Curriculum for the B.Tech. Program in Aerospace Engineering

1. Overview of the Basic B.Tech. Program

To obtain a B.Tech. Degree in Aerospace Engineering, a student will have to complete 252 credits as summarized in Table A.1 in Appendix I.

The only departures from the recommendations of the Biswas Committee are as follows:

a) The departmental introductory course (DIC) is proposed to be 8 credits instead of the 6 credits recommended by the Biswas Committee. As a result, the basic engineering group of courses adds up to 41 credits instead of the 39 credits recommended by the Biswas Committee. The additional two credits will enable the inclusion of a much needed hands-on component in the DIC.

b) To compensate, the departmental group of courses proposed add up to only 139 credits, so that the total credits add up to 252.

The Aerospace Department has opted not to include practical training and works visits among the requirements for its B.Tech. and Dual Degree programs.

2. Departmental Inputs

2.1 Departmental Core Course and Labs

The core departmental input consists of 13 courses and 7 labs totaling to 115 credits as listed in Table A.2 in Appendix II.

2.2 Electives

Students are required to successfully clear a minimum of 12 credits from the undergraduate elective courses offered by the Aerospace Department listed in Table A.3 in Appendix III. The number of courses may vary depending on the credits of the courses taken. Students satisfying eligibility criteria (such as CPI requirements) laid down by the Senate may take postgraduate courses offered by the Aerospace Department listed in Table A.4 in Appendix IV to fulfill part or whole of this requirement. Both lists of electives will be updated by the department from time to time with senate approval. For any given student any course that is counted towards this requirement will not be counted in part or full towards any other requirement of this or any other program in the Institute.

2.3 Supervised Learning

Students are required to successfully clear a minimum of 12 credits by choosing from a) and b) below in any combination:

a) Directed Study I and II: -Students will have the option of registering for one or two units of directed study under supervised learning. The units called Directed Study I and Directed Study II, will each have a different AE course number, and each will be of 6 credits.

Each unit has to be registered for, and performed under, the supervision of a guide over the duration of a semester. In cases where a student takes two units of directed study, they are to be in different semesters, and may or may not be under the same supervisor. Even when performed under the same supervisor, they may or may not be in continuation. In other words, the two units are to be viewed as operationally independent.

Each unit may involve a literature survey (seminar), design/development/fabrication/testing of equipment/prototype, design project, research project, design/development of algorithms/software, collection/analysis of experimental data using sophisticated equipment/methods, or design of an experiment, and is expected to require 6-8 hours of effort per week.

Norms for registration and evaluation for both units of directed study will be evolved by the DUGC. The availability of directed study units depend upon offerings by individual faculty members in their areas of interest. Faculty members may prescribe/expect additional abilities such as skill sets (mathematical/programming etc.) and/or demonstrated interest/motivation from students, in conjunction with the eligibility norms, depending upon the type and area of work involved in the directed study unit. The realization of directed study units is therefore envisaged as a coming together of student interest backed by abilities with faculty interest backed by specific expectations. Therefore, all the students from a batch, may or may not be able to able to opt for directed study.

b) Students who have not opted for, or are unable to complete successfully, one or both units of directed study, will be required to register and clear 6 to12 credits from the departmental undergraduate elective courses listed in Table A.3 (and/or post-graduate elective courses listed in Table A.4 subject to eligibility criteria), in lieu of supervised learning. These electives will be in addition to the compulsory requirement of two electives described in subsection 2.2 above. Thus, students in the 252 credit program, opting and successfully completing both units of directed study are not required to take any additional electives. Students opting and completing one unit of directed study are required to take an additional 6 credits under electives. Students not earning any credits through directed study are required to take 12 credits under electives.

For any given student any course or directed study that is counted towards this requirement of supervised learning will not be counted in part or full towards any other requirement of this or any other program in the Institute.

3. Honors in Aerospace Engineering

To obtain an honors in Aerospace Engineering, a student has to obtain 30 credits in addition to the 252 credits for the basic B.Tech program described in Section 1. A student may obtain these 30 additional credits by choosing from the following options in any combination of his/her choice.

a) B.Tech Project: A student may obtain 18 credits by choosing BTP Stage I for 6 credits and BTP Stage II for 12 credits in two different and consecutive semesters of the IIIrd and IVth years of the BTech program. Stages I and II are expected to involve 6-8 and 13-15 hours of effort, respectively, per week, and should together represent a unified body of work performed under the supervision of the same guide(s). The department also proposes to evolve and implement with Senate approval exit options to enable a student and his/her guide(s) to mutually agree to end the BTP after Stage I, with the student earning credit for stage I, if completed successfully.

b) Departmental UG Electives: A student may fulfill whole or part of the 30 credit honors requirement by choosing courses from the list of departmental UG courses given in Table A.3 in Appendix III.

c) Departmental PG Electives: A student satisfying Senate approved eligibility criteria may also fulfill whole or part of the requirement of the 30 credit honors requirement by choosing courses from the list of departmental PG courses listed in Table A.4 in Appendix IV.

