Indian Institute of Space Science and Technology

Thiruvananthapuram

B.Tech. Aerospace Engineering

Curriculum & Syllabus (For 2008 Admission)

DEPARTMENT OF AEROSPACE ENGINEERING

SEMESTER I

CODE	TITLE	L	T	P	C
MA111	Geometry and Calculus	3	1	0	4
PH111	Physics I	3	1	0	4
CH111	Chemistry I	3	1	0	4
AE111	Basic Mechanical Engineering	3	0	0	3
AV111	Basic Electrical Engineering	3	0	0	3
PH131	Physics Lab I	0	0	3	1
CH131	Chemistry Lab I	0	0	3	1
AE131	Basic Engineering Lab	0	0	3	1
HS131	Communication Skills Lab	0	0	3	1
	Total	15	3	12	22

SEMESTER II

CODE	TITLE	L	T	P	C
MA121	Linear Algebra and Differential Equations	3	1	0	4
PH121	Physics II	3	1	0	4
CH121	Chemistry II	3	1	0	4
AE121	Engineering Mechanics	3	1	0	4
AV121	Basic Electronics and Computer Engineering	3	0	0	3
MA141	Basic Programming Lab	0	0	3	1
AE141	Engineering Graphics	1	0	3	2
AV141	Basic Electrical and Electronics Engineering Lab	0	0	3	1
	Total	16	4	9	23

SEMESTER III

CODE	TITLE	L	T	P	C
MA211	Complex Analysis and Integral Transforms	3	0	0	3
AE211	Engineering Thermodynamics	3	0	0	3
AE212	Mechanics of Solids	3	0	0	3
AE213	Fluid Mechanics	3	0	0	3
AE214	Manufacturing Technology I	3	0	0	3
HS211	Introduction to Economics	2	0	0	2
AE231	Machine Drawing	0	0	3	1
AE232	Strength of Materials Lab	0	0	3	1
	Total	17	0	6	19

SEMESTER IV

CODE	TITLE	L	T	P	C
MA221	Numerical Methods, Partial Differential Equations, and Calculus of Variation	3	0	0	3
AE221	Gas Dynamics	3	0	0	3
AE222	Heat Transfer	3	0	0	3
AE223	Kinematics and Dynamics of Mechanisms	3	1	0	4
AE224	Metrology and Computer Aided Inspection	3	0	0	3
HS221	Introduction to Social Science and Ethics	2	0	0	2
AE241	Thermal and Fluid Lab	0	0	6	2
	Total	17	1	6	20

SEMESTER V

CODE	TITLE	L	T	P	C
MA311	Probability and Statistics	3	0	0	3
AE311	Aerodynamics	3	0	0	3
AE312	Aerospace Structures I	3	1	0	4
AE313	Manufacturing Technology II	3	0	0	3
AV315	Instrumentation and Control Systems	3	0	0	3
CH311	Environmental Science and Engineering	2	0	0	2
AE331	Aerodynamics Lab	0	0	3	1
AE332	Metrology Lab	0	0	3	1
AV335	Instrumentation and Control Systems Lab	0	0	3	1
	Total	17	1	9	21

SEMESTER VI

CODE	TITLE	L	T	P	C
AE321	Atmospheric Flight Mechanics	3	0	0	3
AE322	Spaceflight Mechanics	3	0	0	3
AE323	Air-Breathing Propulsion	3	0	0	3
AE324	Aerospace Structures II	3	1	0	4
E01	*Stream Elective I*	3	0	0	3
HS321	Principles of Management Systems	3	0	0	3
AE341	Aerospace Structures Lab	0	0	3	1
AE342	Manufacturing Processes Lab	0	0	3	1
	Total	18	1	6	21

SEMESTER VII

CODE	TITLE	L	T	P	C
AE411	Rocket Propulsion	3	0	0	3
AE412	Aerospace Vehicle Design	3	0	0	3
E02	*Stream Elective II*	3	0	0	3
E03	*Stream Elective III*	3	0	0	3
E04	*Department Elective IV*	3	0	0	3
E05	*Institute Elective*	3	0	0	3
AE431	Modeling and Analysis Lab	0	0	3	1
AE432	Flight Mechanics and Propulsion Lab	0	0	3	1
AE451	Summer Internship and Training	0	0	0	3
AE452	Seminar	0	0	0	2
	Total	18	0	6	25

SEMESTER VIII

CODE	TITLE	L	T	P	C
AE453	Comprehensive Viva-Voce	0	0	0	3
AE454	Project Work	0	0	0	12
	Total	0	0	0	15

SEMESTER–WISE CREDITS

Semester	I	II	III	IV	V	VI	VII	VIII	Total
Credits	22	23	19	20	21	21	25	15	166

LIST OF ELECTIVES

Stream I	Aerodynamics and Flight Mechanics
Stream II	Materials and Manufacturing
Stream III	Design and Structures
Stream IV	Thermal and Propulsion

CODE	TITLE	Stream I	Stream II	Stream III	Stream IV
AE461	Advanced Aerodynamics	√			
AE462	Advanced Aerospace Structures			√	
AE463	Advanced Fluid Mechanics	√			√
AE464	Advanced Heat Transfer				√
AE465	Advanced Propulsion Systems				√
AE466	Aeroelasticity	√		√	
AE467	Analysis & Design of Composite Structures			√	
AE468	Computational Fluid Dynamics	√			√
AE469	Computer Integrated Manufacturing		√		
AE470	Design of Aerospace Structures			√	
AE471	Convection Heat Transfer				√
AE472	Experimental Aerodynamics	√			
AE473	Finite Element Method	√	√	√	√
AE474	Fracture Mechanics			√	
AE475	Engineering Vibration			√	
AE476	Industrial Engineering		√		
AE477	Fundamentals of Combustion				√
AE478	Supply Chain Management		√		
AE479	Introduction to Optimization	√	√	√	√
AE480	Nontraditional Machining		√		
AE481	Operations Research		√		
AE482	Project Management		√		
AE483	Robot Mechanisms and Motion Planning		√	√	
AE484	Space Mission Design and Optimization	√			√

CODE	TITLE	Stream I	Stream II	Stream III	Stream IV
AE485	Quality Engineering and Management		√		
AE486	Refrigeration and Cryogenics				√
AE487	Turbomachines				√
AE488	Aerospace Materials and Processes		√		
AE489	Advanced Manufacturing and Automation		√		
AE490	Heat Transfer in Space Applications				√
AE491	Structural Dynamics			√	
AE492	Tool Engineering and Design		√		

SEMESTER I

MA111 GEOMETRY AND CALCULUS (3 – 1 – 0) 4 credits

Analytical Geometry: systems of circles, parabola, ellipse, hyperbola – polar equations – planes, sphere, cone, and cylinder.

Differential Calculus: Taylor's theorem – partial differentiation – maxima and minima by using Lagrange multipliers – concavity and convexity of a curve, points of inflexion, asymptotes, curvature – curve tracing.

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.

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

Textbooks:

1. Stewart, J., *Calculus: Early Transcendentals*, 5th ed., Brooks/Cole (2007).
2. Kreyszig, E., *Advanced Engineering Mathematics*, 9th ed., John Wiley (2005).

References:

1. Greenberg, M. D., *Advanced Engineering Mathematics*, Pearson Education (2007).
2. James, G., *Advanced Modern Engineering Mathematics*, Pearson Education (2004).
3. Thomas, G. B. and Finney, R. L., *Calculus and Analytic Geometry*, 9th ed., Pearson Education (2003).
4. Jain, R. K. and Iyengar, S. R. K., *Advanced Engineering Mathematics*, Narosa (2005).

PH111 PHYSICS I (3 – 1 – 0) 4 credits

Newtonian Mechanics: Newton's laws of motion – Galilean invariance – concepts of inertia, momentum, force, work, and energy – conservation laws – solar system, planetary orbits, Kepler's laws – Newton's law of gravitation.

Optics: corpuscular and wave theories of light – concepts of reflection, refraction, interference, diffraction, polarization, and dispersion – optical instruments.

Oscillations and Waves: damped and forced oscillations – coupled oscillators – traveling waves, superposition of waves – wave energy, energy transfer by waves – sound waves, Doppler effect.

Quantum Mechanics: inadequacy of classical mechanics – Planck's law – photoelectric effect – wave particle duality, de Broglie hypothesis – formulation of quantum mechanics, probability interpretation – Heisenberg's uncertainty principle – Schrodinger's equation.

Relativity: constancy of speed of light – relativity principle, Lorentz contraction and time dilation – mass-energy relation.

Introduction to Remote Sensing: principles of the electromagnetic spectrum – platforms for RS – spatial, spectral, and radiometric resolution – optical, microwave remote sensing – radiometric and geometric errors and their correction – types of data products – image processing applied to RS – applications of RS.

Introduction to Atmospheric Physics: earth's atmosphere, structure, classification, constituents – greenhouse effect – radiation budget, differential heating, general circulation – cloud formation and classification – solar radiation – interaction with planetary atmospheres.

Textbooks:

1. Serway, R. A. and Jewett, J. W., *Principles of Physics: A Calculus Based Text*, 4th ed., Thomson Brooks/Cole (2006).
2. Halliday, D., Resnick, R., and Walker, J., *Fundamentals of Physics*, 6th ed., John Wiley (2001).
3. Lecture Notes on Remote Sensing.

References:

1. Young, H. D., Freedman, R. A., Sundin, T. R., and Ford, A. L., *Sears and Zemansky's University Physics*, 11th ed., Pearson Education (2004).
2. Feynman, R. P., Leighton, R. B., and Sands, M., *The Feynman Lectures on Physics*, Narosa (2005).
3. Beiser, A., *Concepts of Modern Physics*, 6th ed., McGraw-Hill (2002).
4. Tipler, P. A., *Physics for Scientists and Engineers*, 4th ed., W. H. Freeman (1998).
5. Crawford, F. S., *Waves and Oscillations, Berkeley Physics Course*, Vol. 3, McGraw-Hill (1968).
6. Giancoli, D. C., *Physics: Principles with Applications*, 6th ed., Prentice Hall (2004).
7. Wallace, J. M. and Hobbs, P. V., *Atmospheric Science: An Introductory Survey*, 2nd ed., Academic Press (2006).
8. Houghton, J., *The Physics of Atmosphere*, 3rd ed., Cambridge Univ. Press (2001).
9. Goody, R. M. and Walker, J. C. G., *Atmospheres*, Prentice Hall (1972).
10. Jensen, J. R., *Remote Sensing of the Environment: An Earth Resource Perspective*, 2nd ed., Prentice Hall (2007).
11. Jensen, J. R., *Introductory Digital Image Processing: A Remote Sensing Perspective*, 3rd ed., Prentice Hall (2005).
12. Lillesand, T. M., Kiefer, R. W., and Chipman, J. W., *Remote Sensing and Image Interpretation*, 6th ed., John Wiley (2007).

