, R.W., Numerical Methods for Scientist and Engineers, Dover Publications.
- Acton, F.S., Numerical Methods that Work, Mathematical Association of America.
- Conte, S.D., Boor, C de, Elementary Numerical Analysis, McGraw-Hill.
- Atkinson, K.E., An Introduction to Numerical Analysis, Wiley Publications.
- William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, Numerical
- Recipes 3rd Edition: The Art of Scientific Computing, Cambridge University Press.
- Hairer, E., Wanner, G., Norsett, S.P., Solving Ordinary Differential Equations I, Springer.
- Hairer, E., Wanner, G, Solving Ordinary Differential Equations II, Springer.

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INDUSTRIAL ENGINEERING AND MANAGEMENT [3-0-0-3]

Syllabus

Introduction to management - functions of a manager: planning, organizing, leading, controlling – functional areas of management – corporate objectives – product design and value engineering – productivity – demand forecasting – Introduction to production planning and control – work study - motion study – work measurement techniques – facilities location and layout – inventory management – total quality management – Introduction to production management: CPM, PERT – case studies in industrial engineering.

References

- H. Koontz, H. Weihrich, M.V. Cannice, Essentials of Management, McGraw Hill, 11th Edition, 2020.
- R. B. Chase, F. R. Jacobs, N. J. Aquilano, N. K. Agarwal, Operations Management for competitive advantage, McGraw Hill Educaton, 11th Edition, 2005.
- ILO, Introduction to Work study, Oxford and IBH Publishing Co., 2010.
- R. M. Barnes, Motion and Time Study – Design and Measurement of Work, John Wiley & Sons, New York, 1990
- E. S. Buffa and R.K. Sarin, Modern Production/Operations Management, Wiley, 8th Edition, 2010.
- K.N. Krishnaswamy and M. Mathirajan, Cases in Operations Management, PHI learning, 2010.

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FLIGHT MECHANICS AND PROPULSION LAB [0-0-4-2]

Syllabus

Flight Mechanics: Simulation of accelerated maneuvers using whirling arm, Estimation of neutral point from simulated flight data, Estimation of drag polar of glider from simulated flight data, Estimation of moment of inertia of UAV using Bi-filar pendulum.

Propulsion: Study and analysis of gas turbine cycle – Performance analysis of turbojet engine – Experiments on axial flow fan – Experimental impulse turbine module – Experimental reaction turbine module – Experiments on ramjet engine.

References

- Lab Manuals /Study Materials

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INSTRUMENTATION AND CONTROL LAB [0-0-2-1]

Syllabus

Familiarization with MATLAB and SIMULINK – Linear system modelling, simulation, analysis and compensator design for various applications- Open loop and close loop examples.
Study of sensors and instrumentation systems

References

Lab Manual

SEMESTER-VI

FLIGHT DYNAMICS AND CONTROL [3-0-0-3]

Syllabus

Equations of Motion: rigid body dynamics, coordinate transformation, Euler angle & quaternion formulation

Stability and control: Longitudinal, directional and lateral stability criteria, stick fixed and stick free stability, hinge moments, trim-tabs, aerodynamic balancing – effect of maneuvers – Control using Elevator, Aileron and Rudder

Linearized equations of motion, Estimation of aerodynamic derivatives, Linearized longitudinal & lateral dynamics, modes of motion – Response to Control Inputs.

Feedback Control for Aircraft: stability augmentation, Autopilot using PID and Full State Feedback.

Textbooks

- Nelson, R. C., Flight Stability and Automatic Control, 2nd ed., Tata McGraw Hill (1997).

References

- Etkin, B. and Reid, L. D., Dynamics of Flight: Stability and Control, 3rd ed., Wiley (1996).
- Phillips, W. F., Mechanics of Flight, 2nd ed., John Wiley (2009).
- Pamadi, B. N., Performance, Stability, Dynamics, and Control of Airplanes , 2 nd ed., AIAA Edu. Series (2004).

- Cook, M., Flight Dynamics Principles: A Linear Systems Approach to Aircraft Stability and Control, 3rd ed., Elsevier (2012).
- Stevens, B. L. and Lewis, F. L., Aircraft Control and Simulation, 2nd ed., Wiley (2003).
- Stengel, R. F., Flight Dynamics, Princeton Univ. Press (2004).

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OPTIMIZATION TECHNIQUES IN ENGINEERING [3-0-0-3]

Syllabus

Introduction to optimization – 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.

Textbook

- S.S. Rao, Engineering Optimization: Theory and Practice, John Wiley and Sons, 4th edition 2009.

References

- H.A. Taha, Operations Research: An Introduction", Pearson, 10th edition, 2016.
- E. K. P. Chong and S. H. Zak, An introduction to optimization, Wiley Publishers, 2017.
- Bertsekas, D. P., Non-linear programming, Athena Scientific, 3rd edition, 2016.
- K. Deb, Optimization for Engineering Design: Algorithms and Examples, Prentice-Hall of India 2012.
- K. Deb, Multi-objective optimization using Evolutionary Algorithms, Wiley, 2010.

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AEROSPACE PROPULSION- II [3-0-0-3]

Syllabus

Introduction to rocket propulsion systems – Overview of rocket propulsion engines (Chemical, Electric, Nuclear, Solar) – Types of rocket nozzles and thrust vector control – Parameters for chemical rockets – Combustion in rocket engines – Propellants – Solid rocket motors – Elements of liquid propulsion systems – Hybrid rockets – Non-conventional propulsion techniques – Chemical Equilibrium Concentration Calculations- Combustion Instability - Rocket testing and performance evaluation – Selection of rocket motors.

Textbook

- Sutton, G. P. and Biblarz, O., Rocket Propulsion Elements, 7th ed., John Wiley

(2000).

- Ramamurthi, K, Rocket Propulsion, Macmillan publishers.

References

- Hill, P. G. and Peterson, C. R., Mechanics and Thermodynamics of Propulsion, 2nd ed., Addison–Wesley (1992).

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MODELLLING AND ANALYSIS LAB [1-0-2-2]

Syllabus

Modeling and analysis using FEM: Geometric modeling and finite element meshing of beam, plate and solid structures – stress, free vibration and buckling analyses
Modeling and simulation of multi-rigid body systems using Scilab/MATLAB/ADAMS
Modeling of heat transfer and fluid flow

References

Lab Manuals

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SEMESTER-VII

AEROSPACE VEHICLE DESIGN [2-0-2-3]

Syllabus

Introduction to the design process – requirements capture – design optimization.

Aircraft Design: design considerations for civilian and military aircraft – weight estimation – airfoil and geometry selection – thrust to weight ratio and wing loading – initial sizing – propulsion – landing gear and subsystems – aerodynamics – stability, control, and handling qualities – flight mechanics and performance issues – aircraft layout and configuration – structural aspects – constraint analysis.
Space Vehicle Design: requirements, specifications and design process – rocket equation – velocity budget, staging, launch vehicle sizing, launch into an orbit, range safety – rocket propulsion options – configuration and structural design – NGC systems – thermal control – power systems – communication systems – design for re-entry – vehicle integration and recovery.

Textbooks

- Sadraey, M. H., Aircraft Design: A Systems Engineering Approach, Wiley (2012).
- Griffin, M. D. and French, J. R., Space Vehicle Design, 2nd ed., AIAA Edu. Series (2004).

References

- Raymer, D. P., Aircraft Design: A Conceptual Approach, 4th ed., AIAA Edu. Series

(2006).

- Anderson, J. D., Aircraft Performance and Design, McGraw Hill (1999).
- Corke, T. C., Design of Aircraft, Prentice Hall (2002).
- Fielding, J. P., Introduction to Aircraft Design, Cambridge Univ. Press (1999).
- Bruhn, E. F., Analysis and Design of Flight Vehicle Structures, Jacobs Publishing (1973).
- Niu, M. C. Y., Airframe Structural Design: Practical Design Information and Data on Aircraft Structures, 2nd ed., Adaso/Adastra Engineering Center (1999).

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LIST OF ELECTIVES

C: Program Core Elective M: Minor Stream Elective H: HEC elective

*[** Course Codes may vary slightly in the final allocation/grouping]*

1. AE461C/M: Applied Aerodynamics [3-0-0-3]
2. AE462C/M: Experimental Aerodynamics
3. AE463C/M: Aeroacoustics [3-0-0-3]
4. AE464C/M: High Temperature Gas Dynamics [3-0-0-3]
5. AE465C/M: Hypersonic Aerothermodynamics [3-0-0-3]
6. AE466C/M: Modern Aircraft Control Design [3-0-0-3]
7. AE467C/M: Modeling and Simulation of Aerospace Vehicles [3-0-0-3]
8. AE468C/M: Space Mission Design and Optimization [3-0-0-3]
9. AE469C/M: Design and Modeling of Rocket Propulsion System [3-0-0-3]
10. AE470C/M: Optical & Laser Based Combustion Diagnostics [3-0-0-3]
11. AE471C/M: Advanced Fluid Mechanics [3-0-0-3]
12. AE472C/M: Boundary Layer Theory [3-0-0-3]
13. AE473C/M: Turbulence in Fluid Flows [3-0-0-3]
14. AE474C/M: Introduction to Flow Instability [3-0-0-3]
15. AE475C/M: Computational Methods for Compressible Flows [3-0-0-3]
16. AE476C/M: Computational Fluid Dynamics [3-0-0-3]
17. AE477C/M: Navigation Guidance and Control [3-0-0-3]-
18. AE478C/M: Optimal Control Theory [3-0-0-3]
19. AE479C/M: Heat Transfer [3-0-0-3]
20. AE480C/M: Conduction and Radiation [3-0-0-3]
21. AE481C/M: Convective Heat Transfer [3-0-0-3]
22. AE482C/M: Viscous Flow [3-0-0-3]
23. AE483C/M: Nanoscale and Microscale Transport Phenomenon [3-0-0-3]
24. AE484C/M: Radiative Heat Transfer [3-0-0-3]
25. AE485C/M: Two-Phase Flow and Heat Transfer- I [3-0-0-3]
26. AE486C/M: Two-Phase Flow and Heat Transfer- II [3-0-0-3]
27. AE487C/M: Cryogenic Engineering [3-0-0-3]
28. AE488C/M: Physiological Fluid Mechanics [3-0-0-3]
29. AE489C/M: Heat Transfer in Aerospace Applications [3-0-0-3]
30. AE490C/M: Introduction to Human Space Flight [3-0-0-3]
31. AE491C/M: Spacecraft Thermal Control [3-0-0-3]
32. AE492C/M: Advanced Aerospace Structures [3-0-0-3]
33. AE493C/M: Multi Rigid Body Dynamics [3-0-0-3]