4. Minor in Aerospace Engineering

A student of the B.Tech or DD program offered by departments other than the Aerospace Engineering Department may obtain a minor in Aerospace Engineering by completing 30 credits. To obtain these 30 credits,

a) The student has to compulsorily take AE 152, Introduction to Aerospace Engineering (DIC, 8 credits), in any semester of his/her choice subject to availability.

b) In addition, the student has to take a minimum of 22 credits from the following set of nine courses.

1) AE xxx Fluid Mechanics (8 credits)
2) AE xxx Thermodynamics (6 credits)
3) AE xxx Solid Mechanics (8 credits)
4) AE xxx Aerodynamics (6 credits, prerequisite Fluid Mechanics or equivalent)
5) AE xxx Propulsion (8 credits, prerequisite Thermodynamics or equivalent)
6) AE xxx Aerospace Structural Mechanics (8 credits, prerequisite Solid Mechanics or equivalent)
7) AE xxx Flight Mechanics (6 credits)
8) AE 415 Spaceflight Mechanics (6 credits)
9) AE 332 Aircraft Design (6 credits, prerequisite DIC and Fluid Mechanics or equivalent)

It is recommended that, to derive maximum benefit from a minor in Aerospace Engineering, students who study thermodynamics, solid mechanics and fluid mechanics as part of their basic B.Tech program in their respective parent departments, should not repeat related courses from the list of optional courses above, and instead should complete the 30 credit requirement from the remaining courses listed above.

The Aerospace Engineering Department will evolve application procedures and selection norms for students interested in a minor in aerospace engineering.

5. Dual Degree Program

To obtain a dual degree in aerospace engineering, a student has to complete

i. 252 credits towards the basic B.Tech degree as described in Sec. 1 including the departmental inputs as described in Sec. 2,

ii. 30 credits as part of the compulsory honors requirement as described in Sec. 3,

iii. 24 credits of postgraduate courses as specified below, and

iv. 76 credits of M.Tech dissertation work, amounting to a total of 378 credits. A detailed breakup of the DD program is given in Table A.5 in Appendix V.

To earn the required 24 credits of postgraduate coursework, a student must take

a) at least three courses from the list of postgraduate courses offered by the Aerospace Department given in Table A.4 of Appendix IV, and

b) not more than one course from the non departmental PG courses listed in Table A.6 of Appendix VI, which may be updated with Senate approval from time to time.

The M.Tech dissertation work must be supervised or co-supervised by a faculty member of the Aerospace Department.

6. Semester-wise Schedule of Courses

The distribution of the first year common courses between the first two semesters is decided by the Academic Section based on logistics of course delivery. The distribution of the remaining courses between semesters III to VIII (III to X in the case of DD) is given in Appendix VII.

6.1 B.Tech.

Assuming that the normal student load is four theory courses in each semester, the semester-wise schedule shown in Appendix VII has seven vacant slots (marked XX xxx) among the semesters VI, VII and VIII to accommodate two Institute electives, two departmental electives and two units of supervised learning.

To obtain 30 additional credits towards an honors or a minor, the student will have to take one course over and above the assumed normal load of four theory courses per semester in five of the semesters III to VIII. On doing so, the student will have 13 vacant slots in semesters III to VIII to accommodate two Institute electives, two departmental electives, two units of supervised learning, and 30 credits of honors/minor requirement (equivalent to 11 six-credit courses).

To obtain 60 additional credits towards an honors and a minor, the student will have to take as many as two courses over and above the assumed normal load of four theory courses per semester in several of the semesters III to VIII. On doing so, the student will have 19 vacant slots in semesters III to VIII to accommodate two Institute electives, two departmental electives, two units of supervised learning, 30 credits of honors requirement, and 30 credits of minor requirement (equivalent to a total of 16 six-credit courses).

6.2 Dual Degree

The distribution of the core courses and labs in semesters I to VIII of the DD program is identical to that of the B.Tech program. To complete the program in 5 years, a DD student will have to take 5 courses in each of the semesters III to VIII including the vacant slots shown in semesters VI-VIII, and one course in each of the semesters IX and X in addition to dissertation work as shown in Appendix VII. On doing so, the student will have 15 course slots to accommodate two Institute electives, two departmental electives, two units of supervised learning, 30 credits of mandatory honors requirement and 24 credits of postgraduate coursework (equivalent to a total of 15 six-credit courses).

In order to obtain a minor in a different field, a DD student will have to take six courses in five of the six semesters III to VIII.