Chemical Kinetics: basic concepts of chemical kinetics; reaction stoichiometry, empirical rate equations, elementary reactions, order and molecularity – composite reactions: reversible reactions, chain reactions, reaction mechanisms – effect of temperature on reaction rates: Arrhenius equation – catalysis; different types of catalysts, enzyme catalysis, inhibition – dynamics of chemical processes; theories of reaction rates.

Electrochemical Systems: introduction to electrochemical cells; EMF, applications of EMF measurements, thermodynamic data – electrolytic conductance; Kohlrausch's law, Arrhenius theory, Ostwald's dilution law, transport number, electrochemical series, concentration cell.

Polymer Chemistry: basic concepts; molecular weights and distributions, thermal transitions, morphology – classification of polymers: methods of polymerization – copolymers – polymers for space applications – polymer degradation.

Propellants and Explosives: basics of explosives and propellants; classification of explosives and propellants, initiators, detonators – explosion, detonation, RDX, HMX, plastic bonded explosives, explosive polymers – different types of propellants; calorific value, efficiency factor – composite propellants.

Textbooks:

1. Jain, P. C. and Jain, M., *Engineering Chemistry*, 15th ed., Dhanpat Rai Pub. Company (2007).
2. Krishnamurthy, N., Vallinayagam, P., and Madhavan, D., *Engineering Chemistry*, Prentice Hall of India (2007).

References:

1. Atkins, P. and de Paula, J., *Atkins' Physical Chemistry*, 8th ed., Oxford Univ. Press (2007).
2. Laidler, K. J., *Chemical Kinetics*, 3rd ed., Pearson Education (2005).
3. Young, R. J. and Lovell, P. A., *Introduction to Polymers*, 2nd ed., CRC Press (2000).
4. *Dryden's Outlines of Chemical Technology*, 3rd ed., Affiliated East-West Press (1997).
5. Urbenskey, T., *Chemistry and Technology of Explosives*, Vol. 2, Vol. 3 and Vol. 4, Pergamon Press (1988).
6. Bailey, A. and Murray, S. G., *Explosives, Propellants & Pyrotechnics*, 2nd ed., Brassey's (2001).

AE111 BASIC MECHANICAL ENGINEERING (3 – 0 – 0) 3 credits

Introduction to mechanical engineering – role of mechanical engineers – engineering thermodynamics; basic laws and thermal engineering applications – introduction to engineering materials and manufacturing processes – introduction to mechanisms – introduction to measurement systems and data analysis.

Textbooks:

1. Agrawal, B. and Agrawal, C. M., *Basic Mechanical Engineering*, Wiley India (2008).
2. Lecture Notes.

References:

1. Shanmugham, G., *Introduction to Mechanical Engineering*, Tata McGraw-Hill (2007).
2. Çengel, Y. A. and Boles, M. A., *Thermodynamics - An Engineering Approach*, 5th ed., Tata McGraw-Hill (2006).
3. Kalpakjian, S. and Schmidt, S. R., *Manufacturing Engineering and Technology*, 4th ed., Prentice Hall (2001).
4. Holman, J. P., *Experimental Methods for Engineers*, 7th ed., Tata McGraw-Hill (2004).

AV111 BASIC ELECTRICAL ENGINEERING (3 – 0 – 0) 3 credits

Circuit analysis, Kirchoff's law, mesh and nodal methods – transient analysis for RLC circuit – alternating current theory – resonance, Q factor and power measurement by two wattmeter circuits – network theorems – magnetic circuit, principles of magnetic circuits – DC and AC excitation – hysteresis loop, BH curve – losses, energy, and force production – electrical machines – power electronics, SCR, TRIAC, DIAC, and UJT; application in DC-DC converter and inverter circuit – introduction to transducer – storage batteries, different technologies, specification, maintenance and usage in aerospace applications.

Textbooks:

1. Hughes, E., *Electrical and Electronic Technology*, Pearson Education (2002).
2. Del Toro, V., *Principles of Electrical Engineering*, 2nd ed., Prentice Hall (1986).

References:

1. Hayt, W. H. and Kemmerley, J. E., *Engineering Circuit Analysis*, 4th ed., McGraw-Hill (1986).
2. Murthy, K. V. V. and Kamath, M. S., *Basic Circuit Analysis*, Jaico Publishing (1998).
3. Kothari, D. P. and Nagrath, I. J., *Theory and Problems of Basic Electrical Engineering*, Prentice Hall (2000).

4. Pal, M. A., *Introduction to Electrical Circuits and Machines*, Affiliated East-West Press (1975).
5. Kassakian, J. G., Schlecht, M. F., and Verghese, G. C., *Principles of Power Electronics*, Addison-Wesley Series in Electrical Engineering (1991).
6. Erickson, R. W., *Fundamentals of Power Electronics*, Chapman & Hall (1997).
7. Mohan, N., Undeland, T., and Robbins, W., *Power Electronics: Converters, Applications, and Design*, 2nd ed., John Wiley (1995).

PH131	PHYSICS LAB I	(0 – 0 – 3) 1 credit
CH131	CHEMISTRY LAB I	(0 – 0 – 3) 1 credit
AE131	BASIC ENGINEERING LAB	(0 – 0 – 3) 1 credit
HS131	COMMUNICATION SKILLS LAB	(0 – 0 – 3) 1 credits

SEMESTER II

MA121 LINEAR ALGEBRA AND DIFFERENTIAL EQUATIONS (3 – 1 – 0) 4 credits

Linear Algebra: matrices; solution space of system of equations $Ax = b$, eigenvalues and eigenvectors, Cayley–Hamilton theorem – group, ring, field – vector spaces: subspaces, linear dependence, independence, basis, dimension – inner product – Gram–Schmidt orthogonalization process – linear transformation; null space and nullity, range and rank of a linear transformation.

Sequences and Series: real sequences, complex sequences – sequences of functions – uniform convergence of series – test for convergence – uniform convergence for series of functions.

Differential Equations: first order ordinary differential equations – classification of differential equations – existence and uniqueness of solutions 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 singular point – Frobenius method to solve variable coefficient differential equations – special functions: Legendre polynomials, Bessel's function, gamma function, and their properties – Sturm–Liouville problems – self-adjoint operators – Green's functions.

Textbook:

- Kreyszig, E., *Advanced Engineering Mathematics*, 9th ed., John Wiley (2005).

References:

1. Lay, D. C., *Linear Algebra and Its Applications*, Pearson Education (2007).
2. Ross, S. L., *Differential Equations*, Blaisedell (1995).
3. Stewart, J., *Calculus: Early Transcendentals*, 5th ed., Brooks/Cole (2007).
4. Jain, R. K. and Iyengar, S. R. K., *Advanced Engineering Mathematics*, Narosa (2005).
5. Greenberg, M. D., *Advanced Engineering Mathematics*, Pearson Education (2007).

PH121 PHYSICS II (3 – 1 – 0) 4 credits

Electromagnetic Theory: conservative vector fields and their potential functions, electrostatic examples – Gauss' theorem, Stokes' theorem – physical applications in electrostatics – electrostatic potential and field due to discrete and continuous charge distributions – dipole and quadrupole moments – energy density in an electric field – dielectric polarization – conductors and capacitors – electric displacement vector – dielectric susceptibility – Biot–Savart's law and Ampere's law in magnetostatics – magnetic induction due to configurations of current-carrying conductors – magnetization and surface currents – energy density in a magnetic field – magnetic permeability and susceptibility – force on a charged particle in electric and magnetic fields – electromotive force – Faradays' law of electromagnetic induction, self and mutual inductance – displacement current – Maxwell's equations in free space and in linear media – scalar and vector potentials, gauges – plane electromagnetic waves – electromagnetic energy density – Poynting vector.

Introduction to Astronomy: coordinate system – electromagnetic spectrum, flux, magnitude scale – interstellar reddening – telescopes, stellar spectrum, H-R diagram – star formation and evolution – solar system.

Introduction to Space Systems: basic of orbital mechanics, concepts of orbits – propulsion, aerodynamic, navigation, guidance and control systems – Indian space programme.

Textbooks:

1. Griffith, D. J., *Introduction to Electrodynamics*, 3rd ed., Prentice Hall (1999).
2. Sadiku, M. N. O., *Elements of Electromagnetics*, 8th ed., Oxford Univ. Press (2007).

References:

1. Purcell, E. M., *Electricity and Magnetism*, Berkeley Physics Course, Vol. 2, Tata McGraw-Hill (1981).
2. Feynman, R. P., Leighton, R. B., and Sands, M., *The Feynman Lectures on Physics*, Narosa (2005).
3. Reitz, J. R., Milford, F. J., and Christy, R. W., *Foundations of Electromagnetic Theory*, 3rd ed., Narosa (1998).
4. Wangsness, R. K., *Electromagnetic Fields*, 2nd ed., Wiley (1986).
5. Spiegel, M. R., *Schaum's Outline of Vector Analysis*, McGraw-Hill (1968).
6. Carroll, B. W. and Ostlie, D. A., *An Introduction to Modern Astrophysics*, 2nd ed., Pearson Addison-Wesley (2007).
7. Shu, F. H., *Physical Universe: An Introduction to Astronomy*, University Science Books (1982).
8. Palen, S., *Schaum's Outline of Astronomy*, McGraw-Hill (2001).
9. Curtis, H. D., *Orbital Mechanics for Engineering Students*, Butterworth-Heinemann (2004).
10. Hale, F. J., *Introduction to Space Flight*, Prentice Hall (1994).
11. Wertz, J. R. and Larson, W. J. (eds.), *Space Mission Analysis and Design*, Microcosm Press (2006).
12. Corliss, W. R., *Propulsion Systems for Space Flight*, McGraw-Hill (1960).

CH121 CHEMISTRY II (3 – 1 – 0) 4 credits

Corrosion Science: introduction to corrosion; electrochemical mechanisms, theories of corrosion, factors influencing corrosion – testing and measurement of corrosion – protection against corrosion.

Introduction to Ceramic and Composite Materials: general characteristics – applications of composites materials – classification of composites; fibers, matrices, factors influencing composite properties, mechanical properties of fibers – ceramic materials; bonding in ceramics, structure of glasses and silicates, processing of ceramics, properties of ceramics.

Material Characterization: spectroscopic techniques; basics of IR and UV – thermal characterization; TGA, DSC, DTA.

Textbook:

- Callister Jr., W. D., *Materials Science and Engineering: An Introduction*, 7th ed., John Wiley (2007).