34. AE494C/M: Engineering Vibration [3-0-0-3]
35. AE495C/M: Non-Linear Oscillation [3-0-0-3]
36. AE496C/M: Finite Element Method [3-0-0-3]
37. AE497C/M: Fracture Mechanics [3-0-0-3]
38. AE498C/M: Design of Aerospace Structures [3-0-0-3]
39. AE499C/M: Molecular Dynamics and Materials Failure [3-0-0-3]
40. AE500C/M: Advanced Finite Element Method [3-0-0-3]-
41. AE501C/M: Structural Dynamics [3-0-0-3]-
42. AE502C/M: Robot Mechanisms and Technology [3-0-0-3]
43. AE503C/M: Analysis and Synthesis of Mechanisms [3-0-0-3]
44. AE504C/M: Rotor Dynamics [3-0-0-3]
45. AE505C/M: Structural Acoustics and Noise Control [3-0-0-3]
46. AE506C/M: Experimental Modal Analysis [2-0-3-3]
47. AE507C/M: Random Vibrations and Applications [3-0-0-3]
48. AE508C/M: Design of Aerospace Mechanisms [3-0-0-3]
49. AE509C/M: Smart Materials and Structures [3-0-0-3]-
50. AE510C/M: Aerospace Materials and Processes [3-0-0-3]
51. AE511C/M: Mechanical Behaviour of Materials [3-0-0-3]-
52. AE512C/M: Thermodynamics and Phase Transformations in Materials [3-0-0-3]
53. AE513C/M: Heat Treatment Techniques [3-0-0-3]
54. AE514C/M: Solidification Processing [3-0-0-3]
55. AE515C/M: Advanced Engineering Materials [3-0-0-3]
56. AE516C/M: Materials Characterization Techniques [3-0-0-3]
57. AE517C/M: Plasticity and Advanced Deformation Processes [2-1-0-3]
58. AE518C/M: Composite Manufacturing Technology [3-0-0-3]
59. AE519C/M: Advanced Welding Technology [3-0-0-3]
60. AE520C/M: Subtractive and Computer Aided Manufacturing [3-0-0-3]
61. AE521C/M: Additive Manufacturing and Smart Practices [3-0-0-3]
62. AE522C/M: Advanced Machining Processes [3-0-0-3]
63. AE523C/M: Design for Manufacturing [3-0-0-3]
64. AE524C/M: Digital Manufacturing and Automation [3-0-0-3]
65. AE525C/M: Metrology and Computer Aided Inspection [3-0-0-3]
66. AE526C/M: Micro/ Nano Machining [3-0-0-3]
67. AE527C/M: Non-Traditional Machining [3-0-0-3]
68. AE528C/M: Multidisciplinary Design Optimization [3-0-0-3]
69. AE529C/M/H: Operations Research [3-0-0-3]
70. AE530C/M/H: Quality Engineering [3-0-0-3]
71. AE531C/M/H: Advanced Operations Research [3-0-0-3]

72. AE532C/M/H: Total Quality Management [3-0-0-3]
73. AE533C/M/H: Manufacturing Planning and Control [3-0-0-3]
74. AE534C/M/H: Air Traffic Management [3-0-0-3]
75. AE535C/M/H: Human Behaviour in Organizations [3-0-0-3]
76. AE536M/H: Introduction to Space Laws [3-0-0-3]
77. AVXXX M/H: Sensors and Actuators [3-0-0-3]
78. MAXXX M/H: Foundation of Machine Learning [3-0-0-3]
79. AVXXX M/H: Internet of Things [3-0-0-3]
80. MAXXX M/H: Data Mining [3-0-0-3]
81. AVXXX M/H: Computer Vision [3-0-0-3]

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SYLLABUS DOCUMENT FOR ELECTIVE SUBJECTS

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AEROACOUSTICS [3-0-0-3]

Syllabus

Basics of acoustics – general theory of aerodynamic sound – flow and acoustic interactions – feedback phenomenon – supersonic jet noise – sonic boom – noise radiation from rotors and fans – aeroacoustic measurements.

References

- *Pierce, A. D., Acoustics: An Introduction to Its Physical Principles and Applications, Acoustical Society of America (1989).*
- *Dowling, A. P. and Ffowcs Williams, J. E., Sound and Sources of Sound, Ellis Horwood (1983).*
- *Goldstein, M. E., Aeroacoustics, McGraw Hill (1976).*
- *Blake, W. K., Mechanics of Flow-Induced Sound and Vibration, Volume I and II, Academic Press (1986).*
- *Crighton, D. G., Dowling, A. P., Ffowcs Williams, J. E., Heckl, M. A., and Leppington, F. A.,*
- *Modern Methods in Analytical Acoustics: Lecture Notes, Springer-Verlag (1992).*

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APPLIED AERODYNAMICS [3-0-0-3]

Syllabus

Panel methods – unsteady potential flows – compressible flow over wings – axisymmetric flows and slender body theories – flight vehicle aerodynamics – rotor aerodynamics – low Reynolds number aerodynamics – flapping wings – two- and three-dimensional flow separation.

References

- *Drela, M., Flight Vehicle Aerodynamics, MIT Press (2014).*
- *Rom, J., High Angle of Attack Aerodynamics: Subsonic, Transonic, and Supersonic Flows, Springer-Verlag (1992).*
- *Shyy, W., Aono, H., Kang, C.-K., and Liu, H., An Introduction to Flapping Wing Aerodynamics, Cambridge Univ. Press (2013).*
- *Chattot, J. J. and Hafez, M. M., Theoretical and Applied Aerodynamics: and Related Numerical Methods, Springer (2015).*
- *Bisplinghoff, R. L., Ashley, H., and Halfman, R. L., Aeroelasticity, Dover (1996).*
- *Telionis, D. P., Unsteady Viscous Flows, Springer (2012).*

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EXPERIMENTAL AERODYNAMICS [3-0-0-3]

Syllabus

Concept of similarity and design of experiments – measurement uncertainty – design of subsonic, transonic, supersonic, hypersonic, and high enthalpy test facilities – transducers and their response characteristics – measurement of pressure, temperature, velocity, forces, moments and dynamic sta- bility derivatives – flow visualization techniques: optical measurement techniques, refractive index based measurements, scattering based measurements – data acquisition and signal conditioning – signal and image processing.

References

- *Tropea, C., Yarin, A., and Foss, J. F. (Eds.), Springer Handbook of Experimental Fluid Me- chanics, Springer (2007).*
- *Barlow, J. B., Rae Jr, W. H., and Pope, A., Low-Speed Wind Tunnel Testing, 3rd ed., Wiley (1999).*
- *Pope, A. and Goin K., High-Speed Wind Tunnel Testing, Krieger Pub. Co. (1978).*
- *Settles, G. S., Schlieren and Shadowgraph Techniques: Visualizing Phenomena in Transparent Media, Springer (2001).*
- *Mayinger, F. and Feldmann, O. (Eds.), Optical Measurements: Techniques and Applications, 2nd ed., Springer (2001).*
- *Doebelin, E. O., Measurement Systems: Application and Design, 5th ed., McGraw Hill (2003).*

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BOUNDARY LAYER THEORY [3-0-0-3]

Syllabus

Introduction to Tensors, Governing equations for compressible viscous fluid flow and its different forms; Incompressible boundary layers: Laminar boundary layer approximations, Prandtl boundary layer equations, Similar solutions, Effect of pressure gradient, Momentum integral methods, Flow separation, Methods to delay/control the flow separation, Free shear layers; Thermal boundary layers: Effect of Prandtl number, similar solutions;

Compressible boundary layers: Simple solutions to energy equation, Recovery factor, Reynolds analogy, Transformations of Boundary layer equation, Similar solutions; Turbulent Flows: Phenomenological theories, Reynolds stress, Turbulent boundary layer, Momentum integral methods, Turbulent free shear layer.

References:

- *Schlichting, H. and Gersten, K., Boundary Layer Theory, 8th ed., McGraw-Hill (2001).*

- *White, F. M., Viscous Fluid Flow, 3rd ed., McGraw-Hill (2006).*
- *Panton, R. L., Incompressible Flow, 4th ed., Wiley (2013).*
- *Kundu, P. K., Cohen, I. M., and Dowling, D. R., Fluid Mechanics, 6th ed., Academic Press (2015)*
- *Pope, S. B., Turbulent Flows, Cambridge Univ. Press (2000).*

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HIGH TEMPERATURE GAS DYNAMICS [3-0-0-3]

Syllabus

General features and applications of high temperature flows – equilibrium kinetic theory: Maxwellian distribution, collision rates and mean free path – chemical thermodynamics – mixture of perfect gases, law of mass action – statistical mechanics: enumeration of micro-states, energy distribution, contribution of internal structure – equilibrium flow: ideal dissociating gas, equilibrium shock wave relations, nozzle flows – vibrational and chemical rate processes – flows with vibrational and chemical non-equilibrium.

References

- *Vincenti, W. G. and Kruger, C. H., Introduction to Physical Gas Dynamics, Krieger Pub. (1975).*
- *Anderson, J. D., Hypersonic and High-Temperature Gas Dynamics, 2nd ed., AIAA (2006).*
- *Clarke, J. F. and McChesney, M., The Dynamics of Real Gases, Butterworths (1964).*
- *Brun, R., Introduction to Reactive Gas Dynamics, Oxford Univ. Press (2009).*

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HYPERSONIC AEROTHERMODYNAMICS [3-0-0-3]

Syllabus

Introduction to Hypersonic Flows – Inviscid Hypersonic Flow: Newtonian flow, Mach number inde- pendence, Hypersonic similarity, Blast wave theory, Hypersonic small disturbance theory, Stagnation region flow – Viscous Hypersonic Flow: Similarity parameters, Self-similar solutions, Hypersonic tur- bulent boundary layer, Reference temperature method, Stagnation region flow field, Viscous interac- tions – Real Gas effects: Inviscid equilibrium and non-equilibrium flows, Viscous high temperature flows – Experimental facilities – Hypersonic design considerations.

