DEPARTMENT OF INSTRUMENTATION AND CONTROL ENGINEERING, MIT Manipal

M.Tech. AEROSPACE ENGINEERING

Program Structure (Applicable to 2019 admission onwards)

YEAR	FIRST SEMESTER						SECOND SEMESTER					
	SUB CODE	**SUBJECT NAME**	**L**	**T**	**P**	**C**	**SUB CODE**	**SUBJECT NAME**	**L**	**T**	**P**	**C**
I	MAT 5156	APPLIED LINEAR ALGEBRA AND PROBABILITY	4	0	0	4	ICE 5271	FLIGHT MECHANICS	4	0	0	4
	HUM 5151	RESEARCH METHODOLOGY AND TECHNICAL COMMUNICATION	1	0	3	2	ICE 5272	SPACECRAFT DYNAMICS AND CONTROL	4	0	0	4
	ICE 5171	AEROSPACE SYSTEM MODELLING	4	0	0	4	ICE ****	ELECTIVE I	4	0	0	4
	ICE 5172	CONTROL SYSTEM DESIGN	3	1	0	4	ICE ****	ELECTIVE II	4	0	0	4
	ICE 5173	NAVIGATION AND GUIDANCE OF AEROSPACE VEHICLES	4	0	0	4	ICE ****	ELECTIVE III	4	0	0	4
	ICE 5174	ORBITAL MECHANICS	3	1	0	4	*** ****	OPEN ELECTIVE	3	0	0	3
	ICE 5161	CONTROL SYSTEM DESIGN LAB	0	0	3	1	ICE 5263	AEROSPACE SYSTEM SIMULATION LAB – II	0	0	3	1
	ICE 5164	AEROSPACE SYSTEM SIMULATION LAB - I	0	0	3	1	ICE 5264	SPACE DYNAMICS LAB	0	0	3	1
	ICE 5165	NUMERICAL METHODS FOR TRAJECTORY DESIGN LAB	0	0	3	1						
	Total		**19**	**2**	**12**	**25**			**23**	**0**	**6**	**25**
	THIRD AND FOURTH SEMESTER											
II	ICE 6098	PROJECT WORK							**0**	**0**	**0**	**25**

PROGRAM ELECTIVES		OPEN ELECTIVES	
ICE 5001	ADVANCED SENSOR TECHNOLOGY	ICE 5051	ROBUST CONTROL
ICE 5007	OPTIMAL CONTROL	ICE 5052	VIRTUAL INSTRUMENTATION
ICE 5008	ROBOTICS AND AUTOMATION		
ICE 5010	DISCRETE AND NONLINEAR CONTROL SYSTEMS		
ICE 5011	FLIGHT INSTRUMENTATION		
ICE 5012	RENDEZVOUS AND DOCKING OF SPACECRAFTS		
ICE 5013	SATELLITE COMMUNICATION SYSTEMS		
ICE 5014	SOFT COMPUTING		
ICE 5015	SPACE ENVIRONMENT AND SYSTEMS DEGRADATION IN SPACE		
ICE 5016	SPACE MISSION ANALYSIS AND DESIGN		
ICE 5017	SPACECRAFT ENGINEERING		
ICE 5018	SYSTEM IDENTIFICATION		