References:

1. Revie, R. W. and Uhlig, H. H., *Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering*, 4th ed., Wiley (2008).
2. Bockris, J. O'M. and Reddy, A. K. N., *Modern Electrochemistry 1: Ionics*, Springer (1998).
3. Reed, J. S., *Principles of Ceramics Processing*, 2nd ed., Wiley Interscience (1995).
4. Kemp, W., *Organic Spectroscopy*, 3rd ed., Palgrave (2007).
5. James, W. D. and Kenneth, H. T., *Thermal Methods*, John Wiley (1987).
6. Skoog, D. A., West, D. M., and Holler, F. J., *Fundamentals of Analytical Chemistry*, 8th ed., Thomson Brooks/Cole (2004).

AE121 ENGINEERING MECHANICS (3 – 1 – 0) 4 credits

Basics of statics – fundamental principles and concepts – analysis of structures – trusses, frames, machines, beams, cables – friction – center of mass and area moments of inertia – mass moment of inertia – virtual work and energy method – applications of energy method for equilibrium – stability of equilibrium – review of particle dynamics – curvilinear motion – plane kinematics of rigid bodies, rotation – plane kinetics of rigid bodies – introduction to vibration.

Textbooks:

1. Meriam, J. L. and Kraige, L. G., *Engineering Mechanics: Statics* (Vol. 1), *Dynamics* (Vol. 2), 5th ed., Wiley (2002).
2. Beer, F. B. and Johnston, E. R., *Vector Mechanics for Engineers: Statics* (Vol. 1), *Dynamics* (Vol. 2), 8th ed., Tata McGraw-Hill (2007).

References:

1. Timoshenko, S. P. and Young, D. H., *Engineering Mechanics*, 4th ed., McGraw-Hill (2007).
2. Hibbeler, R. C., *Principles of Statics and Dynamics*, 10th ed., Prentice Hall (2006).
3. Shames, I. H., *Engineering Mechanics: Statics and Dynamics*, 4th ed., Prentice Hall (1996).

AV121 BASIC ELECTRONICS AND COMPUTER ENGINEERING (3 – 0 – 0) 3 credits

Semiconductor Diodes: characteristics, applications in rectifiers and power supplies – BJT characteristics, biasing circuit – small signal and low frequency transistors – field effect devices: JFET/HFET, MOSFET operation, characteristics and small signal models – amplifiers and oscillators – operational amplifiers: parameters and characteristics, application-active filters – digital circuits: basic logic gates-combinational circuit, flip flops-applications, memories.

Principles of Communication: basic block diagram – modulation, types – overview of satellite communication.

Microprocessor and Computer Architecture: 8 bit microprocessor-architecture, assembly language program – functional block diagram of computer architecture – introduction to computers, microcomputers and its functional block diagram.

Textbooks:

1. Boylestad, R. L. and Nashelsky, L., *Electronic Devices and Circuit Theory*, Pearson Education (2003).
2. Floyd, T. L., *Electronic Devices*, Pearson Education, 8th ed. (2007).
3. Tomasi, W., *Electronic Communication Systems: Fundamentals Through Advanced*, 4th ed., Pearson Education (2005).

References:

1. Mottershed, A., *Electronic Devices and Circuits: An Introduction*, EEE Publication, 12th Indian ed. (1989).
2. Bapat, Y. N., *Electronic Devices and Circuits*, Tata McGraw-Hill, 9th ed. (1989).
3. Malvino, A. P., *Electronic Principles*, 12th ed., 3rd TMH ed., Tata McGraw-Hill (1989).
4. Jain, R. P., *Modern Digital Electronics*, McGraw-Hill (2004).
5. Mano, M. M., *Digital Design*, Prentice Hall (2002).
6. Gaonkar, R. S., *Microprocessor Architecture, Programming, and Applications with the 8085*, 5th ed., Penram International Pub. India Ltd. (2007).

MA141 BASIC PROGRAMMING LAB (0 – 0 – 3) 1 credit

AE141 ENGINEERING GRAPHICS (1 – 0 – 3) 2 credits

Geometrical construction of simple plane figures – free hand sketching – drawing scales – graphical communication through multiple projections – first angle and third angle projections – simple projection of points, lines and planes – projection of simple solids in simple positions (orthographic and isometric) – solid sections – intersection of solids – development of surfaces – introduction to CAD – creation of simple drawing – solid modeling – auxiliary projection – section views.

Textbook:

- Bethune, J. D., *Engineering Graphics with AutoCAD*, Prentice Hall (2007).

References:

1. Venugopal, K., *Engineering Drawing and Graphics*, 2nd ed., New Age International (1994).
2. Luzadder, W. J. and Duff, J. M., *Fundamentals of Engineering Drawing*, 11th ed., Prentice Hall (1992).

AV141 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LAB (0 – 0 – 3) 1 credit

SEMESTER III

MA211 COMPLEX ANALYSIS AND INTEGRAL TRANSFORMS (3 - 0 - 0) 3 credits

Complex Variable: complex numbers and their geometrical representation – functions of complex variable – limit, continuity and derivative of functions of complex variable – analytical functions and applications – harmonic functions – transformations and conformal mappings – bilinear transformation – contour integration and Cauchy's theorem – convergent series of analytic functions – Laurent and Taylor series – zeroes and singularities – calculation of residues – residue theorem and applications.

Fourier Series: Fourier series expansion of periodic functions with period two – Fourier series of even and odd functions – half-range series – Fourier series of functions with arbitrary period – conditions of convergence of Fourier series.

Fourier Transform: Fourier integral – the Fourier transform pair – algebraic properties of Fourier transform – convolution, modulation, and translation – transforms of derivatives and derivatives of transform – inversion theory.

Laplace Transform: Laplace transforms of elementary functions – inverse Laplace transforms – linearity property – first and second shifting theorem – Laplace transforms of derivatives and integrals – Laplace transform of Dirac delta function – applications of Laplace transform in solving ordinary differential equations.

Textbook:

- Kreyszig, E., *Advanced Engineering Mathematics*, 9th ed., John Wiley (2005).

References:

1. Churchill, R. V. and Brown, J. W., *Complex Variables and Applications*, 6th ed., McGraw-Hill (2004).
2. Mathews, J. H. and Howell, R., *Complex Analysis for Mathematics and Engineering*, Narosa (2005).
3. Wylie, C. R. and Barrett, L. C., *Advanced Engineering Mathematics*, McGraw-Hill (2002).
4. Jain, R. K. and Iyengar, S. R. K., *Advanced Engineering Mathematics*, Narosa (2005).
5. Greenberg, M. D., *Advanced Engineering Mathematics*, Pearson Education (2007).
6. James, G., *Advanced Modern Engineering Mathematics*, Pearson Education (2004).

AE211 ENGINEERING THERMODYNAMICS (3 – 0 – 0) 3 credits

Basic concepts of thermodynamics – properties of pure substances – energy transfer by heat, work, and mass – first law of thermodynamics – second law of thermodynamics – entropy and exergy – gas power, vapor power, and combined cycles – refrigeration cycle – thermodynamics property relations – gas mixtures, gas-vapor mixture – air conditioning – applications in thermal engineering.

Textbook:

- Çengel, Y. A. and Boles, M. A., *Thermodynamics – An Engineering Approach*, 5th ed., Tata McGraw-Hill (2006).

References:

1. Nag, P. K., *Engineering Thermodynamics*, 3rd ed., Tata McGraw-Hill (2005).
2. Moran, M. J. and Shapiro, H. N., *Fundamentals of Engineering Thermodynamics*, 6th ed., Wiley (2007).

AE212 MECHANICS OF SOLIDS (3 – 0 – 0) 3 credits

Concepts of stress, strain – compatibility – generalized Hooke's law – torsion – axial force, shear, and bending moment – pure bending – shear stress in beams – transformation of stresses and strains – deflection of beams – stability – energy methods.

Textbook:

- Popov, E. P., *Engineering Mechanics of Solids*, 2nd ed., Prentice Hall (1998).

References:

1. Hibbeler, R. C., *Mechanics of Materials*, 6th ed., Prentice Hall (2004).
2. Beer, F. P., Johnston, E. R., and DeWolf, J. T., *Mechanics of Materials*, 4th ed., McGraw-Hill (2005).
3. Srinath, L. S., *Advanced Mechanics of Solids*, 2nd ed., Tata McGraw-Hill (2003).

AE213 FLUID MECHANICS (3 – 0 – 0) 3 credits

Fluid properties – fluid statics – fluid kinematics – control volume equations (integral formulation) – differential formulation – continuity and Navier–Stokes equations – exact solutions – dimensional analysis – pipe flow – potential flow – boundary layer flow – turbulence.

Textbook:

- Fox, R. W. and McDonald, A. T., *Introduction to Fluid Mechanics*, 6th ed., John Wiley (2003).

References:

1. White, F. M., *Fluid Mechanics*, 5th ed., McGraw-Hill (2003).
2. Çengel, Y. A. and Cimbala, J. M., *Fluid Mechanics: Fundamental and Applications*, McGraw-Hill (2005).
3. Kundu, P. K. and Cohen, I. M., *Fluid Mechanics*, 3rd ed., Academic Press (2004).

AE214 MANUFACTURING TECHNOLOGY I (3 – 0 – 0) 3 credits

Basic concepts and principles of manufacturing – introduction to metallurgy – phase rule, phase diagrams – iron-carbon diagram – heat treatment – steels (iron alloys).

Metal casting technology – principles of solidification – various metal forming techniques and their analysis – joining processes; welding, brazing, and soldering – inspection and NDT – plastics, ceramics, and composites manufacturing.

Textbooks:

1. Kalpakjian, S. and Schmidt, S. R., *Manufacturing Engineering and Technology*, Pearson Education (2009).
2. Ghosh, A. and Mallik, A. K., *Manufacturing Science*, 6th ed., Wiley Eastern (2003).
3. Rao, P. N., *Manufacturing Technology: Foundry, Forming and Welding*, 2nd ed., Tata McGraw-Hill (2007).

References:

1. Singh, V., *Physical Metallurgy*, Standard Publishers, 1999.
2. Campbell, J. S., *Principles of Manufacturing Materials and Processes*, Tata McGraw-Hill (1995).
3. Degarmo, E. P., *Black, J. T., and Kohser, R. A., Materials and Processes in Manufacturing*, 10th ed., Prentice Hall of India (2007).
4. Linnert, G. E., *Welding Metallurgy*, AWS (1994).
5. Heine, R. W., Loper, C. R., and Rosenthal, P. C., *Principles of Metal Casting*, 2nd ed., Tata McGraw-Hill (1976).

HS211 INTRODUCTION TO ECONOMICS (2 – 0 – 0) 2 credits

Exploring the Subject Matter of Economics: why we study economics – types - definitions – economic systems – economics as a science.

Principles and Concepts of Micro Economics: demand – supply – production – costs – markets – equilibrium.

Basics of Macro Economics: role of government – national income concepts – inflation concepts – classical vs. Keynesianism.