References

- *Anderson, J. D., Hypersonic and High-Temperature Gas Dynamics, 2nd ed., AIAA (2000).*
- *Rasmussen, M., Hypersonic Flow, Wiley (1994).*
- *Bertin, J. J., Hypersonic Aerothermodynamics, AIAA (1994).*

- *Hirschel, E. H., Basics of Aerothermodynamics, Springer (2005).*
- *Hirschel, E. H., Selected Aerothermodynamic Design Problems of Hypersonic Vehicles, Springer (2009).*

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TURBULENCE IN FLUID FLOWS [3-0-0-3]

Syllabus

Introduction to turbulence – Equations of fluid motion – Statistical description of turbulent flows – Mean-flow equations – Space and time scales of turbulent motion – Jets, wakes and boundary layers – Coherent structures – Spectral dynamics – Homogeneous and isotropic turbulence – Two-dimensional turbulence – Coherent structures – Vorticity dynamics – Intermittency – Modelling of turbulent flows.

References

- *Tennekes, H. and Lumley, J. L., A First Course in Turbulence, The MIT Press (1972).*
- *Frisch, U., Turbulence, Cambridge Univ. Press (1996).*
- *Davidson, P. A., Turbulence: An Introduction to Scientist and Engineers, Oxford Univ. Press (2004).*
- *Pope, S. B., Turbulent Flows, Cambridge Univ. Press (2000).*
- *Mathieu, J. and Scott, J., An Introduction to Turbulent Flow, Cambridge Univ. Press (2000).*
- *Lesieur, M., Turbulence in Fluids, 2nd ed., Springer (2008).*
- *Monin, A. S. and Yaglom, A. M., Statistical Fluid Mechanics, Dover (2007).*
- *McComb, W. D., The Physics of Fluid Turbulence, Oxford Univ. Press (1992).*

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INTRODUCTION TO FLOW INSTABILITY [3-0-0-3]

Syllabus

Introduction to stability – Review of dynamical systems concepts – Instabilities of fluids at rest – Stability of open shear flows: Inviscid and viscous theory, spatio-temporal stability analysis (absolute and convective instabilities) – Parabolized stability equation – Transient growth – Introduction to global instabilities.

References

- *Charru, F., Hydrodynamic Instabilities, Cambridge Univ. Press (2011).*
- *Drazin, P. G., Introduction to Hydrodynamic Stability, Cambridge Univ. Press (2002).*
- *Drazin, P. G. and Reid, W. H., Hydrodynamic Stability, 2nd ed., CUP (2004).*
- *Criminale, W. O., Jackson, T. L., and Joslin, R. D., Theory and Computation of Hydrodynamic Stability, Cambridge Univ. Press (2003).*
- *Schmid, P. J. and Henningson, D. S., Stability and Transition in Shear Flows,*

Springer (2001).

- *Sengupta, T. K., The Instabilities of Flows and Transition to Turbulence, CRC Press (2012).*

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SPACE MISSION DESIGN AND OPTIMIZATION [3-0-0-3]

Syllabus

Launch vehicle ascent trajectory design – reentry trajectory design – low thrust trajectory design – satellite constellation design – rendezvous mission design – ballistic lunar and interplanetary tra- jectory design – basics of optimal control theory – mission design elements for various missions – space flight trajectory optimization – direct and indirect optimization techniques – restricted 3-body problem – Lagrangian points – mission design to Lagrangian point.

Textbooks

- *Osborne, G. F. and Ball, K. J., Space Vehicle Dynamics, Oxford Univ. Press (1967).*
- *Hale, F. J., Introduction to Space Flight, Prentice Hall (1994).*
- *Naidu, D. S., Optimal Control Systems, CRC Press (2002).*

References

- *Chobotov, V., Orbital Mechanics, AIAA Edu. Series (2002).*
- *Griffin, M. D. and French, J. R., Space Vehicle Design, 2nd ed., AIAA (2004).*
- *Kirk, D. E., Optimal Control Theory: An Introduction, Dover (1998).*
- *Bulirsch, R., Miele, A., Stoer, J., and Well, K. H. (Eds.), Optimal Control: Calculus of Varia- tions, Optimal Control Theory and Numerical Methods, Birkhauser Verlag (1993).*

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COMPUTATIONAL METHODS FOR COMPRESSIBLE FLOWS [3-0-0-3]

Syllabus

Basic equations – Hierarchy of mathematical models – Mathematical nature of flow equations and boundary conditions – Finite difference and finite volume methods – Analysis of Schemes: Numerical errors, stability, numerical dissipation – Grid generation – Wave equation – NumericalSolution of Compressible Euler Equation: Discontinuities and entropy, mathematical propertiesof Euler equation – Reconstruction-evolution – Upwind methods – Boundary conditions – Nu-merical solution of compressible Navier-Stokes equations – Turbulence Modeling: RANS, LES, DNS – Higher-order methods – Uncertainty in CFD: Validation and verification.

References

- *Hirsch, C., Numerical Computation of Internal and External Flows, Vol. I & II, Wiley*

(1998).

- *Laney, C. B., Computational Gasdynamics, Cambridge Univ. Press (1998).*
- *LeVeque, R. J., Numerical Methods for Conservation Laws, 2nd ed., Birkhauser (2005).*
- *Hoffmann, K. A. and Chiang, S. T., Computational Fluid Dynamics for Engineers, Vol. I, II& III, Engineering Education Systems (2000).*
- *Toro, E. F., Riemann Solvers and Numerical Methods for Fluid Dynamics: A PracticalIntroduction, 3rd ed., Springer (2009).*
- *Blazek, J., Computational Fluid Dynamics: Principles and Applications, 2nd ed., Elsevier(2006).*
- *Roache, P. J., Fundamentals of Verification and Validation, Hermosa Publishers (2009).*

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NAVIGATION GUIDANCE AND CONTROL [3-0-0-3]

Syllabus

Principles of Inertial Navigation: Components, two-dimensional navigation – Coordinate systems – 3D strapdown navigation system – Strapdown system mechanizations – Attitude representation – Navigation equations expressed in component form – Effects of elliptic earth – Inertial Sensors: Gyroscope principles, single-axis rate gyroscope, accelerometers, rate integratinggyroscope – Elements of guidance system – Guidance phases – Guidance trajectories – Guidance sensors – Classification of Guidance and Navigation Systems: Basic navigation systems, combined navigation systems – Classification of guidance systems – Three-point tactical guidance laws – Two-point Tactical Guidance Laws: Strategic guidance laws, UAVs guidance laws

–Control systems-classical linear time invariant control systems – Transfer function representa tions – Stability – Time domain characteristics – PID controller design for aerospace systems – Frequency domain characteristics – Root locus – Nyquist and Bode plots and their applicationto controller design for aerospace systems.

References

- *Zarchan, P., Tactical and Strategic Missile Guidance, 4th ed., AIAA (2002).*
- *Siouris, G. M., Missile Guidance and Control Systems, AIAA (2004).*
- *Titterton, D. H. and Weston, J. L., Strapdown Inertial Navigation Technology, AIAA (2004).*
- *Rogers, R. M., Applied Mathematics in Integrated Navigation Systems, 2nd ed., AIAA(2003).*
- *Nise, N. S., Control Systems Engineering, Wiley India (2004).*
- *Friedland, B., Control System Design, Dover (2005).*

……

OPTIMAL CONTROL THEORY [3-0-0-3]

Syllabus

Problem formulation – Performance measures – Selection of performance measures – Dynam- ics programming – Optimal control law – Application to a routing problem – Recurrence relations

– Computational procedures – Alternative approach through Hamiltonial-Jacobi-Bellman equa- tion – Review of Calculus of Variations: Functionals involving several independent functions – Constrained minimization of functional – Optimal control: Variational approach – Necessary con-dition for optimal control – Pontryagin's minimum principle – Additional necessary conditions – Minimum time problems – Optimal control switches (bangbang control) – Numerical techniques for the solution of optimal control problem – Two point boundary value problem.

References

- *Kirk, D. E., Optimal Control Theory: An Introduction, Dover (1998).*
- *Bryson Jr., A. E. and Ho, Y.-C., Applied Optimal Control: Optimization, Estimation, andControl, Taylor & Francis (1975).*
- *Subchan, S. and Zbikowski, R., Computational Optimal Control: Tools and Practice, Wiley(2009).*
- *Naidu, D. S., Optimal Control Systems, CRC Press (2002).*

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MODERN AIRCRAFT CONTROL DESIGN [3-0-0-3]

Syllabus

Fundamentals of matrix algebra and vector spaces – Solution of simultaneous equations for square, under-determined, and over-determined systems – Concepts of basis vector transfor- mations – Similarity and adjoint transformations – Eigenvalues and eigenvectors – Jordan form

Characteristic equation – Analytic functions of square matrices and Cayley-Hamilton theorem

Concepts of state, state-space, state-vector – Methods for obtaining the system mathematicalmodel in the state-space form – State-space Form for Aerospace Systems: Aircraft dynamics, missile dynamics, inertial navigation system – Solution of homogeneous state equations – Concept of fundamental matrix and state transition matrix – Methods for evaluating state transition matrix – Solution of non-homogeneous equations – Phase variable and Jordan canonical forms

Controllability and observability of the systems, pole placement design with full state feedback

Introduction to optimal control.

References

- *Friedland, B., Control System Design: An Introduction to State-Space Methods, McGraw-*

- *Hill (1987).*
- *Dazzo, J. J. and Houpis, C. H., Linear Control System Analysis and Design: Conventionaland Modern, McGraw-Hill (1995).*
- *Etkin, B., Dynamics of Atmospheric Flight, Dover (2005).*
- *Pamadi, B. N., Performance, Stability, Dynamics, and Control of Airplanes , 2 nd ed., AIAA Edu. Series (2004).*
- *Aircraft Control and Simulation: Brian L Stevens, Frank L. Lewis, 2nd edition, Wiley India, 2010.*

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MODELING AND SIMULATION OF AEROSPACE VEHICLES [3-0-0-3]

Syllabus

Introduction: Simulation classification – Objectives, concepts, and types of models – Modeling: 6-DOF models for aerospace vehicle with prescribed control surface inputs – Control Systems: Mechanical (structural), Hydraulic systems and their modeling – Block diagram representation of systems – Dynamics of aerospace vehicles – Pilot station inputs – Cues for the Pilot: Visual, biological, and stick force – Virtual Simulation: Fly-by-wire system simulation – Uncertainty Modeling & Simulation: Characterization of uncertainty in model parameters and inputs, use ofsimulation to propagate the uncertainty to system response, Monte Carlo simulation – Simulation of stiff systems – Differential algebraic equations – Applications: Modeling and simulation methodologies for a complex engineering system simulation, aerospace system simulation – Model Building Techniques: Parameter identification, system identification – Least square estimation, maximum likelihood estimation, Kalman filters, neural networks.