SEMESTER I

MAT 5156 Applied Linear Algebra and Probability [4 0 0 4]
Finite dimensional vector space, subspaces, linear independence, bases and dimension, Algebra of transformations, range and null space of a linear transformation, matrix algebra, simultaneous equations. Sum and intersection of subspaces, direct sum of invariant subspaces, eigen values, characteristic vectors, Cayley-Hamilton theorem, minimal polynomial, Sylvester's interpolation method, various canonical form. Algebra of polynomial matrices, invariant.Polynomial matrices, invariant polynomials, Smith canonical form. Inner-product spaces, Gram Schmidt orthogonalization, decomposition, Some computational methods of linear algebra., Probability theory: Review of Set theory; introduction to probability, axioms of probability; joint and conditional probability; Bayes theorem. **Reference Books:** 1. P.L.Meyer, Introduction to probability and Statistical Applications. Addison-Wesley Publishing Company 2. Finkbeiner D.T. I, Introduction to Matrices and linear Transformation, D.B. Taraorewala's 1968. 3. Hoffman, K and Kunze, R, Linear Algebra, Prentice Hall of India 1972. 4. Gantmocher F.R., The Theory of Matrices, Cheisea, 1960. 5. Goult, R.J., Hoskin, R.P., Milner, J.A and Pratt, M.J, Computational methods in Linear Algebra, Stanley Thomas Pub. Ltd., 1974.
HUM 5151 Research Methodology and Technical Communication [1 0 3 2]
Mechanics of Research Methodology, Types of research, Significance of research, Research framework, Case study method, Experimental method, Sources of data, Data collection using questionnaire, Interviewing, and experimentation. Research formulation, Criteria of a good research problem. Characteristics and Types of hypothesis, Procedure for hypothesis testing., Introduction to various sampling methods and their applications. Sources of data, Collection of data, Measurement and scaling technique, and Different techniques of Data analysis, Writing thesis, Writing journal and conference papers, IEEE and Harvard styles of referencing, Effective Presentation, Copyrights, and avoiding plagiarism. **Reference Books:** 1. Dr.Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE, 2005. 2. Geoffrey R.Marczyk, David DeMatteo & David Festinger, Essentials of Research Design and Methodology, John Wiley & Sons, 2004. 3. John W.Creswel, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, SAGE, 2004. 4. Suresh C.Sinha and Anil K.Dhiman, Research Methodology (2Vols-Set), Vedam Books, 2006.

5. C.R.Kothari, Research Methodology; Methods and Techniques, New Age International Publisher, 2008.

ICE 5171 Aerospace System Modelling [4 0 0 4]

Basic Aerodynamics, Incompressible and compressible flow, Momentum equation, Mach number, Aerodynamic forces over the wing surfaces, Stalling of airfoil, Lift-to-drag ratio, Aspect ratio, Drag polar, Modeling of Aircrafts, Forces and Moments, Aerodynamic coefficients, Equations of motion for straight, level and un-accelerated flight, Aircraft force and Moment equations. Missile dynamics, Force and Moment equations, Translational and rotational equations, Modeling helicopter and Quadcopter dynamics, Position and orientation dynamics. Dynamic model of a quadcopter.

Reference Books:

1. R C. Dorf and R H. Bishop, Modern Control Systems, 12th Edition, Pearson Publication, 2014
2. John. D. Anderson, Introduction to Flight, 6th Edition, McGraw Hill Education, 2010
3. G.D Padfield, Helicopter flight dynamics, 2nd Edition, Blackwell Publishing, 2007
4. George. M. Siouris, Missile Guidance and Control System, Springer, 2004
5. Marcel. J. Sidi, Spacecraft Dynamics and Control, Cambridge University Press, 1997

ICE 5172 Control System Design [3 1 0 4]

Time and Frequency domain performance specifications, Steady state error coefficients, Compensator design using Root Locus and Bode plots. PID controller characteristics, design principles. State variable methods, Modeling of systems, Invariance property, transfer function, Eigen values, Eigen vectors, diagonalization, Solution of state equations, state transition matrix, Cay ley Hamilton method, zero state and zero input responses, total response for standard inputs. Controllability, observability, duality, pole placement-direct method, Ackerman's formula, State observers, Full order observer design, separation principles, Lyapunov stability.

Reference Books:

1. K Ogata, Modern Control Engineering 5 edition, Pearson education, 2011
2. M Gopal, Digital Control and State Variable methods, 3 edition Tata McGraw-hill, 2008
3. Les Fenical, Control Systems, Cengage Learning, India Edition, 2007
4. C.T. Chen Analog and Digital control System Design, Oxford University Press,2006.

ICE 5173 Navigation and Guidance of Aerospace vehicles [4 0 0 4]

Introduction to NGC, NGC Loop, Applications, Navigation Systems - Basic Principle of Navigation and Position fixing, Deck Reckoning Navigation, Inertial Navigation, Inertial Platforms, Strapdown systems. Radio and Satellite Navigation, Air Navigation Radio aids, Radar, Integrated Navigation, Navigation equations. Navigation Sensors, Gyroscopic Instruments, Precession and Nutation, Force Sensors, Angular rate sensors, Guidance and

Control Systems, Different Phases of Guidance, Intercept geometry, Homing Guidance, Proportional Navigation Guidance, Command Guidance, Target intercept rules in guidance strategy, Fundamental Guidance Equations, Missile control.