Economic Problems and Policies: meaning of development – problems of growth – population – agriculture and industry – balance of payments – planning – study report related to economics of space program.

Textbooks:

1. Samuelson, P. A. and Nordhaus, W. D., *Economics*, 18th ed., McGraw-Hill (2005).
2. Dewett, K. K., *Modern Economic Theory*, 22nd ed., S. Chand (2005).
3. Thirlwall, A. P., *Growth and Development with Special Reference to Developing Economies*, 7th ed., Palgrave Macmillan (2003).

References:

1. Gardner, A., *Macroeconomic Theory*, Surjeet Publications (1998).
2. Koutsoyiannis, A., *Modern Microeconomics*, 2nd ed., Palgrave Macmillan (2003).
3. Black, J., *A Dictionary of Economics*, Oxford Univ. Press (2003).
4. Meir, J. M. and Rauch, J. E., *Leading Issues in Economic Development*, 7th ed., Oxford Univ. Press (2005).
5. Todaro, M. P. and Smith, S. C., *Economic Development*, 8th ed., Pearson Education Ltd. (2008).
6. *Economic Survey 2008*, Government of India, Ministry of Finance.
7. O'Connor, D. E., *The Basics of Economics*, Greenwood Press (2004).

AE231 MACHINE DRAWING (0 – 0 – 3) 1 credit

Threaded fasteners – nuts, joints – part drawing of machine elements – couplings, computer aided drafting of machine elements – assembly drawings using CAD for various engine parts – conventions in shop floor drawings – limits, fits, and tolerances, and their interpretations – creation of assembles in solid modeling packages and preparation of 2D drawings – a drawing project on reverse engineering.

Textbook:

- Bhatt, N. D. and Panchal, V. M., *Machine Drawing*, 41st ed., Charotar Publishing House (2006).

References:

1. Manuals of drafting and modeling packages.
2. Sidheswar, N., Kanniah, P., and Sastry, V. V. S., *Machine Drawing*, Tata McGraw-Hill (1983).
3. Luzadder, W. J. and Duff, J. M., *Fundamentals of Engineering Drawing*, 11th ed., Prentice Hall (1995).
4. John, K. C. and Varghese, P. I., *Machine Drawing*, VIP Publication (1995).

AE232 STRENGTH OF MATERIALS LAB (0 – 0 – 3) 1 credit

SEMESTER IV

MA221 NUMERICAL METHODS, PARTIAL DIFFERENTIAL EQUATIONS, AND CALCULUS OF VARIATION (3 – 0 – 0) 3 credits

Numerical Methods: solution of algebraic and transcendental equations – solution of system of linear equations – numerical integration – interpolation and curve fitting – solution of ordinary differential equations – approximation of functions.

Partial Differential Equations: introduction to PDE – modeling problems related and general second order PDE – classification of PDE: hyperbolic, elliptic and parabolic PDE – canonical form – scalar first order partial differential equations – method of characteristics – Charpits method – quasi-linear first order equations – shocks and rarefactions – solution of heat, wave, and Laplace equations using separable variable techniques and Fourier series.

Calculus of Variations: optimization of functional – Euler–Lagrange equations – first variation – isoperimetric problems – Rayleigh–Ritz method.

Textbook:

- Kreyszig, E., *Advanced Engineering Mathematics*, 9th ed., John Wiley (2005).

References:

1. Jain, M. K., Iyengar, S. R. K., and Jain, R. K., *Numerical Methods for Scientific and Engineering Computation*, New Age International (2003).
2. Sneddon, I. N., *Elements of Partial Differential Equations*, McGraw-Hill (1986).
3. Renardy, M. and Rogers, R. C., *An Introduction to Partial Differential Equations*, 2nd ed., Springer-Verlag (2004).
4. Greenberg, M. D., *Advanced Engineering Mathematics*, Pearson Education (2007).
5. McOwen, R. C., *Partial Differential Equations - Methods and Applications*, 2nd ed., Pearson Education (2003).

AE221 GAS DYNAMICS (3 – 0 – 0) 3 credits

Governing equations – static and stagnation properties – speed of sound and Mach number – isentropic flow through variable area ducts – normal and oblique shocks – shock expansion – Fanno flow – Rayleigh flow – Prandtl-Meyer flow – small perturbations theory – unsteady wave motion.

Textbook:

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

References:

1. Zucker, R. D. and Biblarz, O., *Fundamentals of Gas Dynamics*, 2nd ed., John Wiley (2002).
2. John, J. E. A. and Keith, T., *Gas Dynamics*, 3rd ed., Prentice Hall (2006).
3. Yahya, S. M., *Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion*, 3rd ed., New Age International Publishers (2003).

AE222 HEAT TRANSFER (3 – 0 – 0) 3 credits

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 – heat exchangers – black-body radiation and radiative properties – radiative exchange between surfaces.

Textbook:

- Incropera, F. P. and DeWitt, D. P., *Fundamentals of Heat and Mass Transfer*, 5th ed., John Wiley (2002).

References:

1. Holman, J. P., *Heat Transfer*, 9th ed., Tata McGraw-Hill (2007).
2. Çengel, Y. A., *Heat and Mass Transfer: A Practical Approach*, 3rd ed., Tata McGraw-Hill (2006).

AE223 KINEMATICS AND DYNAMICS OF MECHANISMS (3 – 1 – 0) 4 credits

Review of joints and mobility, position, velocity and acceleration analysis of linkages – cams, gears, and gear trains – static and dynamic analysis of mechanisms – gyroscopes – balancing – single degree of freedom systems – free and forced vibration – multi degrees of freedom systems – natural frequencies, modes.

Textbook:

- Uicker, J. J., Pennock, G. R., and Shigley, J. E., *Theory of Machines and Mechanisms*, 3rd ed., Oxford Univ. Press (2003).

References:

1. Rattan, S. S., *Theory of Machines*, 2nd ed., Tata McGraw-Hill (2005).
2. Myszka, D. H., *Machines and Mechanisms: Applied Kinematics Analysis*, 3rd ed., Prentice Hall (2004).

AE224 METROLOGY AND COMPUTER AIDED INSPECTION (3 – 0 – 0) 3 credits

Introduction to metrology, fundamentals of dimensional measurements, length standards, application of light interference for precision measurements – fits and tolerances – concepts and practices of gauging – comparators and their applications – linear and angular measurements – thread and gear inspection – form, flatness, straightness, and alignment measurements – surface metrology – co-ordinate metrology – laser applications in metrology – vision inspection – micro- and nano-metrology.

Textbooks:

1. Shotbolt, C. S. and Galyer, J., *Metrology for Engineers*, 5th ed., Cassell Pub. (1990).
2. Jain, R. K., *Engineering Metrology*, Khanna Pub. (2008).
3. Busch, T., *Fundamentals of Dimensional Metrology*, Delmar Pub. (1988).

References:

1. Smith, G. T., *Industrial Metrology: Surfaces and Roundness*, Springer-Verlag (2002).
2. Whitehouse, D. J., *Handbook of Surface Metrology*, Taylor & Francis (1994).

HS221 INTRODUCTION TO SOCIAL SCIENCE AND ETHICS (2 – 0 – 0) 2 credits

Social Science: introduction to sociology, anthropology – social science research design and sampling.

Ethics: professional and personal ethics – values & norms and human rights.

Textbook:

- Lecture Notes

References:

1. Perry, J. and Perry, E., *Contemporary Society: An Introduction to Social Science*, 11th ed., Allyn & Bacon (2005).
2. Giddens, A., *Sociology*, 5th ed., Wiley (2006).
3. Flyvbjerg, B., *Making Social Science Matter*, Cambridge Univ. Press (2001).
4. Singer, P., *A Companion to Ethics*, Wiley-Blackwell (1993).

AE241 THERMAL AND FLUID LAB (0 – 0 – 6) 2 credits

SEMESTER V

MA311 PROBABILITY AND STATISTICS (3 – 0 – 0) 3 credits

Probability Distributions: random Variable: discrete and continuous random variables – probability distributions: binomial distribution, hyper geometric distribution, Poisson approximation to the binomial, geometric distribution, normal distribution, normal approximation to the binomial distribution, uniform distribution, gamma distribution, beta distribution, and Weibull distribution – mathematical expectation and moments: mean, variance, moment generating function, and characteristic function.

Sampling Distributions and Inference Concerning Means: population and samples – central limit theorem – sampling distributions of mean and variance – point estimation – confidence interval for mean, variance and proportions – tests of hypotheses: the null hypotheses and the significance tests – control charts for variables and attributes – acceptance sampling by attributes – simple, double and sequential sampling plans – design of experiments.

Correlation and Regression Analysis: curve fitting by the method of least squares – Chi-square test of goodness of fit – contingency tables – inference based on the least square estimators – regression – correlation – inference concerning correlation coefficient.

Markov Chains: stochastic processes – Markov chains with finite and countable state space, classification of states, limiting behavior of n-step transition probabilities, continuous Markov process, and hidden Markov chain with applications.

Textbooks:

1. Johnson, R. A., *Miller & Freund's Probability and Statistics for Engineers*, 6th ed., Prentice Hall (2000).
2. Medhi, J., *Stochastic Processes*, Wiley Eastern Ltd. (1982).

References:

1. Levin, R. I. and Rubin, D. S., *Statistics for Management*, 7th ed., Prentice Hall (1998).
2. Milton, J. S. and Arnold, J. C., *Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences*, McGraw-Hill (2002).
3. Ross, S. M., *Introduction to Probability and Statistics for Engineers and Scientists*, 3rd ed., Academic Press (2004).
4. Feller, W., *An Introduction to Probability Theory and Its Applications*, Vol. 1 & Vol. 2, John Wiley (1968).
5. Hogg, R. V., Craig, T., and McKean, J. W., *Introduction to Mathematical Statistics*, 6th ed., Prentice Hall (2004)
6. Hogg, R. V. and Tanis, E. A., *Probability and Statistical Inference*, 7th ed., Prentice Hall (2005).

7. Larsen, R. J. and Marx, M. L., *An Introduction to Mathematical Statistics and Its Applications*, 4th ed., Prentice Hall (2005).
8. Mendenhall, W., Wackerly, D., and Scheaffer, R. L., *Mathematical Statistics with Applications*, 7th ed., Duxbury Press (2007).
9. Chung, K. L. and AitSahlia, F., *Elementary Probability Theory with Stochastic Processes and an Introduction to Mathematical Finance*, 4th ed., Springer (2006).
10. Gorden, S. P. and Gorden, F. S., *Contemporary Statistics, A Computer Approach*, McGraw-Hill (1994).