References

- Ogata, K., *System Dynamics*, 4th ed., Pearson Education (2004).
- Doebelin, E. O., *System Dynamics: Modeling, Analysis, Simulation, Designs*, MarcelDekker (1998).
- Ljung, L., *System Identification: Theory for the User*, Prentice Hall (1987).
- Jategaonkar, R., V., *Flight Vehicle System Identification: A Time Domain Methodology*,AIAA Progress in Aeronautics and Astronautics, Vol. 216 (2006).
- Klein, V. and Morelli, E, A., *Aircraft System Identification: Theory and Practice*, AIAA Education Series (2006).
- Modeling and Simulation of Aerospace Vehicle Dynamics: Peter H. Zipfel, AIAA Education Series, (2007)

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ADVANCED FLUID MECHANICS [3-0-0-3]

Syllabus

Fluid kinematics -- physical conservation laws -- review of integral and differential formulations – continuity, momentum, and energy equations in differential form – special

cases of Navier-Stokes equations -- exact solution of incompressible Navier-Stokes equations; steady and unsteady flows – surface waves in fluids (potential flow formulation) -- boundary layer theory; Blasius solution, Falkner-Skan solutions, momentum integral approach -- introduction to turbulent flows.

Reference Books

- White, F. M., *Viscous Fluid Flow*, 3rd ed., McGraw Hill (2006).
- Panton, R. L., *Incompressible Flow*, 4th ed., John Wiley (2013).
- Kundu, P. K., Cohen, I. M., and Dowling, D. R., *Fluid Mechanics*, 6th ed., Academic Press (2015).
- Leal, L. G., *Advanced Transport Phenomena: Fluid Mechanics and Convective Transport Processes*, Cambridge Univ. Press (2007).
- Schlichting, H. and Gersten, K., *Boundary Layer Theory*, 8th ed., McGraw Hill (2001).

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COMPUTATIONAL FLUID DYNAMICS [3-0-0-3]

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 – consistency and stability analysis -- numerical solution of hyperbolic equations -- finite volume method -- Burgers equation – application of CFD: flow through a CD nozzle -- time integration schemes -- incompressible Navier-Stokes equations and their solution algorithms.

Textbook

- Hirsch, C., *Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics*, Vol. I, 2nd ed., Butterworth-Heinemann (2007).

Reference Books

- Hoffmann, K. A. and Chiang, S. T., *Computational Fluid Dynamics for Engineers*, 4th ed., Engineering Education Systems (2000).
- Tannehill, J. C., Anderson, D. A., and Pletcher, R. H., *Computational Fluid Mechanics and Heat Transfer*, 2nd ed., Taylor & Francis (1997).
- Anderson, J. D., *Computational Fluid Dynamics: The Basics with Applications*, McGraw Hill (1995).
- Patankar, S. V., *Numerical Heat Transfer and Fluid Flow*, Hemisphere (1980).
- Ferziger, J. H. and Peric, M., *Computational Methods for Fluid Dynamics*, 3rd ed., Springer (2002).

……

HEAT TRANSFER [3-0-0-3]

Introduction to heat transfer – steady state heat conduction – transient heat conduction – introduction to convective heat transfer – external forced convection – internal forced convection- natural/free convection – introduction to boiling and condensation – heat exchangers – blackbody radiation and radiative properties – radiative exchange between surfaces.

References

- *Bergman, T. L., Lavine, A. S., Incropera, F. P., and DeWitt, D. P., Fundamentals of Heat and Mass Transfer, 7th ed., John Wiley (2011).*
- *Holman, J. P., Heat Transfer, 10th ed., Tata McGraw-Hill (2010).*
- *Cengel, Y. A. and Ghajar, A. J., Heat and Mass Transfer: Fundamentals and Applications, 5th ed., Tata McGraw-Hill (2014).*

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CONDUCTION AND RADIATION [3-0-0-3]

Syllabus

Heat conduction governing equation, extended surface heat transfer, multi-dimensional steady and unsteady conduction, conduction in semi-infinite domain, concept of superposition integral, applications, solidification and melting, inverse heat conduction.
Laws of thermal radiation, radiation properties of surfaces, view factor for diffuse radiation, radiation exchange in black and diffuse gray enclosure, spectrally diffuse enclosure surfaces, specularly reflecting surfaces, Radiative transport equation in participating media, radiative properties of molecular gases, approximate solution methods for one dimensional media : Optically thick and optically thin approximations, gas radiation, combined conduction and radiation.

References

- Fundamentals of Heat and Mass transfer, Frank.P Incropera & David P. De Witt– John Wiley and Sons
- Heat conduction ,Third edition, Latif M.Jiji, Springer
- Heat conduction , David W. Hahn, M.Necati Ozisik, Wiley
- Radiative Heat Transfer, Michael F.Modest, Third edition, Academic Press
- Thermal Radiation Heat Transfer, John R Howell, M. Pinar Menuguc, Robert Siegel , CRC press.

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CONVECTIVE HEAT TRANSFER [3-0-0-3]

Syllabus

Introduction- transport properties for viscous, conducting fluids – kinematic properties – fundamental conservation equations; Navier-Stokes equations and energy equation– dimensionless parameters and scaling approaches to solve flow with heat transfer – solution of Newtonian viscous flows, boundary layer solutions – laminar shear layers

momentum, thermal –laminar heat transfer in ducts – incompressible turbulent mean flows – free convection flows –mass transfer coupled flows- convection with phase change – convection in porous media.

References

- Bejan, A., Convection Heat Transfer, Wiley, 3rd ed., Wiley (2004).
- Burmeister, L. C., Convective Heat Transfer, 2nd ed., Wiley (1993).
- Heat convection , Latif M.Jiji, Springer
- Convective heat and mass transfer, S. Mostafa Ghiaasian,Cambridge Univ Press

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VISCOUS FLOW [3-0-0-3]

Syllabus

Boundary Layer Theory, Falkner–Skan Similarity solution, Separation Criterion for Wedge Flow, Stagnation Point Flow, Laminar Mixing Layer, Plane Laminar Jet

low Reynolds number hydrodynamics, flow around, cylinder, creeping flow around spheres, Spherical harmonic solution

Temporal and Spatial Instability, Some Instability Mechanisms, waves and wave interactions, Method of solution by normal modes, Kelvin-Helmholtz, Centrifugal instability, Squire's theorem and Orr–Sommerfeld Equation, Inviscid instability of parallel flows.

Turbulence fluids, statistical description, Introduction to turbulence modelling, K-Epsilon transport equation, turbulent boundary layer, turbulent jets.

Gravity waves, potential flow solutions, analytical solution-sloshing in containers,

References

- Frank M White , Viscous Fluid Flow, Mc-Graw Hill, 2005
- Pijush K. Kundu, Ira M. Cohen, David R. Dowling , Fluid Mechanics, Academic Press, 2011
- Ronald Panton , Incompressible Flow, Wiley- India, 2006
- Peter S Bernard, Fluid Dynamics, Cambridge univ.Press, 2015
- Hermann Schlichting and Klaus Gersten, Boundary_layer theory, Springer, 2018
- Peter Davidson, Turbulence: An introduction to scientists and Engineers, Oxford univ.Press, 2015
- Tritton, D. J, Physical Fluid dynamics, Calendron press, 1988

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NANOSCALE AND MICROSCALE TRANSPORT PHENOMENON [3-0-0-3]

Syllabus

Introduction to microscale and nanoscale transport- basic phenomenon of conductive transport in nanoscale- basic aspects of quantum mechanics- basics of kinetic theory and statistical mechanics – thermodynamic relations– Boltzmann transport equation – microscale heat conduction– basics of electron and phonon transport – thermal

conductivity models – Equilibrium breakdown and characterisation of flow regimes in micro and nano scale – continuum approach – heat transfer in Poiseuille microflows – single phase convection in micro channels–rarefied gas flows– Slip models– Burnett and Grad equations – boiling and condensation in mini and micro channels – introduction to microscale and nanoscale radiative transport- heat transfer enhancement using nanoparticles.

References

- Chang-Lin Tien, Arunava Majumdar, Frank M Gerner., Microscale Energy Transport
- Zhang, Z. M., Nano/Microscale Heat Transfer, McGraw-Hill (2007).
- Van P. Carey , Statistical thermodynamics and microscale physics Cambridge Press
- Panigrahi, P. K., Transport Phenomena in Microfluidic Systems, Wiley (2015).
- Gang Chen Nanoscale Energy Transport and Conversion, Oxford
- Microscale Flow and Heat Transfer- *Mathematical Modeling and flow physics,* Amit Agrawal, Hari Mohan Kushawaha, Ravi Sudam Jadhav

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RADIATIVE HEAT TRANSFER [3-0-0-3]

Syllabus

Overview of thermal radiation, radiation properties of surfaces, view factor for diffuse radiation, radiation exchange in black and diffuse gray enclosure, spectrally diffuse enclosure surfaces, secularly reflecting surfaces, Monte Carlo ray tracing, Windows, Coatings, Introduction to satellite thermal control.

Radiative transport equation in participating media, approximate solution methods for one dimensional media: Optically thick and optically thin approximations. Formal solution and one-dimensional transfer. Moment methods: diffusion and spherical harmonics. Gas Radiation: Introduction to gas radiation, Plane parallel model, Diffusion approximation, radiative equilibrium, Optically thick limit, radiation spectroscopy, Isothermal gas emissivity, band models, total emissivity method, Isothermal gas enclosures.

Radiative transfer in absorbing, emitting, and scattering media. The discrete ordinates method: spatial and angular discretization, false scattering and ray effects, the finite volume method. Handling interaction with other modes, heat radiation at micro/nanoscales.

References

- Radiative Heat Transfer, Michael F.Modest, Fourth edition, Academic Press
- Thermal Radiative Transfer and Properties, M.Q. Brewster, Wiley
- Thermal Radiation Heat Transfer, John R Howell, M. Pinar Menuguc, Robert Siegel , CRC press.
- Radiative heat transfer: A Statistical approach, Robert Mahan,Wiley
- Spacecraft Thermal Control, J. Meseguer, I.Perez-Grande and A. Sanz-Andrez, Woodhead Publishing

TWO-PHASE FLOW AND HEAT TRANSFER- I [3-0-0-3]

Syllabus

Review of field equations in single phase flows and heat transfer– introduction to two-phase flows – basic averaging concepts- formulation and treatment of one-dimensional homogeneous flow model – separated flow model – drift flux model –predictive methodologies for flow pattern transition in adiabatic and diabatic flows –Liquid-Vapour Phase Change Phenomenon: pool boiling – wetting phenomenon – nucleation and bubble growth– bubble dynamics –convective boiling – heat transfer in partially and fully developed sub-cooled boiling – heat transfer in saturated boiling-Condensation- condensation in the presence of non-condensable gases- Choked two-phase flows.