Reference Books:

1. Anthony Lawrence, Modern Inertial Technology, (2ed), Springer, 1998
2. David H Titterton, Strapdown Inertial Navigation Technology, (2ed), IEE, 2004.
3. D. Biezad, Integrated Navigation and Guidance Systems, AIAA, 1999
4. Blakelock, Automatic Control of Aircraft & Missile, John Wiley and Sons, 1991
5. George M. Siouris, Missile Guidance and Control Systems, Springer, 2004

ICE 5174 Orbital Mechanics [3 1 0 4]

Two-body orbital mechanics, Constants of the motion, Trajectory equation, Types of orbit, Canonical units. Coordinate systems, Classical orbital elements, Orbit determination, Space surveillance, Type and location of sensors, Ground track of a satellite. The Gauss problem, Solution of the Gauss problem, Orbital maneuvers, Sensitivity analysis, Thrust transfer, Bi-elliptical transfer, Propulsion for maneuvers. Interplanetary trajectories, Departure orbits, Transit orbits, Arrival orbit, Flyby maneuvers, Non-coplanar interplanetary trajectories, Lunar trajectories, Three-body problem, Isomass and Euler configuration, Lagrange configuration, Restricted three-body problem, Jacobi's integral, Stability and dynamics at Eulerian points, Orbit perturbations, Numerical integration methods, Analytic formulation of perturbative accelerations.

Reference Books:

1. Roger R. Bate, Donald D. Mueller, Jerry E. White, Fundamentals of Astrodynamics, Dover publications, New York, 1971.
2. Marshall H. Kaplan, Modern spacecraft dynamics and controls, John wiley and sons, 1976
3. W.E. Wiesel, Spacecraft dynamics, McGraw-Hill, 1996
4. Ulrich Walter, Astronautics, Wiley, 2005
5. Charles D. Brown, Spacecraft Mission design second edition, AIAA education series, 1998

ICE 5161 Control System Design Lab [0 0 3 1]

Block diagram reduction, Time domain and Frequency domain analysis, Stability analysis, Compensator design using Root locus and Bode plot, Pole Placement, DC Motor control, PID controller Characteristics, Compensator design in hardware, Temperature control.

References:

1. K Ogata, Modern Control Engineering 5 edition, Pearson education, 2011
2. M Gopal, Digital Control and State Variable methods, 3 edition Tata McGraw-hill, 2008
3. Les Fenical, Control Systems, Cengage Learning, India Edition, 2007
4. C.T. Chen Analog and Digital control System Design, Oxford University Press,2006.

ICE 5164 Aerospace System Simulation Lab - I [0 0 3 1]

Modeling, Simulation and control implementation for Ball and Beam Systems, Modeling, Simulation and control implementation for Magnetic Levitation system, Modeling, Simulation and control implementation for Twin Rotor MIMO system, Modeling, Simulation and control implementation for 3DOF Helicopter System.

Reference Books:

1. Technical Manual for Ball and Beam System, Maglev system, Twin Rotor MIMO system, 3DOF helicopter System and dSpace Control software provided by the respective company manual.
2. R C. Dorf and R H. Bishop, Modern Control Systems, 12th Edition, Pearson Publication, 2014
3. John. D. Anderson, Introduction to Flight, 6th Edition, McGraw Hill Education, 2010
4. G.D Padfield, Helicopter flight dynamics, 2nd Edition, Blackwell Publishing, 2007

ICE 5165 Numerical Methods for Trajectory Design Lab [0 0 3 1]

Locating Roots of Equations, Systems of Linear Equations, Matrix factorization, Interpolation and Numerical Differentiation, Numerical integration, Solution of Linear and nonlinear differential equation, Initial value problem using MATLAB, Curve fitting with polynomial functions using MATLAB, Find the functional relationship between variable using interpolation, Monte Carlo Methods and Simulation, Case Study of Trajectory design.