AE311 AERODYNAMICS (3 – 0 – 0) 3 credits

Fundamental aerodynamic variables – inviscid, incompressible flows – elementary flows – non-lifting and lifting flows over cylinders – Kutta–Joukowski theorem – airfoil nomenclature and characteristics – incompressible flow past airfoils – starting vortex – classical thin airfoil theory – symmetrical and cambered airfoils – incompressible flow past finite wings – vortex filament and sheet – Biot–Savart law – Prandtls lifting line theory – elements of vortex panel method – viscous flow over wings – rocket aerodynamics.

Textbook:

- Anderson, J. D., *Fundamentals of Aerodynamics*, 4th ed., McGraw-Hill (2006).

References:

1. Bertin, J. J. and Cummings, R. M., *Aerodynamics for Engineers*, 5th ed., Prentice Hall (2008).
2. Kuethe, A. M. and Chow, C.-Y., *Foundations of Aerodynamics*, 5th ed., John Wiley (1997).
3. Clancy, L. J., *Aerodynamics*, Reprint ed., Himalayan Books (2006).
4. Nielsen, J. N., *Missile Aerodynamics*, AIAA (1988).

AE312 AEROSPACE STRUCTURES I (3 – 1 – 0) 4 credits

Introduction to theory of elasticity – linear and nonlinear strain descriptions – stress-strain relations – thermal stresses – isotropic and orthotropic materials – introduction to laminated composites – stress functions – torsion of solid sections – theory of thin plates and axisymmetric shells – structural instability – virtual work, energy and matrix methods – introduction to finite element method.

Textbook:

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

References:

1. Timoshenko, S. P. and Goodier, J. N., *Theory of Elasticity*, 3rd ed., McGraw-Hill (1970).
2. Timoshenko, S. P. and Woinowsky-Krieger, S., *Theory of Plates and Shells*, 2nd ed., McGraw-Hill (1964).
3. Osgood, C. C., *Spacecraft Structures*, Prentice Hall (1966).

AE313 MANUFACTURING TECHNOLOGY II (3 – 0 – 0) 3 credits

Principles of Metal Cutting: mechanics of metal cutting – cutting tools – cutting processes – process variables – tool life.

Abrasive Machining Processes: Grinding – fine finishing process.

Machine Tools: conventional machine tool configuration – CNC technology – CNC machine tools and programming.

Nontraditional Machining: principles, equipment, process variables and applications – surface engineering – concept of CIM and FMS – additive manufacturing – advanced manufacturing techniques.

Textbooks:

1. Groover, M. P., *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, 4th ed., Wiley India (2010).
2. Kalpakjian, S. and Schmidt, S. R., *Manufacturing Engineering and Technology*, Pearson Education (2009).

References:

1. Pandey, P. C. and Shah, H. S., *Modern Machining Processes*, Tata McGraw-Hill, 1988.
2. Juneja, B. L., Sekhon, G. S., and Seth, N., *Fundamentals of Metal Cutting and Machine Tools*, New Age International (2008).

AV315 INSTRUMENTATION AND CONTROL SYSTEMS (3 – 0 – 0) 3 credits

Instrumentation: sensitivity, linearity, and resolution of instruments – uncertainty of measurements – signal conditioners - bridge circuits, amplifiers, and filters – measurement of displacement, velocity, acceleration, force, torque, pressure, flow, temperature, and level.

Control Systems: classification of control systems – block diagram representation and reductions – mathematical background and mathematical model of physical systems – time domain analysis, transient response, and stability – frequency response methods, polar plot, bode diagrams, Nyquist stability criteria.

Controllers: types of controllers – types of control action; proportional, integral, derivative, on-off controls – hydraulic, electronic, and pneumatic controllers.

Textbooks:

1. Doebelin, E. O., *Measurement Systems: Application and Design*, 5th ed., McGraw-Hill (2003).
2. D'Azzo, H., *Feedback Control System Analaysis and Synthesis*, CRC Press (2007).
3. Mutambara, A. G. O., *Design and Analysis of Control Systems*, CRC Press (2008).

References:

1. Beckwith, T. G., Lewis Buck, N., and Marangoni, R. D., *Mechanical Measurements*, 3rd ed., Addison-Wesley (1982).
2. Holman, J. P., *Experimental Methods for Engineers*, 7th ed., Tata McGraw-Hill (2004).
3. Raman, R., *Principles of Mechanical Measurements*, Oxford & IBH (1997).
4. Bryson, A. E., *Control of Spacecraft and Aircraft*, Princeton Univ. Press (1994).
5. Nise, N. S., *Control Systems Engineering*, 4th ed., Wiley India (2003).
6. Qiu, L. and Zhou, K., *Introduction to Feedback Control*, Prentice Hall (2009).

CH311 ENVIRONMENTAL SCIENCE AND ENGINEERING (2 – 0 – 0) 2 credits

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.

Textbook:

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

References:

1. Baird, C. and Cann, M., *Environmental Chemistry*, 3rd ed., W. H. Freeman and Company (2005).
2. *Manual on Water Supply and Treatment*, CPHEEO, Ministry of Urban Development, GOI (1999).
3. *Manual on Sewerage and Sewage Development*, CPHEEO, Ministry of Urban Development, GOI (1993).

4. Hauser, B. A., *Practical Hydraulics Hand Book*, Lewis Pub. (1991).
5. Hammer, M. J., *Water and Wastewater Technology*, Regents/Prentice Hall (1991).
6. Sharma, J. P., *Comprehensive Environmental Studies*, Laxmi Pub. (2004).
7. Garg, S. K., *Environmental Engineering* (Vol. 1 & Vol. 2), Khanna Pub. (2004).
8. Kiely, G., *Environmental Engineering*, McGraw-Hill (1997).
9. Bharucha, E., *Textbook of Environmental Studies*, University Grants Commission (2004).
10. Vanloon, G. W. and Duffy, S. J., *Environmental Chemistry: A Global Perspective*, Oxford Univ. Press (2000).

AE331	AERODYNAMICS LAB	(0 – 0 – 3) 1 credit

AE332	METROLOGY LAB	(0 – 0 – 3) 1 credit

AV335	INSTRUMENTATION AND CONTROL SYSTEMS LAB	(0 – 0 – 3) 1 credit

SEMESTER VI

AE321 ATMOSPHERIC FLIGHT MECHANICS (3 – 0 – 0) 3 credits

Overview of aerodynamics, propulsion, atmosphere and aircraft instrumentation – frames of reference – body axis, wind axis, earth centric, inertial – equations of motion in non-rotating earth and flat-earth frames of reference – aircraft performance – gliding, cruise and climbing flight, optimal cruise trajectories, take-off and landing – V-n diagrams – static longitudinal, directional, and lateral stability and control – stick fixed and stick free stability, hinge moments, trim-tabs, aerodynamic balancing – effect of manoeuvres – aerodynamic modelling, simulation, concept of steady states, linearisation, decoupling of longitudinal and lateral/directional motion – dynamic stability, longitudinal motion and short period and phugoid modes, lateral/directional motion, spiral, divergence, roll subsidence and dutch roll modes – stability, control and performance characteristics of sounding rockets and launch vehicles.

Textbooks:

1. Hull, D. G., *Fundamentals of Airplane Flight Mechanics*, Springer (2007).
2. Perkins, C. D. And Hage, R. E., *Airplane Performance Stability & Control*, John Wiley (1949).

References:

1. Etkin, B., *Dynamics of Flight*, John Wiley (1989).
2. McCormick, B. W., *Aerodynamics, Aeronautics, and Flight Dynamics*, 2nd ed., John Wiley (1994).
3. Pamadi, B. N., *Performance, Stability, Dynamics, and Control of Airplanes*, 2nd ed., AIAA Edu. Series (2004).
4. Smetana, F. O., *Flight Vehicle Performance and Aerodynamic Control*, AIAA Edu. Series (2001).

AE322 SPACEFLIGHT MECHANICS (3 – 0 – 0) 3 credits

Dynamics of particle: reference frames and rotations, energy, angular momentum – two body motion: equations of motion, Kepler's laws, solution to two-body problem, conics and relations, vis-viva equation, Kepler equation, orbital elements, orbit determination, Lambert problem, satellite tracking – earth satellite operations: orbit maneuvers, Hohmann transfer, inclination change maneuvers, combined maneuvers, bi-elliptic maneuvers, effects due to atmospheric drag, earth oblateness effects, orbit maintenance – rocket performance: rocket equation, multi-staging – rigid body dynamics, satellite attitude dynamics, attitude control of spinning and non-spinning spacecrafts, re-entry trajectories, aerobraking – interplanetary trajectories: n-body problem, sphere of influence, synodic period, launch opportunity, methods of trajectory design, restricted three-body problem, Lagrangian points.

Textbooks:

1. Wiesel, W. E., *Spaceflight Dynamics*, 2nd ed., McGraw-Hill (1996).
2. Tewari, A., *Atmospheric and Space Flight Dynamics: Modeling and Simulation with MATLAB and Simulink*, Birkhuser (2007).

References:

1. Hale, F. J., *Introduction to Space Flight*, Prentice Hall (1994).
2. Cornelisse, J. W., Schoyer, H. F. R., and Wakker, K. F., *Rocket Propulsion and Spaceflight Dynamics*, Pitman Publishing (1979).

AE323 AIR-BREATHING PROPULSION (3 – 0 – 0) 3 credits

Review of combustion and flames – introduction to air breathing propulsion systems – review of basic gas dynamics equations – types of nozzles – design and operating characteristics – aircraft engine types – performance measures – fundamentals of aircraft gas turbine engine cycles – engine components and configurations – working performance evaluation – design and off design performance – basics of turbomachinery– compressor and turbine blade flow path analysis (centrifugal and axial types) – hypersonic air breathing engines – ramjet and scramjet – combustion systems.

Textbooks:

1. Hill, P. G. and Peterson, C. R., *Mechanics and Thermodynamics of Propulsion*, 2nd ed., Addison-Wesley (1992).
2. Mattingly, J. D., *Elements of Propulsion: Gas Turbines and Rockets*, AIAA Edu. Series, 2006.

References:

1. Flack, R. D., *Fundamentals of Jet Propulsion with Applications*, Cambridge Univ. Press (2005).
2. Mattingly, J. D., *Elements of Gas Turbine Propulsion*, AIAA Edu. Series (2005).
3. Heiser, W. H. and Pratt, D. T., *Hypersonic Air Breathing Propulsion*, AIAA Edu. Series (1994).

AE324 AEROSPACE STRUCTURES II (3 – 1 – 0) 4 credits

Description of essential features of aircraft, rocket and spacecraft structures – type of loads on flight structures – bending, shear and torsion of open and closed thin-walled beams – monocoque, stiffened plate, isogrid 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.

Textbook:

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

References:

1. Timoshenko, S. P. and Goodier, J. N., *Theory of Elasticity*, 3rd ed., McGraw-Hill (1970).
2. Timoshenko, S. P. and Woinowsky-Krieger, S., *Theory of Plates and Shells*, 2nd ed., McGraw-Hill (1964).
3. Bruhn, E. F., *Analysis and Design of Flight Vehicle Structures*, 2nd ed., Jacobs Publishing Inc. (1973).