References

- *J.G Collier & J.R Thome , Convective Boiling and Condensation, Oxford University Press, 1996*
- *Van P. Carey , Liquid-Vapour phase-change phenomenon-An introduction to the thermophysics of vapourisation and condensation process in heat transfer equipment, Taylor and Francis, 1992*
- *G. B Wallis , One-dimensional two-phase flow, Mc Graw Hill, 1969*
- *S Mostafa Ghiaasiaan, Two-phase flow boiling and condensation in Conventional and Miniature systems, Cambridge, 2014*

TWO-PHASE FLOW AND HEAT TRANSFER- II [3-0-0-3]

Syllabus

Generalised flow field equation in two-phase flows-Eulerian averaging-modelling perspectives– one dimensional two-fluid model- modelling annular flow, slug flow and bubbly flow- fluid dispersions- flows with particles of one phase in turbulent field of another phase- gas-particle flows in rocket nozzle, Compressible two-phase flows - 1d transient two-phase flow. Cavitation, Simple modelling of cavitating flows.

Interfacial waves-dynamic behaviour of interface- linear stability analysis- Kelvin-Helmholtz instability, Rayleigh-Taylor Instability- application to typical cases-linear stability analysis in 1D two phase flows and some typical situations -Introduction to waves in fluids-analytical solution of sloshing in tank-introduction to level set and volume of fluid methods. Introduction to Interface tracking problem solving using diffuse interface methods.

Introduction to liquefaction of gases-cryogenic two-phase flows- chilldown modelling. Liquid-Vapour phase change behaviour under reduced gravity conditions.

References

- M.Ishii & T.Hibiki , Thermo -Fluid dynamics of two-phase flows, Springer, 2006
- S Mostafa Ghiaasiaan, Two-phase flow boiling and condensation in Conventional and Miniature systems, Cambridge, 2014
- Nuclear sytems II –Elements of Thermal Hydraulic design, Neil E Todreas and Mujid

S Kazimi- Hemisphere Publishing corporation

- Amir Faghri and Yuwen Zhang, Fundamentals of multi-phase heat transfer and flow, Springer, 2020
- Jean Pierre and Jean Marie Michel, Fundamental of Cavitation, Kluwer Academic press, 2004
- N N Filina and J G Weisend II, Cryogenic two-phase flows: Application to large scale systems, Cambridge university press, 1996

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CRYOGENIC ENGINEERING [3-0-0-3]

Syllabus

Historical background and applications - Gas liquefaction systems - Gas separation and gas purification systems - Cryogenic refrigeration systems - Storage and handling of cryogens - Cryogenic insulations - Liquefied natural gas - Material of construction and techniques of fabrication - Instrumentation - Ultra low temperature techniques – Applications

Textbook

- Cryogenic Systems – Randall Barron; Publisher - Oxford University Press (1985)
- Cryogenic Engineering – Thomas Flynn; Publisher – CRC Press (2004)

References

- The Handbook of Cryogenic Engineering – *J.G. Weisend; Publisher* - Taylor & Francis
- Cryogenic Fundamentals – *G.G. Haselden; Publisher – Academic Press*
- Fundamentals of Cryogenic Engineering – *M. Mukhopadhyay; Publisher – PHI Learning*
- Cryogenic Engineering – *B. A. Hands; Publisher – Academic Press*

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PHYSIOLOGICAL FLUID MECHANICS [3-0-0-3]

Syllabus

Introduction to Physiological Fluid Mechanics; Review of Concepts in Fluid Mechanics; Clinical Fluid Dynamic Measurements; Analysis of Total Peripheral Flow; Circulatory Bio-fluid Mechanics, Blood Rheology, Blood Composition and Structure, Flow Properties of Blood, Blood Vessel Structure; Models of Biofluid Flow, Models of Blood Flow, Applications of Poiseuilli's Law for the study of Blood Flow; Introduction to Non-Newtonian Fluids, Power Law Model, Herschel-Bulkley Model, Casson Model, Non-Newtonian Flow in Elastic Tubes; Introduction to Heart Mechanics, Cardiac Geometry, Materials, and Electric System, Mechanical Cycle Events & Vent. Function Curve, Operation of Heart Valves, Blood Flow in Arteries, Shear Stress on Vessel Wall, Blood Vessel Bifurcation, Bifurcation Patterns, Uniform Shear Hypothesis.

References

- Mazumdar, J. Biofluid mechanics. World Scientific.(2015).
- Fung, Y. C. Biomechanics: circulation. Springer Science & Business Media. (2013).

- Ross C. E, and Craigg A. Simmons, Introductory Biomechanics, Cambridge texts in Biomedical Engineering, (2007).
- Kleinstreuer, C, Biofluid Dynamics: Principles and Applications, CRC Press, Taylor&Francis Group, (2006).
- Waite, L. Applied Biofluid Mechanics, McGraw Hill, (2007)
- Waite, L. Biofluid Mechanics in Cardiovascular Systems, McGraw-Hill , (2006).

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HEAT TRANSFER IN AEROSPACE APPLICATIONS [3-0-0-3]

Syllabus

Review of concepts in Heat Transfer, Governing Equations for Momentum, Mass, and Energy Transport; Ablation; Aerodynamic Heating: Heat Transfer at High Speeds; Low-Density Heat Transfer: Rarefied Gas Heat Transfer; Microchannel Applications; Aerospace Heat Exchangers, General Design Considerations for Aerospace Heat Exchangers; Heat Pipes for Aerospace Application; Microgravity Heat Transfer.

References

- Sundén, B., & Fu, J. (2016). Heat transfer in aerospace applications. Academic Press.
- Meseguer, J., Pérez-Grande, I., & Sanz-Andrés, A. (2012). Spacecraft thermal control. Elsevier.
- Gilmore, D. G. (Ed.). (2002). Spacecraft thermal control handbook: cryogenics (Vol. 2). Aiaa.
- Miao, J., Zhong, Q., Zhao, Q., & Zhao, X. (2021). Spacecraft thermal control technologies (p. 27). Singapore: Springer.

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INTRODUCTION TO HUMAN SPACE FLIGHT [3-0-0-3]

Syllabus

History of Human Spaceflight Spacecraft; Overview Space Environment; Life Support Requirements; Physiological Effects and Countermeasures; Operational Space Medicine; Spaceflight Analogs and Human Factors; Life Support Systems; Habitability and Crew Accommodations; Astronaut Selection and Training; Psychology of Spaceflight - Group Dynamics, Stress, and Coping Space Accidents and Anomalies Working in Space; Extra Vehicular Activity - Physiology and Space Suit Design.

References

- Harrison, A. A. (2002). *Spacefaring: The human dimension*. Univ of California Press.
- Chamitoff, G. E., & Vadali, S. R. (Eds.). (2021). *Human spaceflight operations: Lessons learned from 60 years in space*. American Institute of Aeronautics and Astronautics, Inc..
- Sgobba, T. (2017). *Space safety and human performance*. Butterworth-Heinemann.
- Hawkins, F. H., & Orlady, H. W. (2017). *Human factors in flight*. Routledge.

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SPACECRAFT THERMAL CONTROL [3-0-0-3]

Syllabus

Review of concepts in Heat Transfer, Governing Equations for Momentum, Mass, and Energy Transport; Spacecraft Subsystems & Interfaces; Spacecraft Thermal Environments, External – Orbit and Eclipse dependence, Internal; Thermal Design Techniques, Thermal Coupling (Heat Sinks) a) Mountings and Interfaces, Thermal Contact Resistance, Thermal isolation – Thermal standoff, Thermal Surface Finishes, Thermal Insulation, Phase-Change Materials, Radiators, Heaters, Louvers, Heat Pipes; Thermal Analysis; Thermal Design Examples; Thermal Testing.

References

- Gilmore, D. G. (Ed.). (2002). *Spacecraft thermal control handbook: cryogenics* (Vol. 2). AIAA.
- Karam, R. D. (1998). *Satellite thermal control for systems engineers* (Vol. 181). AIAA
- Miao, J., Zhong, Q., Zhao, Q., & Zhao, X. (2021). *Spacecraft thermal control technologies* (p. 27). Singapore: Springer.
- Donabedian, M. (2004). *Spacecraft thermal control handbook, I & II: AIAA*

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OPTICAL & LASER BASED COMBUSTION DIAGNOSTICS [3-0-0-3]

Syllabus

Role of Optical Diagnostic Techniques in Combustion Studies - Planar Imaging Systems (Lasers, Camera, Optics, Signal and Noise) - Optical Diagnostics (Shadowgraphy, Schlieren, Luminosity, Chemiluminescence) - Scattering Processes (Elastic, Inelastic) - Laser Diagnostics (Background Physics, Absorption, LIF, Rayleigh, Raman, CARS, LII, PIV, LDV, PDPA) - High speed Diagnostics - Simultaneous Diagnostics - Safety Procedures

Textbook

- Laser Diagnostics For Combustion Temperture and Species - Alan C. Eckbreth; Publisher - Taylor & Francis
- Spectroscopy and Optical Diagnostics for Gases - Ronald K. Hanson, Spearrin & Goldenstein; Publisher - Springer
- Physical Chemistry - Atkins; Publisher - Oxford University Press
- Optical Measurements: Techniques and Applications – Franz Mayinger & Oliver Feldmann (Eds.) - Springer

References

- Applied Combustion Diagnostics - Kohse-Hoinghaus & Jeffries; Publisher - Taylor & Francis
- Particle Image Velocimetry - Raffel, Willert, Wereley & Kompenhans; Publisher – Springer
- Optical Diagnostics for Reacting and Non-Reacting Flows: Theory and Practice - Adam Steinberg and Sukesh Roy

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DESIGN AND MODELING OF ROCKET PROPULSION SYSTEM [3-0-0-3]

Syllabus

Overall and optimized rocket performance- ideal velocity gain, gravitational losses, optimal mass ratio for multistage rockets, trajectory analysis, vertical flight of staged rocket, thrust programming along the path -elements of rocket propulsion- nozzle design, characteristic parameters,– aerothermochemistry of combustion, dissociation, equilibrium composition, adiabatic temperature, and combustion product equilibrium flow nozzle expansion- elements of solid propellant system- internal ballistics and design of solid propellant - grain design and optimization- elements of liquid propulsion system- design and selection of Injectors, combustion chambers, nozzle, cooling system, feed systems and tanks- hybrid propulsion system-combustion instability, low and high frequency instability

Text Book/ References

- *Rocket Propulsion*, Barrere, M., Jaumotte A., De Veubeke, B., F., Vandenkerckchove, J., Elsevier Publishing Company (1960)
- *Rocket Propulsion, 4th edition,* K Ramamurthi, Universal Science Press (2023)
- *Modern Engineering for Design of Liquid-Propellant Rocket Engines,* Huzel, D.K., Huang, D. H., Prog. in Astronautics and Aeronautics, Vol. 147 (1992)
- *4)) Rocket Propulsion Elements*, Sutton & Biblarz, 7th Edition Wiley (2001)
- *Mechanics and Thermodynamics of Propulsion*, 2nd Edition, Hill & Peterson, Pearson (1992)
- Howard D.Curtis 'Orbital Mechanics for Engineering Students', ELSEVIER

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MULTI RIGID BODY DYNAMICS [3-0-0-3]

Syllabus

Coordinate systems, vectors and tensors; Dynamics of a system of particles; 3D rotations, Euler angles, and 3D angular velocity; Kinematics of rigid bodies; Constraints: holonomic and non-holonomic constraints; General 3D rigid body dynamics, including the gyroscope; Advanced examples including numerical solution of initial value problems; Steady mass flow and variable mass problems;

Analytical mechanics: Degrees of freedom, generalized coordinates, virtual work, Hamilton's principle, Lagrange's equations. Lagrange's equations for a finite-dimensional non-conservative mechanical system.