Reference Books:

1. Ward Cheney and David Kincaid, *Numerical Mathematics & Computing (5e),* Brooks/Cole, 2004.
2. Van Loan, *Introduction to Scientific Computing (2e),* Prentice Hall, 1999
3. Rudra Pratap, *Getting started with MATLAB 7,* Oxford university press 2007
4. Duane C. Hanselman and Bruce L. Littlefield, *Mastering MATLAB 7*

SEMESTER II

ICE 5271 Flight Mechanics [4 0 0 4]

Review on Longitudinal and lateral equations of motion, Aircraft performance, Thrust and Power required for un-accelerated flight, Rate of climb, Gliding flight, Take-off and Landing performance, Turning flight and V-n Diagram. Longitudinal, directional and lateral static stability, stability modes, dynamic stability, autopilot, Control augmentation systems**,** Fly-by-wire systems.

Reference Books:

1. John. D. Anderson, Introduction to Flight (6/e), McGraw Hill Education, 2010.
2. Thomas. R. Yechout, Introduction to Aircraft Flight Mechanics (1/e), AIAA Education, 2003.
3. Michael. V. Cook, Flight Dynamics Principle (2/e), Butterworth, Heinemann, USA, 2007.
4. Brian L. Stevens and Frank L. Lewis, Aircraft control and simulation (2/e), Wiley India, 2003.
5. John. H. Blakelock, Automatic control of Aircraft and Missiles, Wiley, 1991.

ICE 5272 Spacecraft Dynamics and Control [4 0 0 4]

Attitude Dynamics and Kinematics, Rotational motion of spacecraft, attitude parameters and spacecraft torques, attitude motions of simple space-crafts and their stability, Single- and Dual-Spin Stabilization, attitude sensors and control actuators, Gravity-gradient stabilization, Equations for basic control laws, control with momentum exchange devices, magnetic attitude control, time-optimal attitude control, stabilization with and without active control, Roll-Yaw attitude control with magnetic torques and reaction thruster, Active nutation damping, Reaction torques and attitude control loops.

Reference Books:

1. Bong Wie, Space Vehicle Dynamics and Control, AIAA Education Series, 1998.
2. W. E. Wiesel, Spacecraft Dynamics, McGraw-Hill, 1996.
3. A. E. Roy, Orbital Motion, Bristol, England, Adam Hilger, 1988
4. M. M. Kaplan, Modern Spacecraft Dynamics Control, Wiley, 1976

ICE 5263   Aerospace System Simulation Lab – II[0 0 3 1]

Six DOF simulation of aircraft flight path, Aerospace embedded system design using ARM controller, Missile guidance experiments using MATLAB, Flight data acquisition experiments using LabVIEW.

Reference Books:

1. Thomas. R. Yechout, Introduction to Aircraft Flight Mechanics: Performance, Static Stability, Dynamic Stability, and Classical Feedback Control, AIAA, 2003.
2. Paul Zarchan, Tactical and Strategic Missile Guidance (6E), AIAA, 2012.
3. Ward Cheney and David Kincaid, Numerical Mathematics & Computing (5e), Brooks/Cole, 2004.
4. Van Loan, Introduction to Scientific Computing (2e), Prentice Hall, 1999.
5. Duane C. Hanselman and Bruce L. Littlefield, Mastering MATLAB *7*

ICE 5264 Space Dynamics Lab [0 0 31]

Computation Astrodynamics, Solution of Kepler's Equation, orbital elements from the state vector , Orbit determination using Gibbs method, analysis of Spacecraft relative motion, gravity-turn trajectory, orbital Maneuvers, Earth-to-Mars Mission Design, Earth-to-Moon Mission Design, Analysis of Orbital Elements and Spacecraft Trajectory using Orbwin

Reference Books:

1. Howard D Curtis, *Orbital Mechanics for Engineering Students, (2e),* Elsevier Aerospace Series
2. Ward Cheney and David Kincaid, *Numerical Mathematics & Computing (5e),* Brooks/Cole, 2004.
3. Charles D Brown, *Spacecraft Mission Design,* AIAA series.

SECOND YEAR

ICE 6098 PROJECT WORK [0 0 0 25]

Students are required to undertake innovative and research oriented projects, which not only reflect their knowledge gained in the previous two semesters but also reflects additional knowledge gained from their own effort. The project work can be carried out in the institution/ industry/ research laboratory or any other competent institutions. The duration of project work should be a minimum of 36 weeks. There will be a mid-term evaluation of the project work done after about 18 weeks. An interim project report is to be submitted to the department during the mid-term evaluation. Each student has to submit to the department a project report in prescribed format after completing the work. The final evaluation and viva-voice will be after submission of the report. Each student has to make a presentation on the work carried out, before the departmental committee for project evaluation. The mid-term & end semester evaluation will be done by the departmental committee including the guides.