E01 *STREAM ELECTIVE I* (3 – 0 – 0) 3 credits

HS321 PRINCIPLES OF MANAGEMENT SYSTEMS (3 – 0 – 0) 3 credits

Personnel Management: introduction – changing role of personnel manager – new people management – manpower planning – recruitment and selection – performance appraisal – workers participation in management – grievance handling.
Industrial Management: management functions – organization – principles of planning – management by objectives – organization structures – principles of organizing – span of control – delegation, leadership, directing, and controlling.
Project Management: development of project network – project representation – project scheduling – linear time-cost trade-offs in projects: a heuristic approach – project monitoring and control with PERT.

References:

1. Koontz H., ODonnel, C., and Weihrich, H., *Essentials of Management*, McGraw-Hill (1990).
2. Venkataratnam, C. S. and Srivastava, B. K., *Personnel Management and Human Resources*, Tata McGraw-Hill (1991).
3. Mazda F., *Engineering Management*, Prentice Hall (1997)
4. Gido, J. and Clements, J. P., *Successful Project Management*, 2nd ed., South-Western College Publishing (2003)
5. Khanna, O. P., *Industrial Engineering and Management*, Dhanpat Rai Publications (P) Ltd. (2003).
6. Memoria, C. B. and Gankar, S. V., *Personnel Management – Text and Cases*, Himalaya Publishing House (2007).

AE341 AEROSPACE STRUCTURES LAB (0 – 0 – 3) 1 credit

AE342 MANUFACTURING PROCESSES LAB (0 – 0 – 3) 1 credit

SEMESTER VII

AE411 ROCKET PROPULSION (3 – 0 – 0) 3 credits

Introduction to rocket propulsion systems – rocket propulsion engines – types of rocket nozzles and thrust vector control – propellants – combustion in rocket engines – parameters for chemical rockets – elements of liquid propulsion systems – thrust chambers – turbo pumps – nonconventional propulsion techniques – solid rocket motors – grain configuration – hybrid rockets – rocket testing and performance evaluation – selection of rocket motors.

Textbook:

- Sutton, G. P. and Biblarz, O., *Rocket Propulsion Elements*, 7th ed., John Wiley (2000).

References:

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

AE412 AEROSPACE VEHICLE DESIGN (3 – 0 – 0) 3 credits

Aircraft Design: introduction – 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.

Space Vehicle Design: mission design – basic orbital mechanics – range safety – rocket propulsion options – attitude determination and control – configuration and structural design – thermal control – power systems – design for re-entry – vehicle integration and recovery – introduction to multi-disciplinary design optimization.

Textbooks:

1. Raymer, D. P., *Aircraft Design: A Conceptual Approach*, 4th ed., AIAA Edu. Series (2006).
2. Griffin, M. D. and French, J. R., *Space Vehicle Design*, 2nd ed., AIAA Edu. Series (2004).

References:

1. Anderson, J. D., *Aircraft Design*, McGraw-Hill (1999).
2. Corke, T. C., *Design of Aircraft*, Prentice Hall (2002).
3. Fielding, J. P., *Introduction to Aircraft Design*, Cambridge Univ. Press (1999).

E02 *STREAM ELECTIVE II* (3 – 0 – 0) 3 credits

E03	*STREAM ELECTIVE III*	(3 – 0 – 0) 3 credits
E04	*DEPARTMENT ELECTIVE*	(3 – 0 – 0) 3 credits
E05	*INSTITUTE ELECTIVE*	(3 – 0 – 0) 3 credits
AE431	MODELING AND ANALYSIS LAB	(0 – 0 – 3) 1 credit
AE432	FLIGHT MECHANICS AND PROPULSION LAB	(0 – 0 – 3) 1 credit
AE451	SUMMER INTERNSHIP AND TRAINING	3 credits
AE452	SEMINAR	2 credits

SEMESTER VIII

AE453	COMPREHENSIVE VIVA-VOCE	3 credits
AE454	PROJECT WORK	12 credits

ELECTIVES

AE461 ADVANCED AERODYNAMICS (3 – 0 – 0) 3 credits

Introduction to experimental aerodynamic facilities – classification of experimental facilities – continuous, blow-down and impulse facilities – wind tunnel instrumentation – special testing techniques.

Introduction to computational aerodynamics – various levels of approximations – grid generation – boundary conditions.

Introduction to hypersonic flows – analytical and computational methods – hypersonic boundary layer theory – aerodynamic heating – viscous-inviscid interactions.

Re-entry vehicle aerodynamics – earth and Martian atmosphere models – continuum and free molecular flows.

Introduction to aerothermodynamics – real and perfect gases – chemical equilibrium and non-equilibrium – solutions for stagnation point flow.

Introduction to kinetic theory of gases – introduction to turbulence – use of turbulent models for external flows.

Textbooks:

1. Anderson Jr, J. D., *Hypersonic and High-Temperature Gas Dynamics*, 2nd ed., AIAA Edu. Series (2006).
2. Barlow, J. B., Rae Jr, W. H., and Pope, A., *Low-Speed Wind Tunnel Testing*, 3rd ed., Wiley (1999).
3. Versteeg, H. K., Malalasekera, W., *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, 2nd ed., Prentice Hall (2007).

References:

1. Pope, A. and Goin K. L., *High-Speed Wind Tunnel Testing*, Krieger Pub. Co. (1978).
2. Goethert, B. H., *Transonic Wind Tunnel Testing*, Dover (2007).
3. Hirschel, E. H. and Weiland, C., *Selected Aerothermodynamic Design Problems of Hypersonic Flight Vehicles*, AIAA/Springer (2009).
4. Toro, E. F., *Riemann Solvers and Numerical Methods for Fluid Dynamics: A Practical Introduction*, 2nd ed., Springer-Verlag (1999).

AE462 ADVANCED AEROSPACE STRUCTURES (3 – 0 – 0) 3 credits

Description of essential features of aircraft, rocket and spacecraft structures – type of loads on flight structures – bending, shear and torsion of open and closed thin-walled beams – monocoque, stiffened plate, isogrid 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.

Textbook:

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

References:

1. Timoshenko, S. P. and Goodier, J. N., *Theory of Elasticity*, 3rd ed., McGraw-Hill (1970).
2. Timoshenko, S. P. and Woinowsky-Krieger, S., *Theory of Plates and Shells*, 2nd ed., McGraw-Hill (1964).
3. Bruhn, E. F., *Analysis and Design of Flight Vehicle Structures*, 2nd ed., Jacobs Publishing Inc. (1973).

AE463 ADVANCED FLUID MECHANICS (3 – 0 – 0) 3 credits

Fluid kinematics – physical conservation laws – review of integral and differential formulations – Navier–Stokes and energy equations – solution of Navier–Stokes equations; steady and unsteady flows – waves in fluids (potential flow formulation) – boundary layer theory; Blasius solution, Falkner–Skan solutions, momentum integral approach – introduction to turbulent flows.

References:

1. White, F. M., *Viscous Fluid Flow*, 3rd ed., McGraw-Hill (2006).
2. Panton, R. L., *Incompressible Flow*, 3rd ed., John Wiley (2005).
3. Kundu, P. K. and Cohen, I. M., *Fluid Mechanics*, 4th ed., Academic Press (2007).
4. Leal, L. G., *Advanced Transport Phenomena*, Cambridge Univ. Press (2007).
5. Schlichting, H. and Gersten, K., *Boundary Layer Theory*, 8th ed., McGraw-Hill (2001).

AE464 ADVANCED HEAT TRANSFER (3 – 0 – 0) 3 credits

Radiation Heat Transfer: fundamentals – view factors – network method and enclosure analysis for gray – diffuse enclosures containing transparent media – engineering treatment of gas radiation.

Two Phase Flow: fundamentals – flow patterns – basic equations for homogeneous flow and the separated-flow model.

Boiling Heat Transfer: pool boiling – forced convective – cross flow – multicomponent boiling – correlations for boiling coefficient – critical heat flux.

Condensation: modes of condensation – film-wise condensation on vertical surfaces – horizontal tube systems – condensation in multicomponent systems.

Enhancement of Heat Transfer: active, passive, and compound techniques.

Textbooks:

1. Incroprera, F. P. and Dewitt, D. P., *Heat and Mass Transfer*, 5th ed., Wiley (2002).
2. Hewitt, G. F., Shires, G. L., and Bott, T. R., *Process Heat Transfer*, CRC Press (1994).

References:

1. Çengel, Y. A., *Heat and Mass Transfer*, 3rd ed., Tata McGraw-Hill (2007).
2. Das, S. K., *Process Heat Transfer*, Narosa (2006).
3. Sparrow, E. M. and Cess, R. D., *Radiation Heat Transfer*, CRC Press (1978).

AE466 AEROELASTICITY (3 – 0 – 0) 3 credits

Fundamental aspects of structural dynamics – free vibration and modal representation of flexible structures – application to beam extension, shear, bending and torsion dynamics – static aeroelasticity – wind tunnel models – divergence and aileron reversal – Lifting surfaces: torsional divergence and load redistribution, aeroelastic tailoring – aeroelastic flutter – stability characteristics – Flutter analysis: wind tunnel models – flexible wings.

Textbook:

- Hodges, H., *Introduction to Structural Dynamics and Aeroelasticity*, Cambridge Univ. Press (2002).

AE467 ANALYSIS AND DESIGN OF COMPOSITE STRUCTURES (3 – 0 – 0) 3 credits

Introduction – classification and applications of composites – fiber-reinforced composites – micro and macro-mechanical analysis – analysis of simple laminated composite structural elements – failure and fracture of composite lamina – bending and vibration of composite and sandwich structural elements – design of aerospace composite and sandwich structures.

Textbook:

- Jones, R. M., *Mechanics of Composite Materials*, 2nd ed., Taylor & Francis (1999).

References:

1. Gibson, R. F., *Principles of Composite Materials Mechanics*, 2nd ed., McGraw-Hill (1994).
2. Daniel, I. M. and Ishai, O., *Engineering Mechanics of Composite Materials*, 2nd ed., Oxford Univ. Press (2005).
3. Hong, T. H. and Tsai, S. W., *Introduction to Composite Materials*, Technomic Pub. Co. (1980).
4. Vasiliev, V. V. and Morozov, E. V., *Advanced Mechanics of Composite Materials*, 3rd ed., Elsevier (2007).

AE468 COMPUTATIONAL FLUID DYNAMICS (3 – 0 – 0) 3 credits

Mathematical models for fluid dynamics – classification of partial differential equations – discretization methods – finite difference formulation – numerical solution of elliptic equations – linear system of algebraic equations – numerical solution of parabolic equations – stability analysis – numerical solution of hyperbolic equations – Burgers equation – incompressible Navier-Stokes equations and their solution algorithms – finite volume method.