Appendix I

Table A.1 Summary of Courses and Credits to be completed for basic BTech

Group	Courses	LTPC
Basic Sciences and Mathematics (6 courses + 2 labs)	PH 101 Electricity & Magnetism	2 1 0 6
	PH 115 Physics Lab	0 0 3 3
	CH 101 Chemistry	2 1 0 6
	CH 115 Chemistry Lab	0 0 3 3
	MA 105 Calculus	3 1 0 8
	MA 106 Linear Algebra	3 1 0 4
	MA 108 Ordinary Differential Equations I	3 1 0 4
	MA 214 Introduction to Numerical Analysis	3 1 0 8
	ES 403 Environmental Science	3 0 0 6
	Total	**48**
Engineering Sciences/ Skills (4 courses + 3 labs)	CS 101 Computer Prog. and Utilization	2 0 2 6
	AE 152 Introduction to Aerospace Engineering	3 0 2 8
	IC 102 Data Analysis and Interpretation	2 1 0 6
	EE 101 Intro. to Electrical & Electronic Circuits	3 1 0 8
	ME 111 Workshop Practice	0 0.5 3 4
	ME 118 Engg. Graphics and Drawing	0 1 3 5
	XX 115 Experimentation and Measurement Lab	0 0.5 3 4
	Total	**41**
Basic Humanities (2 courses)	HS 101 Economics	3 0 0 6
	HS 202/203/204/205 Philosophy/Psychology/Literature/Sociology	3 0 0 6
	Total	**12**
Departmental Inputs	Core : 13 courses + 7 labs	115
	Elective : 2 courses	12
	Supervised Learning	12
	Total	**139**
Institute Elective	2 courses	**12**
Noncredit activities	NCC/NSS/NSO	**0**
	TOTAL	**252**

Appendix II

Table A.2 Departmental Core Courses and Labs

	Course	LTPC
Theory Courses (13 nos.)	MA 207 Differential Equations II	3 1 0 4
	AE xxx Thermodynamics	2 1 0 6
	AE xxx Fluid Mechanics	3 1 0 8
	AE xxx Solid Mechanics	3 1 0 8
	AE xxx Introduction to Engineering Design	2 0 2 6
	AE xxx Aerodynamics	2 1 0 6
	AE xxx Aerospace Structural Mechanics	3 1 0 8
	AE 308 Control Theory	2 1 0 6
	AE xxx Propulsion	3 1 0 8
	AE xx Flight Mechanics	2 1 0 6
	AE 415 Spaceflight Mechanics	2 1 0 6
	AE 332 Aircraft Design	3 0 0 6
	AE xxx Engineering Design Optimization	2 1 0 6
	Total	**84**
Lab (7 nos.)	AE xxx Modeling and Simulation Laboratory	1.5 0 2 5
	AE xxx Aerospace Measurements Laboratory	1 0 2 4
	AE 411 Control Systems Laboratory	0 0 3 3
	AE 316 Aircraft Propulsion Laboratory	1 0 3 5
	AE 312 Aerodynamics Laboratory	1 0 3 5
	AE 314 Aircraft Structure Laboratory	1 0 3 5
	AE xxx Aircraft Design Laboratory	1 0 2 4
	Total	**31**
	TOTAL	**115**

Appendix III

Table A.3 Departmental UG Electives

Course No.	Course Title	Credits
AE 318	Flight Mechanics Lab	3
AE 320	Computational Fluid Dynamics	6
AE 433	Vibration and Structural Dynamics	6
AE 443	Introduction to Composite Structures	6
AE 454	Dynamics and Bifurcations	6
AE 455	Introduction to Aero elasticity	6
AE 457	Spaceflight Navigation and Guidance	6
AE 459	Classical Dynamics	6
AE 460	Heat Transfer - Aerospace Applications	6
AE 461	Aviation Fuels and Combustion	6

Appendix IV

Table A.4 Departmental PG electives

Course No.	Course Title	Credits
AE 617	Numerical Meth. for Conservation laws	6
AE 622	Computation of High speed flows	6
AE 624	Hypersonic Flow Theory	6
AE 625	Particle Methods for Fluid Flow Simulation	6
AE 651	Aerodynamic Design of Compressors and Turbines	6
AE 658	Design of power plants for aircraft	6
AE 719	Advanced CFD	6
AE 722	Grid generation	6
AE 724	Exp. Meth. in Fluid Mechanics	6
AE 771	Matrix computations	6
AE 774	Special topics in Aerodynamics	6
AE 780	Computational heat transfer	6
AE 782	Flow Control	6
AE 604	Advanced Topics in Aerospace Structures	6
AE 673	Fiber Reinforced Composites	6
AE 676	Elastic Analysis of Plates and Laminates	6
AE 678	Aero elasticity	6
AE 715	Structural Dynamics	6
AE 721	Variation Methods in Engineering	6
AE 730	Experimental Methods in Structural Dynamics	6
AE 732	Composite Structures Analysis and Design	6
AE 736	Advanced Aero elasticity	6
AE 619	Nonlinear systems analysis	6
AE 690	Control systems design techniques	6
AE 695	State space methods	6
AE 703	Digital control systems	6
AE 725	Air transportation	6
AE 759	Systems engineering principles	4
AE 773	Applied mechatronics	6
AE 779	Optimization of multidisciplinary systems	6