Program Electives

ICE 5001 ADVANCED SENSOR TECHNOLOGY [4 0 0 4]

Advanced sensing techniques, Sensor classifications, advanced sensing materials, Optical Sensors: Fiber optic light propagation, Graded index fibers, Fiber optic communication driver circuits, Laser classifications, Driver circuits MEMS sensor, Fabrication and packaging issues, Thick film and thin film technique. Physical sensors: Hall Effect sensors, Eddy current sensors, magneto resistive and magnetostrictive detector. Aerospace Sensor: Accelerometers: Thermal, Humidity and moisture sensor Proximity detectors using polarized light, Semiconductor gas sensor. Fluidic and Micro-fluidic sensors, Gyroscope laser. Chemical sensor: Chemical sensor characteristics, Classification of Chemical sensing mechanism, potentiometric sensors, conductive sensors, amperometric sensors, enhanced catalytic gas sensors, engyme sensors. Lab on chip/senor platform technology. The role of PCA, LDA, Neural network in designing sensor array.

Reference Books:

1. Sabaree Soloman, *Sensors Hand Book*, McGraw Hill, 1998
2. Culshaw B and Dakin J (Eds) *Optical Fibre Sensors,* Vol. 1 & 2 Artech House, Norwood, 1989.
3. Jacob Fraden, Handbook of Modern Sensors: Physics, Designs, and Applications, Springer, 2010.
4. P Ripka, A Tipek, *Modern Sensors Handbook.* Wiley Publication, 2007.
5. Julian W Gardner, Vijay K Varadan, *Microsensors, MEMS and Smart Devices*, John Wiley & Sons, Inc. New York, 2001.

ICE 5007 OPTIMAL CONTROL [4 0 0 4]

Problem formulation, Performance measure, Dynamic programming: Optimal control law, Principle of optimality, optimal control problem, interpolation, Discrete linear regulator problem, Hamilton Jacobi Bellmann equation, continuous linear regulator problem, Calculus of Variations: functionals involving single and several independent functions, Variational Approach to Optimal Control Systems. Linear Regulator problems, Pontryagin's minimum principle and state inequality constraint, Time Optimal Control Systems, Fuel-Optimal Control Systems, Numerical determination of optimal trajectories: Two point boundary value problem, Method of steepest descent, variation of extremals, quasi-linearization.

Reference Books:

1. Donald E. Kirk, Optimal Control Theory: An Introduction, Dover Publications, 1998
2. David G. Hull, Optimal Control Theory for Applications, Springer International, 2003
3. Frank L.Lewis, Applied Optimal Control and Estimation, Prentice Hall, 1992
4. Brian D.O. Anderson, Optimal Control: Linear Quadratic Methods, PHI, 1990
5. D. S. Naidu, Optimal Control Systems, (1e), CRC Press, 2003

ICE 5008 ROBOTICS AND AUTOMATION [4 0 0 4]

Definition and origin of robotics – different types of robotics – degrees of freedom – Asimov's laws of robotics – dynamic stabilization of robots. Power Sources and Sensors: Hydraulic, pneumatic and electric drives – path determination – micro machines in robotics – machine vision – Manipulators, Actuators and Grippers: Construction of manipulators – manipulator dynamics and force control – end effectors – U various types of grippers. Kinematics and Path Planning: Solution of inverse kinematics problem –hill climbing techniques – robot programming languages. Case Studies: Multiple robots – machine interface – robots in manufacturing and non- manufacturing applications – robot cell design – selection of robot.