Textbook:

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

References:

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

AE469 COMPUTER INTEGRATED MANUFACTURING (3 – 0 – 0) 3 credits

Manufacturing Systems: computer integrated manufacturing – computer aided design (CAD) and engineering (CAE) – computer aided manufacturing (CAM) and concurrent engineering.

NC, CNC and DNC; CNC Machines: general concepts, design features, drives and controls, programming – adaptive control – machining centres.

Shop Floor Automation: automated material handling – assembly and inspection – computer aided process planning (CAPP) – computer integrated production management system – group technology and cellular manufacturing – flexible manufacturing system – automatic storage/retrieval systems (AS/RS) – Just In Time (JIT) – lean manufacturing.

Textbook:

- Groover, M. P., *Automation, Production Systems and Computer Integrated Manufacturing*, 3rd ed., Prentice Hall of India (2007).

References:

1. Kant Vajpayee, S., *Principles of Computer Integrated Manufacturing*, Prentice Hall of India (1995).
2. Rehg, J. A. and Kraebber, H. W., *Computer Integrated Manufacturing*, 3rd ed., Pearson Prentice Hall (2004).
3. Venkateswaran, N. and Alavudeen, A., *Computer Integrated Manufacturing*, Prentice Hall of India (2008).
4. Groover, M. P. and Zimmers, E. W., *CAD/CAM: Computer-Aided Design and Manufacturing*, Prentice Hall of India (1984).

AE470 DESIGN OF AEROSPACE STRUCTURES (3 – 0 – 0) 3 credits

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 – design project.

References:

1. Shigley, J. E., Mischke, C., and Budynas, R., *Mechanical Engineering Design*, 7th ed., McGraw-Hill (2003).
2. Bruhn, E. F., *Analysis and Design of Flight Vehicle Structures*, 2nd ed., Jacobs Publishing Inc. (1973).
3. Niu, M. C.Y., *Airframe Structural Design*, 2nd ed., Hongkong Conmilit Press Ltd. (2002).
4. Harvey, J. F., *Theory and Design of Modern Pressure Vessels*, 2nd ed., Van Nostrand (1974).

AE471 CONVECTION HEAT TRANSFER (3 – 0 – 0) 3 credits

Introduction transport properties for viscous, conducting fluids – kinematic properties – fundamental conservation equations; Navier-Stokes equations and energy equation – dimensionless parameters – solution of Newtonian viscous flows – 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.

Textbooks:

1. Bejan, A., *Convection Heat Transfer*, Wiley, 3rd ed., Wiley (2004).
2. Burmeister, L. C., *Convective Heat Transfer*, 2nd ed., Wiley (1993).

AE472 EXPERIMENTAL AERODYNAMICS (3 – 0 – 0) 3 credits

Introduction to aerodynamic test facilities in various Mach number regimes: low speed, transonic, supersonic, hypersonic, and high enthalpy – design of subsonic, transonic, and supersonic wind tunnels – wind tunnel calibration – low speed flow visualisation techniques – dynamic stability derivatives – design of hypersonic wind tunnels – design of shock tube / shock tunnels – calibration of various wind tunnels – Flow visualisation techniques: Schlieren, shadowgraph, interferometry – introduction to laser diagnostic techniques – RTD, thermocouples, thermography, etc. – force measurement techniques in shock tunnel – introduction to wind tunnel instrumentation – Measurements techniques in wind tunnels: forces and moments, pressure, velocity, temperature, aeroacoustic measurements – error analysis – Instrumentation / data acquisition: steady and unsteady, shock tunnel data acquisition – virtual instrumentation – PLCs – measurement of steady and unsteady pressure, velocity, temperature, turbulence intensity, hot-wire, skin friction, forces and moments – Model design and fabrication: RP, FRP, metal, actuators – calibration of force, pressure and acoustic sensors.

References:

1. Barlow, J. B., Rae Jr, W. H., and Pope, A., *Low-Speed Wind Tunnel Testing*, 3rd ed., Wiley (1999).
2. Pope, A. and Goin K., *High-Speed Wind Tunnel Testing*, Krieger Pub. Co. (1972).
3. Goethert, B. H., *Transonic Wind Tunnel Testing*, Dover Publications (2007).
4. Pavian H. C., *Experimental Aerodynamics*, Pitman Publishing (1940).
5. Mueller, T. J., Allen, C. S., Blake, W. K., Dougherty, R. P., Lynch, D., Soderman, P. T., and Underbrink, J. R., *Aeroacoustic Measurements*, Springer (2010).
6. Langley, S. P., *Experiments in Aerodynamics*, Nabu Press (2010).

AE473 FINITE ELEMENT METHOD (3 – 0 – 0) 3 credits

Introduction – weighted residual methods – Galerkin's method – variational approach – Rayleigh-Ritz method – one-dimensional finite element analysis; types of elements, shape functions – heat transfer problems – numerical integration – applications to structural mechanics – fluid flow problems.

Textbook:

- Segerlind, L. J., *Applied Finite Element Analysis*, 2nd ed., John Wiley (1984).

References:

1. Henwood, D. and Bonet, J., *Finite Elements – A Gentle Introduction*, Macmillan (1996).
2. Reddy, J. N., *Introduction to the Finite Element Method*, 3rd ed., McGraw-Hill (2006).
3. Zienkiewicz, O. C., Taylor, R. L., and Nithiarasu, P., *Finite Element Method for Fluid Dynamics*, 6th ed., Elsevier Butterworth-Heinemann (2005).

AE474 FRACTURE MECHANICS (3 – 0 – 0) 3 credits

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.

Textbook:

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

References:

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

AE475 ENGINEERING VIBRATION (3 – 0 – 0) 3 credits

Introduction to vibration – single degree of freedom systems: free, undamped, damped, and forced vibrations – two-degree of freedom systems: principal modes of vibration, undamped vibration, forced vibration, forced damped vibrations – vibration isolation – multi-degree 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 non-linear vibrations.

Textbook:

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

References:

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

AE476 INDUSTRIAL ENGINEERING (3 – 0 – 0) 3 credits

Introduction, production planning and control – product design – value analysis and value engineering – plant location and layout – equipment selection – maintenance planning – job, batch, and flow production methods – group technology – work study – time and motion study – work/job evaluation – inventory control – manufacturing planning – total quality management – Taguchi's quality engineering – network models.

Textbooks:

1. Narasimhan, S. L., McLeavey D. W., and Billington, P. J., *Production, Planning and Inventory Control*, Prentice Hall (1977).
2. Riggs, J. L., *Production Systems: Planning, Analysis and Control*, 3rd ed., Wiley (1981).

References:

1. Muhlemann, A., Oakland, J. O., and Lockyer, K., *Productions and Operations Management*, Macmillan (1992).
2. Taha, H. A., *Operations Research: An Introduction*, Prentice Hall of India (1997).
3. Sharma, J. K., *Operations Research*, Macmillan (1997).

AE477 FUNDAMENTALS OF COMBUSTION (3 – 0 – 0) 3 credits

Combustion and thermochemistry – chemical kinetics and mechanisms – reacting flows-premixed flames – detonation and explosion – diffusion flames.

Textbook:

- Turns, S. R., *An Introduction to Combustion*, 2nd ed., McGraw-Hill (2000).

References:

1. Glassman, I. and Yetter, R. A., *Combustion*, 4th ed., Elsevier (2008).
2. Kuo, K. K., *Principles of Combustion*, 2nd ed., John Wiley (2005).
3. Warnatz, J., Maas, U., and Dibble, R. W., *Combustion* 4th ed., Springer (2006).
4. Law C. K., *Combustion Physics*, Cambridge Univ. Press (2006).

AE478 SUPPLY CHAIN MANAGEMENT (3 – 0 – 0) 3 credits

Introduction and a strategic view of supply chains – evolution of supply chain management (SCM) – decision phases in a supply chain – enablers of supply chain performance – supply chain strategy and performance measures – achieving strategic fit – network design in the supply chain – supply chain drivers and obstacles – operations decisions in supply chains – forecasting, aggregate planning – inventory control in supply chain – sourcing decisions in supply chain – supplier selection – transportation in supply chain – routing and scheduling using savings matrix method – coordination in supply chain – bullwhip effect – enabling supply chain management through information technology.

Textbook:

- Chopra, S. and Meindl, P., *Supply Chain Management: Strategy, Planning, and Operation*, Pearson Prentice Hall of India (2007).

References:

1. Levi, D. S., Kaminsky, P., Levi, E. S., and Shankar, R., *Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies*, Tata McGraw-Hill (2008).
2. Stadtler, H. and Kilger, C., *Supply Chain Management and Advanced Planning: Concepts, Models, Software and Case Studies*, 3rd ed., Springer-Verlag (2003).
3. Shapiro, J. F., *Modeling the Supply Chain*, Thomson Learning (2007).
4. Vollmann, T. E., Berry, W. L., Whybark, D. C., and Jacobs, F. R., *Manufacturing Planning and Control for Supply Chain Management*, Tata McGraw-Hill (2006).

AE479 INTRODUCTION TO OPTIMIZATION (3 – 0 – 0) 3 credits

Optimization in science and engineering – general and special classes of problems – characterization of unconstrained and constrained minima – Lagrange multipliers – KKT conditions – linear programming – simplex tableau – duality – one dimensional optimization – elimination and interpolation techniques – multidimensional unconstrained minimization – steepest descent – Newton's and quasi-Newton techniques – randomized searches – genetic algorithm and simulated annealing – introduction to constrained minimization – large scale problems – multi-disciplinary optimization – applications in design, analysis, and control.

Textbook:

- Deb, K., *Optimization for Engineering Design: Algorithms and Examples*, Prentice Hall of India (2004).

References:

1. Rao, S. S., *Engineering Optimization: Theory and Practice*, Wiley Eastern (1996).

AE480 NONTRADITIONAL MACHINING (3 – 0 – 0) 3 credits

Nontraditional machining – thermal, chemical, and abrasives techniques; need, principle, process mechanics and variables, equipments, performance characteristics – application and recent trends of electrical discharge machining (EDM), wire EDM, wire EDG, electro-chemical machining (ECM), ECG, ultrasonic, laser beam, electron beam, abrasive and water jet machining, and hybrid processes – nontraditional micromachining.

Textbooks:

1. Jain, V. K., *Advanced Machining Processes*, Allied Pub. (2002).
2. Mishra, P. K., *Nonconventional Machining*, Narosa (2006).

References:

1. Sharma, P. C., *A Textbook of Production Engineering*, S. Chand & Co. (2005).
2. Benedict, G. F., *Non-Traditional Machining Processes*, Marcel Dekker (1987).
3. Pandey, P. C. and Shan, H. S., *Modern Machining Process*, Tata McGraw-Hill (2004).