Appendix V

Table A.5 Summary of Courses and Credits to be completed for Dual Degree

Group	Courses	LTPC
Basic Sciences and Mathematics (6 courses + 2 labs)	PH 101 Electricity & Magnetism	2 1 0 6
	PH 115 Physics Lab	0 0 3 3
	CH 101 Chemistry	2 1 0 6
	CH 115 Chemistry Lab	0 0 3 3
	MA 105 Calculus	3 1 0 8
	MA 106 Linear Algebra	3 1 0 4
	MA 108 Ordinary Differential Equations I	3 1 0 4
	MA 214 Introduction to Numerical Analysis	3 1 0 8
	ES 403 Environmental Science	3 0 0 6
	Total	**48**
Engineering Sciences/ Skills (4 courses + 3 labs)	CS 101 Computer Prog. and Utilization	2 0 2 6
	AE 152 Introduction to Aerospace Engineering	3 0 2 8
	IC 102 Data Analysis and Interpretation	2 1 0 6
	EE 101 Intro. to Electrical & Electronic Circuits	3 1 0 8
	ME 111 Workshop Practice	0 0.5 3 4
	ME 118 Engg. Graphics and Drawing	0 1 3 5
	XX 115 Experimentation and Measurement Lab	0 0.5 3 4
	Total	**41**
Basic Humanities (2 courses)	HS 101 Economics	3 0 0 6
	HS 202/203/204/205 Philosophy/Psychology/Literature/Sociology	3 0 0 6
	Total	**12**
Departmental Inputs	Core : 13 courses + 7 labs	115
	Elective : 2 courses	12
	Supervised Learning	12
	Total	**139**
Institute Elective	2 courses	12
Noncredit activities	NCC/NSS/NSO	0
	Total credits towards basic BTech	**252**
Honors requirement	As described in Section 3	**30**
M.Tech. coursework	4 PG Electives	**24**
M.Tech Dissertation		**72**
	TOTAL	**378**

Appendix VI

Table A.6 Non-Departmental PG Electives

Course No.	Course Title	Credits
ME 653	Boundary layer theory	6
ME 704	Comp. Meth. in Thermal and Fluids Engg.	6
ME 602	Fatigue, Fracture and Failure Analysis	6
ME 613	Finite Element and Boundary Element Methods	6
ME 664	Advanced Finite Element and Boundary Element Methods	6
ME 744	Applied Random Vibrations	6
CE 611	Advanced Structural Mechanics	6
CE 620	Finite Element Methods	6
CE 623	Advanced Solids Mechanics	6
CE 624	Nonlinear Analysis	6
MM 658	Fracture Mechanics and Failure Analysis	6
MM 657	Design and Application of Engineering Materials	6
MM 654	Advanced Composites	6
MA 529	Numerical Methods for Partial Differential Equations	6
MA 543	Finite Element Methods and Applications	6
MA 583	Introduction to Continuum Mechanics	6
EE 623	Nonlinear control systems (not available with AE 619)	8
EE 640	Multivariable control systems	6
EE 622	Optimal Control Systems	6

Appendix VII

Semester-wise Schedule of Courses

Semester III					
Course No.	Course Title	L	T	P	C
MA 207	Differential Equations II	3	1	0	4
EE 101	Introduction to Electrical and Electronics Circuits	3	1	0	8
AE xxx	Introduction to Engineering Design	2	0	2	6
AE xxx	Solid Mechanics	3	1	0	8
XX 115	Experimentation and Measurement Laboratory	0	0.5	3	4
AE xxx	Aerospace Measurements Laboratory	1	0	2	4
	Total	12	3.5	7	**34**

Semester IV					
Course No.	Course Title	L	T	P	C
MA 214	Introduction to Numerical Analysis	3	1	0	8
AE xxx	Thermodynamics	2	1	0	6
AE xxx	Fluid Mechanics	3	1	0	8
AE xxx	Aerospace Structural Mechanics	3	1	0	8
AE xxx	Modeling and Simulation Laboratory	1.5	0	2	5
	Total	12.5	4	2	**35**

Semester V					
Course No.	Course Title	L	T	P	C
AE 308	Control Theory	2	1	0	6
AE xxx	Propulsion	3	1	0	8
AE xxx	Aerodynamics	2	1	0	6
HS xxx	Philosophy/ Psychology/Literature/Sociology	3	0	0	6
AE 411	Controls Systems Laboratory	0	0	3	3
AE 314	Structures Laboratory	1	0	3	5
	Total	11	3	6	**34**