Reference Books:

1. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G *Industrial Robotics*, McGraw-Hill Singapore. 1996
2. Deb.S.R, *Robotics technology and flexible Automation*, John Wiley, USA. 1992
3. Asfahl C.R., *Robots and manufacturing Automation*, John Wiley, USA. 1992
4. Klafter R.D., Chimielewski T.A., Negin M *Robotic Engineering – An integrated approach,* Prentice Hall of India, 1994
5. Ghosh, *Control in Robotics and Automation: Sensor Based Integr*ation, Allied Publishers, 1998

ICE 5010 DISCRETE AND NONLINEAR CONTROL THEORY

Discrete time control, Z transforms, Difference equation, pulse transfer function, Block diagram reduction, signal flow graph, steady state errors, Mappping between s- and z- plane, stability, Transient and steady state analysis, Root locus and Bode plot of Discrete time systems. Discrete PID controllers. State variable analysis of discrete time systems, stability, eigen values, eigen vectors, Transformation to Canonical forms, Minimal realization, State transition matrix, solution of state equations, pole placement, Observers. Nonlinear system behaviour, phase plane, phase portraits, phase plane analysis of nonlinear systems, singular points, limit cycles, stability, *Lyapunov theory*, Lyapunov's direct method, Lyapunov analysis of linear time invariant systems, stability analysis of non linear systems, Krasovskii's method, Linearization Methods

References:

1. K. Ogata, *Discrete time control Systems,* 2nd Edition, PHI, 2005
2. M Gopal, *Digital Control and State Variable methods*, 3rd Edition, Tata McGraw-hill, 2008
3. K. Ogata, *Modern Control Engineering*, 5th Edition, PHI, 2010
4. M. Gopal, *Modern Control System Theory,* New Age International,1993

ICE 5011 Flight Instrumentation (4 0 0 4)

Axes system Parts, importance and role of Avionics systems which interface directly with pilot, Aircraft state sensor systems, Navigation systems, External world sensor systems, task automation systems. Avionics architecture evolution. Avionics Data buses - MIL STD 1553, ARINC 429, and ARINC 629. Radio Navigation , Inertial and satellite navigation systems, Air data systems and autopilot: Air data quantities Aircraft Displays, Virtual cockpit.

Reference Books:

1. Albert Helfrick. D, 'Principles of Avionics', Avionics communications Inc., 2004
2. Collinson, R.P.G, 'Introduction to Avionics', Chapman and Hall, 1996.
3. Middleton, D.H, 'Avionics Systems', Longman Scientific and Technical, Longman Group UK Ltd, England, 1989.
4. Spitzer, C.R. 'Digital Avionics Systems', Prentice Hall, Englewood Cliffs, N.J., USA

1993.
5. Spitzer, C.R, ‘The Avionics Handbook’, CRC Press, 2000.
6. Pallet, E.H.J, ‘Aircraft Instruments and Integrated Systems’, Longman Scientific

ICE 5012 Rendezvous and Docking of Spacecraft (4 0 0 4)

Complexity of rendezvous process, Different phases of rendezvous mission**,** Impulsive and Continuous maneuvers. Design rules for trajectory safety, Trajectory disturbances, Protection against trajectory deviations, Collision avoidance maneuvers, Rendezvous Control System Navigation filter, Guidance function and Control function, Mode sequencing and equipment management, Fault identification and recovery concepts, Basic measurement requirements and Concepts, Basic concepts of docking and Berthing – Types of docking and berthing mechanisms, Contact dynamics, Capture devices, Elements of final connection, Space and Ground Station System Setup – Functions and task of space and ground segments, Ground segment monitoring and control functions for RVD, RVD verification/ validation during development life cycle

Reference Books:

1. Wigbert Fehse, Automated Rendezvous and Docking of Spacecraft, Cambridge University Press, 2003.
2. Bong Wie, Space Vehicle Dynamics and Control - 2nd Edition, AIAA Education Series.
3. Marcel J. Sidi, Spacecraft Dynamics and Control, Cambridge University Press, 1997.

ICE 5013 Satellite Communication Systems [4 0 0 4]

Satellite Systems, System design considerations, Laws governing satellite motion, geostationary satellites, Non-geostationary constellation, Launching of geostationary satellites. Equitable use of radio Spectra, propagation considerations: Communication Link design – Antenna basics, Communication satellites Design consideration - Lifetime and reliability, Space craft subsystems, Space craft mass and power estimating, space segment cost estimates, space craft development programs, *Earth Station*, *Non-geostationary orbit satellite systems*, *Thermal Contro*l, Alternative power sources for spacecraft; Solar array components; batteries; outline of power control methods; degradation of power system performance.

Reference Books:

1. M Richharia, Satellite Communication Systems Design Principles, 2nd Edn.
2. Timothy Patt and Charles W Bostin, Satellite Communications John Wiley and Sons.
3. Dennis Roddy, Satellite Communications – 3rd Edn. – McGraw Hill Telecom Engg.