Textbook

- Engineering Mechanics: Dynamics by J.L. Meriam and L.G. Kraige

References

- Engineering Mechanics - Dynamics by R.C. Hibbeler
- Principles of Dynamics by D.T. Greenwood
- Principles of Engineering Mechanics vol. 1 and 2 by M.F. Beatty

- Engineering Dynamics by J. Ginsberg
- Dynamics of Particles and Rigid Bodies by A.V. Rao
- Intermediate Dynamics by A. Chatterjee (https://home.iitk.ac.in/~anindya/bk123.pdf)

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ENGINEERING VIBRATION [3-0-0-3]

Syllabus

Introduction to vibration – single degree of freedom systems: free, undamped, damped and forced vibrations – two degree of freedom system: principal modes of vibration, undamped vibration, forced vibration, forced damped vibrations _ Vibration isolation – multi-degree of freedom systems: eigenvalue problem – orthogonality of mode shapes, modal analysis for free, damped and forced vibration systems – approximate methods for fundamental frequency – introduction to transient vibrations and nonlinear vibrations.

Textbook

- Rao, S. S., Mechanical Vibrations, 4th ed, Pearson Education, 2004

References

- Thomson, W. T. and Daleh, M. D., Theory of Vibration with Applications, 5th ed., Prentice Hall (1997).
- Rao, J. S. and Gupta, K., Introductory Course on Theory and Practice of Mechanical Vibrations, 2nd ed., New Age International (1999).
- Meirovitch, L., Elements of Vibration Analysis, 2nd ed., McGraw-Hill (1986).
- Seto,W.W., Schaum's Outline of Theory and Problems of Mechanical Vibrations, McGraw- Hill (1964).

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NON-LINEAR OSCILLATION [3-0-0-3]

Syllabus

Introduction to concept of trajectories, phase space, singular points and limit cycle; Linear stability analysis and introduction to bifurcations; Analytical methods including perturbation techniques, and heuristic approaches like harmonic balance and equivalent linearization; Stability of periodic solutions: Floquet's theory, Hill's and Mathieu's equations; Nonlinear free and forced responses of the Duffing's and van der Pol equation; Introduction to chaos and Lyapunov exponents.

Text Books/ References

- Nonlinear Dynamics and Chaos. Steven H. Strogatz, Westview Press.
- Nonlinear Ordinary Differential Equations. D. W. Jordan and P. Smith, Oxford University Press.
- Lecture notes on Nonlinear Vibrations. Richard Rand, available online

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FINITE ELEMENT METHOD [3-0-0-3]

Syllabus

Introduction and History of FEM- Spring systems, Truss and Boundary conditions-Finite Element Formulation starting from GDE-Finite Element Formulation starting from stationarity of a functional-One dimensional FE analysis-Two Dimensional FE analysis-Introduction to Dynamic Analysis- Research & industrial applications.

Text Book

- Seshu.P., Textbook of Finite Element Analysis, Prentice Hall of India (2009).

References

- Ferreira, A.J.M. and Fantuzzi, N., MATLAB Codes for Finite Element Analysis. Solid Mechanics and Its Applications, vol 157., Springer (2020).
- Hutton DV., Fundamentals of finite element analysis , McGrawhill Education (India) (2017)
- Belytschko T. and Fish J., A First Course in Finite Elements, Wiley (2007).
- Cook, R. D.; Malkus, D. S.; Plesha, M. E. & Witt, R. J. , Concepts and Applications of Finite Element Analysis, 4th Edition, Wiley (2003).
- Chandrupatla, T. R. and Belegundu, A. D., Finite Elements in Engineering, 2nd edition., Prentice Hall of India (2000).

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ADVANCED AEROSPACE STRUCTURES [3-0-0-3]

Syllabus

Description of essential features of aircraft, rocket and spacecraft structures – type of loads on flight structures –Bending & buckling of plates - monocoque, stiffened plate, isogrid, honey comb and sandwich constructions – idealization and stress analysis of typical aerospace structural components – pressurized structures – stress discontinuities – effects of cut-outs – effects of boundary conditions in open and closed section beams – structural fatigue.

Text Book

- Megson, T. H. G., Aircraft Structures for Engineering Students, 4th ed., Butterworth-Heinemann (2007).

References

- Sun, C.T., Mechanics of Aircraft Structures, John Wiley and Sons, New York, (2006).
- Ventsel, E., Krauthammer, T., Thin Plates and Shells: Theory: Analysis, and Applications, 1st ed., CRC Press (2001).
- Bruhn, E. F., Analysis and Design of Flight Vehicle Structures, 2nd ed., Jacobs Publishing Inc. (1973).

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FRACTURE MECHANICS [3-0-0-3]

Syllabus

Introduction and history of fracture mechanics – linear elastic fracture mechanics; energy release rate, stress intensity factor (SIF), relation between SIF and energy release rate, anelastic deformation at the crack tip – crack growth and fracture mechanisms – elastic-plastic analysis through J-integral – finite element analysis of cracks – fracture toughness testing – fatigue failure.

Text Book

- Kumar, P., Elements of Fracture Mechanics, Tata McGraw-Hill (2009).

References

- Anderson, T. L., Fracture Mechanics: Fundamentals and Applications, 3rd ed., CRC Press (2004).
- Broek, D., Elementary Engineering Fracture Mechanics, 4th ed., Kluwer Academic (1986).

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DESIGN OF AEROSPACE STRUCTURES [3-0-0-3]

Syllabus

Design considerations – codes and standards – aerospace materials and their properties – selection of materials – failure theories – design criteria – strength, stiffness, fatigue, damage tolerance – fail safe and safe life designs – design aspects typical aerospace structural constructions: monocoque, stiffened plate, isogrid, sandwich and laminated composites – weight control – design of pressurized systems – configuration, design calculations and checks applied to typical aerospace structures – structural connections and joints – fasteners.

Text Books

- Bruhn, E. F., Analysis and Design of Flight Vehicle Structures, 2nd ed., Jacobs Publishing Inc. (1973).
- Shigley, J. E., Mischke, C., and Budynas, R., Mechanical Engineering Design, 7th ed., McGraw-Hill (2003).

Reference Book

- Niu, M. C.Y., Airframe Structural Design, 2nd ed., Hongkong Conmilit Press Ltd. (2002).
- Harvey, J. F., Theory and Design of Modern Pressure Vessels, 2nd ed., Van Nostrand (1974).

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MOLECULAR DYNAMICS AND MATERIALS FAILURE [3-0-0-3]

Syllabus

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

Text Book

- Buehler, M. J., Atomistic Modeling of Materials Failure, Springer (2008).

Reference Books

- Frenkel, D. and Smit, B., Understanding Molecular Simulation: From Algorithms to Applications, 2nd ed., Academic Press (2001).
- Rapaport, D. C., The Art of Molecular Dynamics Simulation, 2nd ed., Cambridge Univ. Press (2004).

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ADVANCED FINITE ELEMENT METHOD [3-0-0-3]

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

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

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STRUCTURAL DYNAMICS [3-0-0-3]

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

- Meirovitch, L., Elements of Vibration Analysis, 2nd ed., McGraw-Hill (1986).
- Paz, M., Structural Dynamics: Theory and Computation, 2nd ed., CBS Publishers & Distributors (2004).
- Weaver Jr., W., Timoshenko, S. P., and Young, D. H., Vibration Problems in Engineering, 5th ed., John Wiley (1990).
- Meirovitch, L., Computational Methods in Structural Dynamics, Sijthoff & Noordhoff (1980).
- Cough, R. W. and Penzien, J., Dynamics of Structure, 2nd ed., McGraw-Hill (1993)

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ROBOT MECHANISMS AND TECHNOLOGY [3-0-0-3]

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).

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ANALYSIS AND SYNTHESIS OF MECHANISMS [3-0-0-3]

Syllabus

Introduction to mechanisms: kinematic pair, kinematic chain, inversion, transmission angle, etc.

Kinematic analysis of mechanisms: displacement, velocity and acceleration analysis

Kinematic synthesis: type, number and dimensional synthesis using graphical and analytical methods. –

Coupler curve synthesis and cognate linkage., Synthesis of spatial linkages

References

1. Kinematic Synthesis of Linkages - Richard S. Hartenberg, J. Danavit
2. Arthur G. Erdman, George N. Sandor, and Sridhar Kota, Mechanism Design: Analysis and Synthesis, Prentice Hall, 2001

3. George N. Sandor, Arthur G. Erdman, Advanced Mechanism Design - Analysis and Synthesis Vol.2, Prentice Hall.

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ROTOR DYNAMICS

Syllabus

Introduction to dynamics of rotating machinery, Critical speeds of rotors, rigid and flexible rotors, Lateral and Torsional vibration analysis, Steady state and transient response. Effects of gyroscopic action, internal damping, unequal moments of inertia of shaft section, bearing elasticity and oil film cushioning. Stability of rotors. Transformations and concept of Euler angles, Transfer matrix method for analysis of rotor systems, Finite element modelling of multi-spool rotors.