Semester VI					
Course No.	Course Title	L	T	P	C
AE 305	Flight mechanics	2	1	0	6
AE 415	Spaceflight Mechanics	2	1	0	6
AE xxx	Engineering Design Optimization	2	1	0	6
XX xxx					
AE 316	Aircraft Propulsion Laboratory	1	0	3	5
AE 312	Aerodynamics Laboratory	1	0	3	5
	Total	8	3	6	**28**

Semester VII					
Course No.	Course Title	L	T	P	C
AE 332	Aircraft Design	3	0	0	6
XX xxx					
XX xxx					
XX xxx					
	Total	3	0	0	**6**

Semester VIII					
Course No.	Course Title	L	T	P	C
ES 403	Environmental Studies	3	0	0	6
XX xxx					
XX xxx					
XX xxx					
AE xxx	Aircraft Design Laboratory	1	0	2	4
	Total	4	0	2	**10**

(Only for DD)

Semester IX					
Course No.	Course Title	L	T	P	C
AE xxx	MTech Dissertation Stage I				36
XX xxx					
	Total	0	0	0	**36**

Semester X					
Course No.	Course Title	L	T	P	C
AE xxx	MTech Dissertation Stage II				36
XX xxx					
	Total	0	0	0	**36**

Course Contents

1.	Title of the course	**Thermodynamics** (Course Number : to be assigned)
2.	Credit Structure	2-1-0-6
3.	Prerequisite	Nil
4.	Course Content	Basic concepts: System boundary, surroundings, state, extensive and intensive properties, energy interactions, work and heat transfers, equilibrium, quasi-static and reversible processes, non-equilibrium and irreversible processes. Thermodynamic laws: Zeroth law and temperature, first law and internal energy, first law applied to flow processes, second law, entropy and absolute temperature, third law and absolute entropy, thermodynamics of simple compressible systems, energy and exergy. Applications: Closed and open systems, polytrophic processes, cyclic processes, Carnot cycle; Cycle analysis: Otto cycle, Diesel cycle, Joule-Brayton cycle; ideal and real cycles, design point analysis. Special topics: Elements of heat transfer and combustion, isentropic flow, flow with friction and heat transfer. Introduction to aerospace power plants: Piston prop, turboprop, turbojet, turbofan, turbo shaft, ramjet, rockets.
5.	Texts/References	1. Rogers, G. F. C. and Mayhew, Y. R., Engineering Thermodynamics: work and heat transfer, 4th ed., Longman, 1992. 2. Nag, P. K., Engineering Thermodynamics, Tata McGraw Hill Co., 1989. 3. Cohen , H., Rogers ,G. F. C. and Saravanamuttoo ,H. I. H., Gas Turbine Theory, 5th Ed., Pearson Education Asia, 2001. 4. Sonntag ,R. E., Borgnakke ,C. and Van Wylen , G. J., Fundamentals of Thermodynamics, 6th ed., Wiley, 2002
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Fluid Mechanics** (Course Number : to be assigned)
2.	Credit Structure	3-1-0-8
3.	Prerequisite	Nil
4.	Course Content	Properties of fluid, Statics and Buoyancy. Kinematics of fluid motion; Lagrangian vs. Eulerian description of flow motion; Convective, temporal and substantive acceleration. Fundamental laws of Fluid Mechanics; Conservation of mass and momentum in 1D and 2D flows; Classification of Flows: Uniform vs. non-uniform flows, steady vs. unsteady flows, compressible and incompressible flows, ideal vs. real flows. Potential flow theory; Velocity potential and stream function formulations; Ideal flow past circular cylinder. Euler equation in 1D; Viscous flow on a flat plate; Boundary layer, displacement, momentum and energy thicknesses; Flow between two plates, flow in a pipe; Laminar flow vs. turbulent flow. Dimensional analysis and