ICE 5014 Soft Computing Techniques [4 0 0 4]

Fuzzy Relations – Fuzzy logic and approximate reasoning – Design Methodology of Fuzzy Control Systems – Models and Learning rules of ANN’s. Single layer perceptron networks – Feedback networks – Supervised and unsupervised learning approaches – Neural Networks in Control Systems. Neural

Realization of Basic fuzzy logic operations – Neural Network based fuzzy logic inference – Neural Network based Fuzzy Modelling – Types of Neural Fuzzy Controllers. Fuzzy logic based Neural Network Models: Fuzzy Neurons – Type I, Type II, Type III –Fuzzification of Neural Network Models – Fuzzy Perceptron and Fuzzy classification with back propagation network, Neural Networks with fuzzy training – Fuzzy Neural clustering.

Reference Books:

1. Jyh Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, *Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine*, Prentice Hall. 1997
2. Chin –Teng Lin and C.S. George Lee, *Neural Fuzzy Systems" – A neuro fuzzy synergism to Intelligent systems*, Prentice Hall International. 1996
3. Yanqing Zhang and Abraham Kandel, *Compensatory Genetic Fuzzy Neural Networks and Their Applications*, World Scientific. 1998.
4. T. J. Ross, *Fuzzy Logic with Engineering Applications*, McGraw-Hill, Inc. 1995
5. R. Horst, *Global Optimization*, Springer Publications, 2nd Edition

ICE 5015 Space Environment and System Degradation in Space [4 0 0 4]

Spacecraft Subsystem Design, Orbital Mechanics, The Solar-Planetary Relationship, Space Weather , Solar UV Radiation, Solar UV Degradation, Molecular Contamination, Particulate Contamination. Atmospheric Physics, Elementary Kinetic Theory, Hydrostatic Equilibrium, Neutral Atmospheric Models, aerodynamic Drag, Sputtering, Atomic Oxygen Attack, Spacecraft Glow, Plasma Physics - Single Particle Motion, Debye Shielding, Plasma Oscillations, Spacecraft Charging, Arc Discharging, Radiation Physics, Stopping Charged Particles, Stopping Energetic Photons, Stopping Neutrons, trapped Radiation Belts, Solar Proton Events, Galactic Cosmic Rays, Hostile Environments, total Dose Effects - Solar Cell Degradation, Electronics Degradation; Single Event Effects - Upset, Latchup, Burnout; Dose Rate Effects. Hypervelocity Impact Physics, Micrometeoroids, Orbital Debris.

Reference Books:

1. M. H. Kaplan, Modern Spacecraft Dynamics Control, Wiley, 1976
2. P.W. Fortescue and J P W Stark, *Spacecraft Systems Engineering*, Wiley, 2011

ICE 5016 Space Mission Analysis And Design [4 0 0 4]

The Space Mission Life Cycle, Definition of Mission, Objectives, Preliminary Estimate of Mission Needs, Requirements and Constraints, Identifying Alternative Mission Concepts and Mission Architecture, Identification of Critical Requirements, Mission Analysis, Mission Utility, Mission Concept Selection, Space Mission Geometry, Attitude Determination and Control, Telemetry, Tracking and Command, Command and Data Handling, Power, Thermal, Structures and Mechanisms, Guidance and Navigation, Ground System Design and Sizing, Spacecraft Computer Systems, Space Propulsion Systems, Launch Systems, Communication systems, Developing a Mission Operations Plan, Launch Site

Operations, Overview of Space Mission Operations Functions, Automating Spacecraft and Ground Operations Functions.