Textbook

1. John M Vance, 1988, Rotordynamics of Turbomachinery, John Wiley & Sons, NY

References

1. Dara Childs, 1993, Turbomachinery-Rotordynamics-Phenomena-Modeling-Analysis, John Wiley & Sons, NY
2. S. Sekhar and B. S. Prabhu, 2008, Dynamic Analysis of Rotating Systems and Applications, Multi Science Publishing Co Ltd

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STRUCTURAL ACOUSTICS AND NOISE CONTROL [3-0-0-3]

Syllabus

Basic acoustic principles – acoustic terminology and definitions – plane and spherical wave propagation – theories of monopole, dipole and quadrapole sound sources – sound transmission and absorption – sound transmission through ducts – structure borne sound – sound radiation and structural response – introduction to noise control.

References

1. Munjal, M. L., Noise and Vibration Control, World Scientific Press (2013).
2. Williams, E. G., Fourier Acoustics: Sound Radiation and Nearfield Acoustic Holography, Academic Press (1999).
3. Kinsler, L. E., Frey, A. R., Coppens, A. B., and Sanders, J. V., Fundamentals of Acoustics, 4th ed., Wiley (2000).

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EXPERIMENTAL MODAL ANALYSIS [2-0-3-3]

Syllabus

Review of vibration, Vibrations of single and multiple degree of freedom (SDOF, MDOF) systems, Damping, Orthogonality of modes, Revision of Fourier analysis and Fourier transforms, Excitation of structures (electromagnetic and electrohydraulic shakers, hammers, etc.), Transducers and amplifiers for measurements (force transducer, accelerometers, laser vibrometers, signal conditioners, amplifiers etc.) and its placements.

Revision of Fourier analysis and Fourier transforms, Discussions on aliasing, leakage, windowing, filtering and averaging. Preliminary checks of FRF data (spectrum, coherence, asymptotic behavior, assessment using singular value decomposition (SVD)), Mode indicator functions, SDOF modal analysis methods (peak-picking, circle-fit), Treatment of residuals, MDOF modal analysis in the frequency domain (least square methods, rational fraction polynomial methods), Extraction of natural frequencies, damping ratios and shapes. Modal assurance criteria.

References

1. Ewins, D. J., Modal testing: theory, practice and application, 2nd Ed., Wiley-Blackwell (2000).
2. Maia, N. M. M. and Silva, J. M. M., Theoretical and experimental modal analysis, Research Studies Press (1997).

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RANDOM VIBRATIONS and APPLICATIONS [3-0-0-3]

Syllabus

Introduction, Fundamentals of probability theory: probability space, random variables, functions of random variables, Stochastic processes and random signals: stationarity, ergodicity, power spectrum, covariance functions, calculus of random processes, Linear single and multi degree of freedom structural systems: input-output relations, time domain and frequency domain analysis, linear and nonlinear systems, Computational issues, Level crossing and first passage times, extreme value and peak distributions, Applications: random fatigue, probabilistic crack growth, risk analysis

References

1. N.C. Nigam, Introduction to random vibrations, MIT Press (1983).
2. N.C. Nigam and S. Narayanan, Applications of random vibrations, Springer (1994).
3. A. Papoulis Probability, random variables and stochastic processes, McGraw-Hill (1997).
4. J. Solnes, Stochastic processes and random vibrations: Theory and practices, John Wiley & Sons (1997).

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DESIGN OF AEROSPACE MECHANISMS [0-0-0-3]

Syllabus

Introduction to Aerospace Mechanisms – Elements of Mechanisms – Actuators and Release Devices – Standards and Design Guidelines – System Requirements to Design Specifications – Definition of Interfaces and Loads – Selection of Materials – System Design and Sizing – Tolerance Stack Up Analysis – Assembly/ Integration Requirements and Procedures – Joints Preloading – Thermal and Radiation Control – Redundancy concepts – Reliability assessment – Verification by Analysis – Verification by Development and Qualification Tests – Safety Critical Mechanisms – Integrated design cases for Launch Vehicle & Satellite applications.

References

- Peter L. Conley, Space Vehicle Mechanisms Elements of Successful Design, John wiley & sons, Inc.

- Moving Mechanical Assemblies for Space & Launch Vehicles, AIAAS-114A-2020 or MIL A 83577 B.
- Joseph E. Shigley & Charles R. Mishke , Mechanical Engineering Design, McGraw-Hill
- Design and Development Requirements for Mechanism, NASA-STD-5017 B
- B.N Suresh & K. Sivan, Integrated Design for Space Transportation System, Springer
- Space Vehicle Mechanisms, Naval Research Laboratory Washington, DC 20375-5000

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SMART MATERIALS AND STRUCTURES [3-0-0-3]

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

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

References

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

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AEROSPACE MATERIALS AND PROCESSES [3-0-0-3]

Syllabus

Properties of materials – Strength, Hardness, Fatigue and Creep, Brief history on evolution of aerospace materials, Materials and material requirements for aerospace structures & engines and Rockets, Testing and Certification of aerospace materials, Requirements for aerospace industry, Special Processes, NDT and structural health monitoring, Space Environment and its effect of spacecraft – materials Approach, Case studies on aircraft failures.

Aluminum alloys –Alloy Designation and tempers, Al-Cu alloys, Principles of age hardening, Hardening mechanisms, Al-Li alloys, Processing of aluminium alloys, Titanium alloys- □ - □ alloys, Superplasticity, Magnesium alloys, Superalloys- Processing and properties of superalloys, Environmental degradation and protective coatings, Composites –Polymer based composites, Carbon Carbon composites. Ferrous alloys – Stainless steels, Maraging steels.

Text book

- Adrian P Mouritz, Introduction to Aerospace Materials, Woodhead publishing (2012)
- F C Campbell, Manufacturing Technology for Aerospace Structural Materials. Elsevier publications (2006)

Reference books

- B Cantor, Hazel Assender and Patrick Grant, Aerospace Materials. Institute of Physics Publishing, (2001)

- ASM Speciality Handbook, Heat Resistant Materials ASM (1997)
- I.J Polmear, David Stjohn, Jian-feng Nie, Ma Qian, Light Alloys: Metallurgy of the Light Metals, Butterworth-Heinemann Ltd, 5th edition (2016)
- Roger C. Reed, The Superalloys- Fundamentals and Applications. Cambridge University Press (2008)
- Eshwara Prasad and R. J. H. Wanhill, Aerospace Materials and Material Technologies, Vol I and II, Springer (2018)

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MECHANICAL BEHAVIOUR OF MATERIALS [3-0-0-3]

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

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

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THERMODYNAMICS AND PHASE TRANSFORMATIONS IN MATERIALS [3-0-0-3]

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

- 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).

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HEAT TREATMENT TECHNIQUES [3-0-0-3]

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

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

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SOLIDIFICATION PROCESSING [3-0-0-3]

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

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

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ADVANCED ENGINEERING MATERIALS [3-0-0-3]

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 - □, □, □ - □ 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

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

Reference books

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

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MATERIALS CHARACTERIZATION TECHNIQUES [3-0-0-3]

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

- Characterization of Materials by Elton N. Kaufmann, Wiley & Sons.
- David Brandon, Wayne D. Kaplan, Microstructural Characterization of Materials, Wiley,

2008

- B.D. Cullity, Elements of X-Ray Diffraction
- David B. Williams and C. Barry Carter, Transmission Electron Microscopy: A Textbook for Materials Science, springer, 2009
- 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
- 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)

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PLASTICITY AND ADVANCED DEFORMATION PROCESSES [2-1-0-3]

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 book

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

Reference books

- Andrzej Sluzalec, Theory of Metal Forming Plasticity: Classical and Advanced Topics, Springer, (2004)
- Sadhu Singh, Theory of Plasticity and Metal Forming Processes, Khanna Publishers (2003)
- 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)
- Taylor Altan and Erman Tekkaya, Sheet metal forming fundamentals, ASM international (2012)
- Taylor Altan and Erman Tekkaya, Sheet metal forming processes and applications, ASM international (2012).

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COMPOSITE MANUFACTURING TECHNOLOGY [3-0-0-3]

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 / Macromechanics of composites, Mechanisms of failure, Testing and characterization, 3D printing and other recent advances in composite technology, Composites for space & defence applications.

Text book

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

Reference books

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

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ADVANCED WELDING TECHNOLOGY [3-0-0-3]

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

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

Reference books

- Cary, Howard, Modern Welding Technology, prentice Hall (1993)

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

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SUBTRACTIVE AND COMPUTER AIDED MANUFACTURING [3-0-0-3]

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

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

References

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

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ADDITIVE MANUFACTURING AND SMART PRACTICES [3-0-0-3]

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

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

References

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

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ADVANCED MACHINING PROCESSES [3-0-0-3]

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

Text Books/ References

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

- Recent research articles in Advanced Machining and Finishing Technologies

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DESIGN FOR MANUFACTURING [3-0-0-3]

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.

Text Books/ References

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

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DIGITAL MANUFACTURING AND AUTOMATION [3-0-0-3]

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.

Text Books/ References

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

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METROLOGY AND COMPUTER AIDED INSPECTION [3-0-0-3]

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- MachineTool 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.

Text Books/ References

- Graham T. Smith, Machine Tool Metrology: An Industrial Handbook, Springer (2016)
- Graham T. Smith, Industrial Metrology: Surfaces and Roundness, Springer (2010).
- Raghavendra, Krishnamurthy, Engineering Metrology And Measurements, Oxford
- University press (2013)
- Alex Hebra, The Physics of Metrology: All about Instruments: From Trundle Wheels to Atomic Clocks, Springer (2009)
- Semyon G. Rabinovich, Measurement Errors and Uncertainties: Theory and Practice, Springer (2010)
- Abdulrahman Al-Ahmari, Emad Abouel Nasr, Osama Abdulhameed, Computer-Aided Inspection Planning: Theory and Practice, CRC Press (2016)
- James Meadows, Geometric Dimensioning and Tolerancing-Applications, Analysis,

Gauging & Measurement, Manetti Shrem Museum (2020)
- Chee Kai Chua, Chee How Wong and Wai Yee Yeong, Standards, Quality Control, and Measurement Sciences in 3D Printing and Additive Manufacturing, Elsevier (2017)
- Anand K. Bewoor, V. Kulkarni, Metrology and Measurement, McGraw Hill Education (2017)
- 10.Richard Leach, Fundamental Principles of Engineering NanoMetrology, William Andrew (2014)

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MICRO/ NANO MACHINING [3-0-0-3]

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

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

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NON-TRADITIONAL MACHINING [3-0-0-3]

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

- ASM Handbook Volume 16: Machining
- Helmi Youssef, Hassan El-Hofy, Non-Traditional and Advanced Machining Technologies, CRC Press (2020).
- Hassan El-Hofy, Advanced Machining Processes: Non-traditional and Hybrid Machining Processes, McGraw-Hill Professional (2005).