Buckingham pi theorem, Reynolds number; turbulence and turbulent flows; Frictional losses, losses in a pipe; Flow past cylinder, critical Reynolds numbers; Incompressible viscous flow past an airfoil, wakes, types of drags. Mach number and its importance in compressible flows; Equation of motion for compressible flow in 1D; Normal shock, Rankine Hugoniot relations, oblique shock relations, strong, weak and detached shocks. Rayleigh and Fanno flows, isentropic flows; Flow through variable area nozzle; Converging diverging nozzle, supersonic diffusers, supersonic wind tunnels, critical pressure ratios; Prandtl Meyer expansion and expansion fans, interaction of shock and expansion waves.
5.	Texts/References	1. White, F. M., Fluid Mechanics, 5th Ed., McGraw Hill 2003. 2. Kundu, P. K. and Cohen, I. M., Fluid Mechanics, 2nd Ed., Academic Press 2002. 3. Shames, I. H., Mechanics of Fluids, 4th Ed, McGraw Hill 2002.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Solid Mechanics** (Course Number : to be assigned)
2.	Credit Structure	3-1-0-8
3.	Prerequisite	Nil
4.	Course Content	Introduction: Engg. statics vs solid mechanics, solid as a continuum, statement of a general solid mechanics problem. Elements of 2-D & 3-D Elasticity: components of stress & strain fields, stress/strain transformation, principal stresses, plane stress/strain, Mohr's circle, equilibrium equations, strain displacement relations, compatibility conditions, natural & kinematic boundary conditions, stress-strain relations, generalized Hooke's Law - isotropy, orthotropy, anisotropy. Displacement and force methods of analysis. Concepts of linear and nonlinear problems. Illustration of linear elasticity solutions - problems in 2-D (rectangular and polar co-ordinates), stress function approach. St. Venant's principle. Material behaviour: introduction to metallic and non-metallic materials of aerospace interest, awareness/overview of structure of materials. Ductile, brittle, elasto-plastic and viscoelastic material behaviour - Elastic and strength properties. Composite materials. Materials selection. Failure of engineering materials, failure theories, concepts of fatigue, fracture and creep. 1-D structural analysis: slender structural elements, assumptions simplifying the general (3-d) stress, strain and deformation fields for uncoupled axial deformation, uncoupled bending, and uncoupled twisting of slender 1-D elements and development of corresponding elementary theories (Elementary Beam Theory, Elementary Torsion theory), idealization of general loads into axial forces, bending moments, shear forces and torque distributions, deflection and stress analysis of rods, beams and circular shafts. Introduction to energy methods – strain energy, virtual work, minimum potential energy and its application. Measurement of strain and displacement. Measurement of elastic and strength properties. ASTM standards.
5.	Texts/References	1. Gere, J. M., ``Mechanics of Materials'', Thomson, 6th ed. 2007. 2. Crandall, S.H., Dahl, N.C. and Lardner, T.J. ``An Introduction to the Mechanics of Materials'', McGraw-Hill, International Edition, 1978. 3. Timoshenko, S.P. and Goodier, J.N. ``Theory of Elasticity'', McGraw-Hill, International Edition, 1970.
6.	Other depts. to whom the course is relevant	