AE483 ROBOT MECHANISMS AND MOTION PLANNING (3 – 0 – 0) 3 credits

Overview of robotics – different types of robots – manipulators and mobile robots – mechanisms used in robots – serial and parallel chains – degrees of freedom – means of mobility, rovers.

Rigid body displacements – homogenous transformation – mechanism parameters – Denavit–Hartenberg notation – forward and inverse kinematic problems – velocity and static analysis.

Higher level control – motion planning, obstacle avoidance – road map and potential field methods – higher level sensors – vision, laser and ultrasonic range finders – localization and mapping.

References:

1. Ghosal, A., *Robotics: Fundamental Concepts and Analysis*, Oxford Univ. Press (2006).

2. Choset, H., Lynch, K. M., Hutchinson, S., Kantor, G., Burgard, W., Kavraki, L. E., and Thrun, S., *Principles of Robot Motion: Theory, Algorithms, and Implementations*, MIT Press, Prentice Hall of India (2005).
3. Craig, J. J., *Introduction to Robotics: Mechanics and Control*, 2nd ed., Pearson Education (2001).

AE484 SPACE MISSION DESIGN AND OPTIMIZATION (3 – 0 – 0) 3 credits

Launch vehicle ascent trajectory design – reentry trajectory design – low thrust trajectory design – satellite constellation design – rendezvous mission design – ballistic lunar and interplanetary trajectory 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:

1. Osborne, G. F. and Ball, K. J., *Space Vehicle Dynamics*, Oxford Univ. Press (1967).
2. Hale, F. J., *Introduction to Space Flight*, Prentice Hall (1994).
3. Naidu, D. S., *Optimal Control Systems*, CRC Press (2003).

References:

1. Chobotov, V., *Orbital Mechanics*, AIAA Education Series (2002).
2. Griffin, M. D. and French, J. R., *Space Vehicle Design*, 2nd ed., AIAA (2004).
3. Newcomb, R. W. and Kirk, D. E., *Optimal Control Theory: An Introduction*, Prentice Hall (1990).
4. Bulirsch, R., Miele, A., Stoer, J., and Well, K. H. (Ed.), *Optimal Control: Calculus of Variations, Optimal Control Theory and Numerical Methods*, Birkhauser Verlag (1993).

AE486 REFRIGERATION AND CRYOGENICS (3 – 0 – 0) 3 credits

Refrigeration: introduction – analysis of VCR cycles – multistage, multi-evaporator, cascade systems – properties and selection of pure and mixed refrigerants – properties of binary mixtures – analysis of vapor absorption cycles – aqua ammonia and LiBr water cycles – air cycle refrigeration, vortex tube, thermoelectric refrigeration.

Cryogenic Engineering: 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-properties of materials of low temperatures – material of construction and techniques of fabrication – instrumentation – ultra-low temperature techniques – application.

Textbooks:

1. Stoecker, W. F. and Jones, J. W., *Refrigeration & Air Conditioning*, Tata McGraw-Hill (1986).
2. Barron, R. F., *Cryogenic Systems*, 2nd ed., Oxford Univ. Press (1985).

References:

1. Gosney W. B, *Principles of Refrigeration*, Cambridge Univ. Press (1982).
2. Weisend, J. G., *The Handbook of Cryogenic Engineering*, Taylor & Francis (1998).

AE487 TURBOMACHINES (3 – 0 – 0) 3 credits

Classification – specific work – representation of specific work in T-s and h-s diagrams – Internal and external losses – Euler's equation of turbomachinery – ideal and actual velocity triangles – slip and its estimation – impulse and reaction type machines – degree of reaction – effect of outlet blade angle on blade shape – model laws, specific speed and shape number – special features of steam and gas turbines – performance characteristics of turbomachines – cavitation, surge and stall – thin aerofoil theory – cascade mechanics.

Textbook:

- Dixon, S. L., *Fluid Mechanics and Thermodynamics of Turbomachinery*, 5th ed., Butterworth-Heinemann (2005).

References:

1. Baskharone, E. A., *Principles of Turbomachinery and in Air-Breathing Engines*, Cambridge Univ. Press (2006).
2. Wright, T., *Fluid Machinery: Performance, Analysis, and Design*, CRC Press (1999).

AE488 AEROSPACE MATERIALS AND PROCESSES (3 – 0 – 0) 3 credits

Properties of materials: strength, hardness, fatigue, and creep – Ferrous alloys: stainless steels, maraging steel, aging treatments – Aluminum alloys: alloy designation and tempers, Al-Cu alloys, principles of age hardening, hardening mechanisms, Al-Li alloys, Al-Mg alloys, nanocrystalline aluminum alloys – Titanium alloys: α-β alloys, superplasticity, structural titanium alloys, intermetallics – Magnesium alloys: Mg-Al and Mg-Al-Zn alloys – Superalloys: processing and properties of superalloys, single-crystal superalloys, environmental degradation and protective coatings – Composites: metal matrix composites, polymer based composites, ceramic based composites, carbon carbon composites.

Textbooks:

1. Polmear, I. J., *Light Alloys: From Traditional Alloys to Nanocrystals*, 4th ed., Elsevier (2005).

2. Reed, R. C., *The Superalloys: Fundamentals and Applications*, Cambridge Univ. Press (2006).

References:

1. Cantor, B., Assender, H., and Grant, P. (Ed.), *Aerospace Materials*, CRC Press (2001).
2. *ASM Speciality Handbook: Heat Resistant Materials*, ASM International (1997).
3. Campbell, F. C., *Manufacturing Technology for Aerospace Structural Materials*, Elsevier (2006).
4. Kainer, K. U. (Ed.), *Metal Matrix Composites*, Wiley-VCH (2006).

AE489 ADVANCED MANUFACTURING AND AUTOMATION (3 – 0 – 0) 3 credits

Precision Engineering: concepts, materials, processes – high speed machining; CNC machine tools and machining centres, adaptive systems, multi axis CNC programming – micro/nano scale manufacturing – recent development in nontraditional machining.

Automation: introduction to automated manufacturing, basic concepts, automated work piece handling, orientation, positioning – flexible automation – assembly automation, product design for automation – automated inspection – sensors and actuators for automation – PLC programming and applications in automation.

Textbooks:

1. Groover, M. P., *Automation, Production Systems, and Computer-Integrated Manufacturing*, 3rd ed., Prentice Hall (2007).
2. Boothroyd, G., *Assembly Automation and Product Design*, 2nd ed., CRC Press (2005).

AE490 HEAT TRANSFER IN SPACE APPLICATIONS (3 – 0 – 0) 3 credits

Space Craft Thermal Environments: launch and ascent environments – environment of earth orbit – environments of interplanetary missions.

Thermal Control Techniques: passive thermal control techniques: thermal coating materials, thermal insulation, heat sinks, phase change materials – Active thermal control techniques: electrical heaters, thermal louvers, HPR fluid systems, heat pipes, spaceborne cooling systems.

Insulation-Blanket Design: materials-attachment – high temperature blankets – insulation for in-atmosphere applications.

Phase change materials – when to use a PCM-PCM design.

Heat Pipes-Types-Analysis-Testing: heat pipe applications and performances.

Thermal Contact Resistance and Its Calculation: parameters influencing thermal joint resistance-effect of oxidation and interstitial effects.

Ablative Heat Transfer: physical process and calculation of ablation rates – hypersonic ablation of graphite – heat transfer at high velocities – heat transfer in rarefied gases-transpiration and film cooling.

Textbook:

- Gilmore, D. G., *Spacecraft Thermal Control Handbook, Volume I: Fundamental Technologies*, 2nd ed., The Aerospace Press, American Institute of Aeronautics and Astronautics (2002).

References:

1. Fortescue, P., Swinerd, G., and Stark, J. (Ed.), *Spacecraft Systems Engineering*, 4th ed., John Wiley & Sons (2011).
2. Mayer, R. X., *Elements of Space Technology for Aerospace Engineers*, Academic Press (1999).
3. NASA SP 8105.

AE491 STRUCTURAL DYNAMICS (3 – 0 – 0) 3 credits

Review of vibration of SDOF systems – response to transient loading – response to general dynamic loading – multi degree of freedom systems – vibration of continuous systems; strings, rods, shafts, beams, and plates – natural modes of vibration; exact solutions and approximate methods – introduction to random vibrations.

Textbook:

- Meirovitch, L., *Elements of Vibration Analysis*, 2nd ed., Tata McGraw-Hill (2006).

References:

1. Meirovitch, L., *Analytical Methods in Vibrations*, Macmillan (1967).
2. Clough, R. W., and Penzien, J., *Dynamics of Structures*, 2nd ed., McGraw-Hill (1993).
3. Craig, R. R., *Structural Dynamics: An Introduction to Computer Methods*, John Wiley (1982).
4. Thomson, W. T. and Daleh, M. D., *Theory of Vibration with Applications*, 5th ed., Prentice Hall (1997).

AE492 TOOL ENGINEERING AND DESIGN (3 – 0 – 0) 3 credits

Cutting Tool: materials, geometry and nomenclature – single point and multi point cutting tools – grinding wheels – effect of tool geometry on machining characteristics – tool wear – tool life and economics of machining.

Inserts: geometry, nomenclature and materials – design concepts – coatings – selection and applications of cutting tools and inserts – design of tool holders – boring, broaching, surface finishing operations.

Tooling for CNC Machining: work holding – modular and automated tool handling – tooling for micro machining – conventional micro tools and electrodes for EDM & ECM – mechanism of ductile cutting, nanometric cutting, and chip formation – job examples and case study.

Design of Jigs and Fixtures: standard work holding devices and clamping elements – fixtures for milling – jigs for drilling and reaming – fixtures for welding – indexing jigs – design and sketching of jigs and fixtures – simple job examples and case study.

References:

1. Spitler, D., Lantrip, J., Nee, J., and Smith, D. A., *Fundamentals of Tool Design*, 5th ed., Society of Manufacturing Engineers (2003).
2. Donaldson, C., LeCain, G. H., and Goold, V. C., *Tool Design*, Tata McGraw-Hill (1998).
3. Hoffman, E., *Jig and Fixture Design*, 5th ed., Delmar Thomson Learning (2004).
4. *Hindustan Machine Tools, Production Technology*, Tata McGraw-Hill (1986).
5. Bhattacharyya A., *Metal Cutting Theory and Practice*, New Central Book Agency (2000).
6. Wilson F. W., *Hand Book of Fixture Design*, McGraw-Hill (1962).
7. Benedict, G. F., *Non-Traditional Machining Processes*, Marcel Dekker Inc. (1987).
8. Mishra, P. K., *Nonconventional Machining*, Narosa (2006).