- Carl Sommer, Non Traditional Machining Handbook, Advanced Publishing (2009).
- Recent research articles in Non-Traditional Machining

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MULTIDISCIPLINARY DESIGN OPTIMIZATION [3-0-0-3]

Syllabus

Need and importance – Review of gradient and non-gradient algorithms - Sensitivity analysis – AD (forward and reverse mode) – Complex variable and hyperdual numbers – Gradient and Hessian - Surrogate modelling – Design of experiments - Multi-objective optimisation - Uncertainty quantification – Moment methods – PDF and CDF – Uncertainty propagation – Monte Carlo methods – Robust design and reliability based design optimisation formulations - Coupled systems - MDO architectures

Textbook

- J. R. R. A. Martins, and A. Ning, "Engineering Design Optimization", Cambridge University Press, 2021.

Reference Books

- Jasbir S. Arora, "Introduction to Optimum Design", 4th edition, Academic Press Inc., 2016.
- Kalyanmoy Deb, "Optimization for Engineering Design", 2nd edition, PHI Learning Ltd, 2012.
- Ranjan Ganguli, "Engineering Optimization: A Modern Approach", 1st edition, CRC Press, 2012.
- Nocedal J. and Wright S., "Numerical Optimization", 2nd edition, Springer, 2006.
- Garret N. Vanderplaats, "Numerical Optimization techniques for engineering design", 1st edition, McGraw-Hill Education, 1984.
- Xin-She Yang, Xing-Shi He, "Mathematical Foundations of Nature-inspired Algorithms", 1st edition, Springer, 2019.
- Kaisa Miettinen, "Nonlinear Multiobjective Optimisation", 1st edition, Springer, 1998.
- Kalyanmoy Deb, "Multi-Objective Optimization using Evolutionary Algorithms", 1st edition, John Wiley & Sons Inc., 2001.
- Alexander Forrester, Andras Sobester, Andy Keane, "Engineering Design via Surrogate Modelling: A Practical Guide", 1st edition, John Wiley & Sons Inc., 2008.
- Khuri A. I. and Cornell J. A., "Response Surfaces: Design and Analyses", 2nd edition, Marcel Dekker, 1996.
- Montgomery, D. C., "Design and Analysis of Experiments", 8th edition, John Wiley & Sons Inc., 2012.
- Robert B. Gramacy, "Surrogates: Gaussian Process Modeling, Design, and Optimization for the Applied Sciences", 1st edition, CRC Press, 2020.
- Griewank A. and Walther A., "Evaluating Derivatives: Principles and Techniques of Algorithmic Differentiation", 2nd edition, SIAM, 2008.
- M. J. Kochenderfer and T. A. Wheeler, "Algorithms for Optimization", 1st edition, The MIT Press, 2019.

- Keane, A. J. and Nair, P. B., "Computational Approaches for Aerospace Design: The Pursuit of Excellence", Wiley (2005).

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OPERATIONS RESEARCH [3-0-0-3]

Syllabus

Introduction – formulation of operations management, logistics and supply chain management problems – linear programming – duality and sensitivity – transportation and assignment problems – goal programming – integer programming – network optimization models – dynamic programming – theory of games - queuing theory – simulation – non-traditional optimization techniques.

References

- Taha, H. A., Operations Research: An Introduction, Pearson, 9th edition, 2010.
- Ravindran, A., Philips, D.T. and Solberg, J.J., Operations Research: principles and practice, Wiley India, 2nd edition, 2006.
- Winston, W.L., Operations Research: Applications and Algorithms, Cengage Learning, 4th edition, 2010.
- Sharma, J.K., Operations Research: Theory and Applications, Macmillan Publishers, 4th edition, 2009.

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QUALITY ENGINEERING [3-0-0-3]

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

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

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ADVANCED OPERATIONS RESEARCH [3-0-0-3]

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

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

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TOTAL QUALITY MANAGEMENT [3-0-0-3]

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

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

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MANUFACTURING PLANNING AND CONTROL [3-0-0-3]

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

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

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AIR TRAFFIC MANAGEMENT [3-0-0-3]

Syllabus

Introduction to air traffic control – navigation systems – airspace classification and classes – air traffic control communication procedures and phraseology – air traffic control organization: delegation of responsibilities in air traffic control tower and air route traffic control centre – control tower procedures – theory of radar operations – non-radar en-route and terminal separation - radar separation – oceanic and international air traffic control – role of ICAO – air traffic management: decision supports systems for operations in en-route and terminal areas of airports, airport surface operations - models and solution methods.

References

- Michael S. Nolan, Fundamentals of air traffic control, Cengage Learning, 5th edition, 2014.
- Andrew Cook, European air traffic management: principles, practice and research, Routledge, 2007.
- N. Durand, D. Gianazza, J-B Gotteland, J-M Alliot, Metaheuristics for air traffic management, Wiley, 2015.
- Federal Aviation Administration, Air traffic control, Order JO 7110.65W, 2015.

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HUMAN BEHAVIOUR IN ORGANIZATIONS [3-0-0-3]

Syllabus

Introduction – foundations of individual behaviour and processes: personality, perception, workplace values, attitudes and emotions, learning, employee motivation, stress management – Group processes: foundations of group behaviour, understanding work teams,

communication, decision making and employee involvement, leadership, power and politics, conflict and negotiation – Organizational processes: organization structure and design, organization culture, organizational change and development – case studies.

Textbook

- Stephen P. Robbins and Timothy A. Judge, Organizational behavior, Pearson eduction, 16th edition, 2015.
- References:
- Jerald Greenberg and Robert A. Barron, Behaviour in organizations, Prentice Hall, 10th edition, 2010.
- Steven Mc Shane and Mary Von Glinov, Organizational behavior, Mc Graw Hill, 7th edition, 2014.
- John W. Newstrom and Keith Davis, Organizational behaviour, Tata Mc Graw Hill, 11th edition, 2002.

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INTRODUCTION TO SPACE LAWS [3-0-0-3]

Syllabus

Introduction to International Law: Concepts of jurisprudence and public international law
Introduction to Space Law: Background and history of space law, UNCOPUOS and its Sub-Committees and Treaty formulation, Definition and Delimitation outer space, Draft space activities bill
Sources of Space law: UN Treaties on outer space (Five treaties), UN Principles, UN GA Resolutions, IADC on space debris management,
Legal aspects of space activities: State Responsibility for space activities, Debris mitigation – Compliance to ISRO Policy on Space Debris management and UN Debris Mitigation guidelines
Legal and Policy aspects of space applications, Legal issues in satellite based services
Space law relating to Commercial space activities: Launch services – Third party Liability, Dispute settlement mechanisms – Arbitration, case laws and regulations in India
Space Law regulation and policy in India, History of Space Sector in India, ISRO,
Space Commission of India and the Department of Space (DOS), Remote Sensing Data Policy (RSDP), National Frequency Allocation Plan (NFAP)
Legal issues in emerging trends of space activities: Human space flight activities, Space tourism, Intellectual Property Rights in space activities

Text book

- FranciS LyaLL and Paul B. LarSen, ‘Space Law – A treatise’, Ashgate publishing Limited, England (2009)
- H. Ph. Uiederiks-Verschoor, V. Kopal, ‘An introduction to space law’ Kluwer Law International (2008)

References

- Frans von der Dunk, Fabio Tronchetti, ‘Handbook of space law’, Edward Elgar

Publishing Limited, (2015)
- R. Venkata Rao V. Gopalkrishnan, Kumar Abhijeet, 'Recent Developments in Space Law - Opportunities & Challenges', Springer (2019)
- Rahul Jairam Nikam, Tanja Masson Zwaan, V.Balakista Reddy, 'Space Activities and IPR Protection, Asia Law House (2013)
- Jenks, C W, Space law, Stevens and Sons (1965).
- Lee, Ricky J, Law and regulation of commercial mining of minerals in outer space, Springer (2012)
- V.S Mani, S.Bhatt, V.Balakista Reddy, 'Recent trends in international space law and policy' Asia Law house, 2016

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SENSORS AND ACTUATORS [3-0-0-3]

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

- M.H. Bao , Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes Elsevier, New York, 2000
- 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.
- William Trimmer, Micromechanics and MEMS: Classic and Seminal Papers to 1990, IEEE Press, IEEE Number PC4390, ISBN 0-7803-1085-3, New York.
- G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, and V. K. Aatre, Micro and Smart Systems, Wiley-India, 2010.

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FOUNDATIONS OF MACHINE LEARNING [3-0-0-3]

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

- *Mohri, M., Rostamizadedh, A., and Talwalkar, A., Foundations of Machine Learning, The MIT Press (2012).*
- *Jordon, M. I. and Mitchell, T. M., Machine Learning: Trends, perspectives, and prospects, Vol. 349, Issue 6245, pp. 255-260, Science 2015.*
- *Shawe-Taylor, J. and Cristianini, N., Kernel Methods for Pattern Analysis, Cambridge Univ. Press (2004).*
- *Haykin, S., Neural Networks: A Comprehensive Foundation, 2nd ed., Prentice Hall (1998).*
- *Hassoun, M. H., Fundamentals of Artificial Neural Networks, PHI Learning (2010).*
- *Ripley, B. D., Pattern Recognition and Neural Networks, Cambridge Univ. Press (2008).*
- *Sutton R. S. and Barto, A. G., Reinforcement Learning: An Introduction, The MIT Press (2017).*

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INTERNET OF THINGS [3-0-0-3]

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

- Soldatos, John –Editor, Building blocks for IoT analytics internet-of-things analytics, River publishers, 2017.

- Perry Lea, Internet of Things for Architects: Architecting IoT solutions by implementing, Packt Publishing Limited, 2018.
- Raj Kamal, Internet of Things, McGraw Hill Education, 2017

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DATA MINING [3-0-0-3]

Syllabus

Introduction to data mining concepts; linear methods for regression; classification methods: k-nearest neighbourclassifiers, 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, datawarehousing.

References

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

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COMPUTER VISION [3-0-0-3]

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.

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

References

- Simon Prince, Computer Vision: Models, Learning, and Interface, Cambridge University Press
- Mubarak Shah, Fundamentals of Computer Vision
- Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010
- Forsyth and Ponce, Computer Vision: A Modern Approach, Prentice-Hall, 2002
- Palmer, Vision Science, MIT Press, 1999,

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

Programming: Python will be the main programming environment for the assignments. The following book (Python programming samples for computer vision tasks) is freely available. Python for Computer Vision. For mini-projects, a Processing programming language can be used too (strongly encouraged for android application development)

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