1.	Title of the course	**Introduction to Engineering Design** (Course Number : to be assigned)
2.	Credit Structure	2-0-2-6
3.	Prerequisite	Nil
4.	Course Content	Background and introduction: Importance of engineering design, life cycle of a product, engineering design process. Overview of engineering design process: Steps involved in the design process, communication during the design process, team behavior and tools, Delta design exercise. Identification and understanding of customer needs: Requirements capture, development of product design specifications, quality function deployment (QFD) technique, case studies in QFD. Concept generation: Generating engineering specifications, functional analysis and design, concept generation methods, creativity and problem solving, creativity method, creative idea evaluation, TRIZ, axiomatic design. Concept evaluation: Information representation, concept evaluation overview, evaluation techniques based on 1) feasibility judgment, 2) GO-NO-GO screening, 3) technological readiness, 4) basic decision matrix (Pugh's Method). Cost estimation: Cost categories, methods of cost estimation, cost indices, cost capacity factors; activity based costing, learning curve. Economic decision making: Time value of money, cost comparison, profitability of investment, sensitivity and break even analysis. Professionalism and ethics: Laws, contracts, liabilities, intellectual property, professional behavior, ethics
5.	Texts/References	1. Dieter, G. E., Engineering Design: a materials and processing approach, McGraw Hill International Series, 2000. 2. Ullman, D. G., Mechanical Design Process, McGraw Hill, 2004. 3. Ulrich, K. T. and Eppinger, S. D., Product Design and Development, Irwin McGraw Hill, 2000. 4. Eide,R., Jenison, R. D., Marshaw , L. H., and Northup L. R., Introduction to Engineering Design, McGraw Hill Basic Engineering Series and Tools, 1998.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Aerodynamics** (Course Number : to be assigned)
2.	Credit Structure	2-1-0-6
3.	Prerequisite	Fluid Mechanics
4.	Course Content	Airfoils, wings and their nomenclature; lift, drag and pitching moment coefficients; centre of pressure and aerodynamic centre. Potential flow Analysis; Scalar and vector fields, velocity potential, line, surface and volume integrals, circulation and lift generation, Kutta-Joukovskii theorem. Method of superposition, thin airfoil theory, source and vortex methods. Subsonic compressible flow past airfoils; Critical Mach number, drag divergence Mach number, supercritical airfoils, effect of sweep, area rule. Full and perturbation velocity potential formulations; Prandtl and Glauert compressibility corrections. Transonic flow past airfoils, transonic similarity rules; Supersonic flow past airfoils, linearised supersonic flow, shock expansion method. Potential flow over lifting wing; lifting line theory, vortex lattice method, slender body theory, panel method, variation of lift and drag coefficients in subsonic flows with angle of attack, Reynolds number, thickness-to-chord ratio. Supersonic flow over airfoils and wings; subsonic/supersonic leading edge. Hypersonic flows, real gas effects, Newtonian theory, lift and drag in hypersonic flows.
5.	Texts/References	1. Anderson, J. D., Jr., Fundamentals of Aerodynamics, McGraw Hill 2001. 2. Bertin, J. J., Aerodynamics for Engineers, Pearson Education, 2002. 3. Houghton , E. L. and Carpenter, P. W., Aerodynamics for Engineers, Butterworth-Heinemann, 2001.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Aerospace Structural Mechanics** (Course Number : to be assigned)
2.	Credit Structure	3-1-0-8
3.	Prerequisite	Solid Mechanics
4.	Course Content	Introduction: semi-monocoque aerospace structures - Loads and Design considerations; construction concepts, layout, nomenclature and structural function of parts, strength vs stiffness based design. Torsion of non-circular prismatic beams: importance of warping; St. Venant or Prandtl's formulation; Membrane analogy and its application to narrow rectangular cross-section. General formulation of Thin-Walled Beam (TWB) Theory: Cartesian and midline systems, CSRD & thin-wall assumptions, general expressions for dominant displacement, strain and stress fields, equilibrium equations in midline system, stress resultants and general boundary conditions. Torsion and Bending of TWBs: Torsion of single and multi cell closed sections - Bredt-Batho theory, shear flow, torsion constant, free warping calculation, concept of center of twist, torsional equilibrium equation and boundary conditions. Torsion of open TWBs without warp restraint, primary & secondary warping, St. Venant torsion constant. Uncoupled bending of open, closed, single cell, multi-cell TWBs - axial stress, shear flow, shear centre, displacement analysis. Torsion of open section TWBs with primary warp restraint - concept and theory of torsion bending, torsion bending constant, secondary warping restraint. Unsymmetric bending and coupled bending torsion analysis. Buckling of TWBs: Concept of structural instability, flexural buckling analysis, bending of beams under combined axial and lateral loads, short column and inelastic buckling. Pure torsional buckling and coupled flexural-torsional buckling of open TWBs. Introduction to the concept of buckling of plates, local buckling of TWBs. Introduction to buckling and post-buckling of stiffened skin panels, ultimate load carrying capacity of a typical semimonocoque TW box-section. Introduction to tension-field beams.
5.	Texts/References	1. Megson, T. H. G., Aircraft Structures for Engineering Students, Butterworth-Heinemann, 4th Ed., 2007. 2. Peery, D. J., Aircraft Structures, McGraw-Hill Education, 1st Ed., 1950. 3. Donaldson, B. K., Analysis of Aircraft Structures (Cambridge Aerospace Series), 2nd Ed., Cambridge University Press, 2008. 4. Sun, C. T., Mechanics of Aircraft Structures, Wiley-Interscience, 1998. 5. Bruhn, E. F., Analysis and Design of Flight Vehicle Structures, Jacobs Pub., 1973.