Reference Books:

1. James R. Wertz & Wiley J. Lason, Space Mission Analysis and Design, Microcosm/Kluwer-1999
2. Thomas P. Sarafin, Spacecraft Structures and Mechanisms, Microcosm/Kluwer-1995
3. Bang Wie, Space Vehicle Dynamics and Control, AIAA Education Series-1998
4. George P. Suttan-Rocket Propulsion Elements: An Introduction to the Engineering of Rockets, John Wiley and Sons-2001
5. Charles D. Brown *Spacecraft Mission Design*, -AIAA Education Series-1998

ICE 5017 Spacecraft Engineering [4 0 0 4]

System view of spacecraft, Space environment and its effect on design**,** space vehicle motion**:** Rocket principle, rocket thrust, Rocket equation of motion, Rocket flight, Rocket staging, Ascent flight, density master equation, Equations of motion of a spacecraft flight, Propulsion systems**,** chemical rockets, Propellants, propellant grain geometry, Chemical rocket design, Secondary propulsion, Electric propulsion, Spacecraft structures**,** Material selection, Attitude control, Torques and torquers, Attitude measurement, Electrical power systems, Power management, distribution and control, Thermal control of spacecraft**,** Thermal environment and balance, Thermal analysis and design, Telecommunications, Techniques of radio communications, The Communications payload, Telemetry, Command, Data handling and Processing**,** Telemetry data formatting, Telecommand, Communication techniques and protocols, On-board data handling and processing, Spacecraft mechanisms, one-shot devices, Continuously and intermittently operating devices, Components, materials

Reference Books:

1. P.W. Fortescue & J P W Stark, Spacecraft Systems Engineering, Wiley, 2011
2. Ulrich Walter, Astronautics, Wiley-VC, 2005
3. George P Sutton, Oscar Biblarz, Rocket Propulsion Elements, (7e), John Wiley and sons, 2001
4. Charles D Brown, Elements Of Spacecraft Design-AIAA education series. 2002
5. Thomas P Sarafin , Spacecraft Structures And Mechanisms,(2e), Microcosm, Inc. and Kluwer Academic publishers. 1997

ICE 5018 System Identification [4 0 0 4]

Classification of inputs and system models, coupling of subsystems, linearization, Analytical and experimental methods of modelling, Response to random inputs, state-space models, pseudo-random signal testing parameter tracking, regression and least-square methods, FIR and ARX models, development of ARX models by least square estimation, unmeasured disturbance modeling, system identification procedure, Non-parametric time and frequency domain methods, parameter estimation method, convergence and consistency, computing the estimate, recursive estimation methods.

Reference Books:

1. E.O. Doeblin, System Modelling and Response, John Wiley Sons, 1980
2. Desai and Lalwani, Identification Techniques, Tata McGraw Hill, 1977
3. L. Ljung, System Identification: Theory for the User, Prentice Hall, 1992
4. Philip D. Cha, Fundamentals of Modeling and Analyzing Engineering Systems, Cambridge, 2000.

Open Electives

ICE 5053 VIRTUAL INSTRUMENTATION [3 0 0 3]

Introduction to LabVIEW: Software environment, Modular Programming: Modular programming in LabVIEW, creating an icon, creating subVIs from sections of VIs, creating stand alone applications. Strings and File I/O: creating string controls and indicators, string functions, Instrument Control: GPIB communication, hardware and software architecture and specifications, instrument I/O assistant, Data Acquisition: Transducers, signal conditioning, DAQ hardware configuration, DAQ hardware, IMAQ Vision: Vision basics, image processing and analysis, building a complete machine vision system.

References Books:

1. Jovitha Jerome, *Virtual Instrumentation using LabVIEW,* PHI, 2010.
2. Gary Johnson, LabVIEW *Graphical Programming*, Second edition, McGraw Hill. 1997

ICE 5052 ROBUST CONTROL [3 0 0 3]

Sources of Model Uncertainties, The Robustness of SISO Systems, Robust Multivariable Control Systems , Matrix Decompositions; Norms, Multivariate Optimization Methods, Computer Aided Design and Analysis, Analysis of Robust Control Systems, Parametric Uncertainties, Critical Perturbation Radius (CPR) Theory, Design of Robust Control Systems, MPDA and the Characteristic Locus Design Method, The Q-Parametrization, Introduction to H-infinity Optimal Control, Introduction to μ-synthesis, Advanced methods of control system analysis and design. LQR, LQG, and L1 optimization techniques. Robust control theory including QFT, H-infinity, and interval polynomial approaches, Research Directions

Reference Books:

1. Kemin Zhou, John Doyle, *Essentials of Robust Control*, Prentice-Hall, 1998.
2. Skogestad S., Postlethwaite I. *Multivariable Feedback Control: Analysis & Design*, second edition, 2005.
3. John.C.Doyle, *Feedback Control Theory*, Macmillan, 1992.