		6. Niu, M., Airframe Stress Analysis & Sizing, Adaso Adastra Engineering Center, 1998. 7. Cutler, J. and Liber, J., Understanding Aircraft Structures, Wiley Blackwell, 4th Ed., 2006.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Control Theory** (Proposed Course Number : AE 308, existing course, contents updated)
2.	Credit Structure	2-1-0-6
3.	Prerequisite	Exposure to Modeling and Simulation Lab
4.	Course Content	Introduction: Control objectives and tasks, open- and closed-loop control structures, negative and positive feedback. System response: Impulse response, convolution integral, response of higher order systems to arbitrary and standard inputs in Laplace and time domains, qualitative dependence on poles and zeros, dominant poles. Stability: Asymptotic and bounded-input-bounded-output stability, characteristic equation and its roots, role of characteristic roots in stability, Routh's criterion, relative and absolute stability, impact of positive feedback on stability. Root locus analysis: Closed-loop stability analysis using root locus, impact of open-loop poles and zeros on the root locus, root locus for positive feedback systems, effect of gain in the feedback path, root loci for multiple parameters. Frequency response: Magnitude and phase, frequency response of higher order systems, Bode, polar and Nichols plots, bandwidth, Nyquist stability criterion, gain and phase margins. Standard control actions: Proportional control, steady state error constants, system type, tracking control and integral control, lag compensator, transient response improvement and derivative control, lead compensators. Control design: Closed-loop performance specifications, gain and phase margins as design specifications, use of root locus, Bode plots in design, design rules for lag and lead compensators. Special Topics: Non-minimum phase systems, PID Controllers and lag-lead compensators, controllers in the feedback path, closed-loop robustness.
5.	Texts/References	1. Ogata, K., Modern Control Engineering, 4th Ed., Prentice Hall India, 2006. 2. Kuo, B. C. and Golnaraghi, F., Automatic Control Systems, 8th Ed., John Wiley & Sons, 2003. 3. D'Azzo , J. J. and Houpis , C. H., Linear Control Systems Analysis and Design - Conventional and Modern, 4th Ed., McGraw-Hill, 1995.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Propulsion** (Course Number : to be assigned)
2.	Credit Structure	3-1-0-8
3.	Prerequisite	Thermodynamics
4.	Course Content	Real cycle analysis for jet engines: Off-design points, engine performance maps, power plant performance with varying speed and altitude, comparison of real cycle turboprops, turbofans, turbojets and ramjets. Jet engine components: Intake, fan, compressors, combustors, turbines, afterburner and nozzle; component performance, cascade theory, matching of propeller/fan/compressor with turbine in turboprop, turbofan and turbojet engines, single and multi-spool engines, turbine blade cooling mechanisms, thrust augmentation, variable geometry intakes and nozzles, thrust vector control. Ramjets and scramjets: Ideal and real cycles, 1-D analysis of intake, isolator, nozzle and reactive flows in combustor. Classification of rockets: Introduction to chemical, electric, ion and nuclear powered rockets. Chemical rockets: Solid and liquid propellant rockets, types of solid and liquid rocket motor propellants, rocket performance parameters, flow through nozzle, real nozzles, equilibrium and frozen flow.
5.	Texts/References	1. Hill, P. G. and Peterson, C., Mechanics and Thermodynamics of Propulsion, 2nd Ed., Prentice Hall, 1991. 2. Cohen , H., Rogers , G. F. C. and Saravanamuttoo ,H. I. H., Gas Turbine Theory, 5th Ed., Pearson Education Asia, 2001. 3. Sutton, G. P. and Biblarz, O., Rocket Propulsion Elements, 7th Ed., Wiley Inter Science, 2000. 4. Oates, G. C. , Aerothermodynamics of Gas Turbine and Rocket Propulsion, AIAA Education Series, 1997.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Flight Mechanics** (Course Number : to be assigned)
2.	Credit Structure	2-1-0-6
3.	Prerequisite	Exposure to AE 152, Introduction to Aerospace Engineering , and Aerodynamics
4.	Course Content	Introduction: Equilibrium, static stability, control. Longitudinal stability and control: Longitudinal equilibrium and static stability, stick fixed neutral point, all moving horizontal tail OR elevator as longitudinal control. Trimmed lift curve slope and advantages of reduced/negative longitudinal static stability. Hinge moments, reversible control, stick force, and trim tab. Stick free static stability, stick-free neutral point. Lateral-directional stability and control: Directional equilibrium, stability and rudder as control. Lateral stability, dihedral angle, aileron control. Dynamical equations: Euler angles. Body angular velocity and Euler angle rates. Body-fixed axis, wind axis, stability axes. Equations of motion of rigid aircraft in body fixed axes. Stability derivatives. Steady flight and perturbed flight leading to linearised equations of motion. Aircraft motion modes: Decoupling of longitudinal dynamics and lateral-directional dynamics. Short period and phugoid modes of longitudinal dynamics. Dutch roll, spiral and roll subsidence modes of lateral-directional dynamics. Effect of winds. Flight simulation.
5.	Texts/References	1. Stengel, R. F., Flight Dynamics, Princeton University Press, 2004. 2. Roskam, J., Airplane Flight Dynamics and Automatic Flight Controls, DAR Corporation, 1995. 3. Nelson, R. C., Flight Stability and Automatic Control, Mc Graw Hill International, 1990. 4. Etkin, B. and Duffy, L. D., Dynamics of Flight: stability and control, John Wiley, NY 1995. 5. Perkins, C. D. and Hage, R. E., Airplane Performance Stability and Control, Wiley, New York, 1949.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Spaceflight Mechanics** (Proposed Course Number : AE 415, existing course, contents updated)
2.	Credit Structure	2-1-0-6
3.	Prerequisite	Nil
4.	Course Content	Introduction: Space environment, types of spacecraft, present-day satellites and launch vehicles. Orbital mechanics: Two-body Problem, Kepler's laws, geometry of orbits, Kepler's equation, classical orbital elements, orbit determination from initial conditions, position and velocity prediction from orbital elements. Satellite operations: Geostationary orbit, Hohmann transfer, inclination change maneuvers, launch windows for rendezvous missions, perturbation effects due to earth oblateness, sun synchronous orbits. Mechanics: Kinematics relative to moving frames, rotations and angular velocity, angular momentum of a system of particles, rotational dynamics for a system of particles. Attitude dynamics and control: Rotation matrices, Euler angles, attitude kinematics, Euler's equations for rotational dynamics, torque-free motion of asymmetric and axisymmetric rigid bodies, effect of energy dissipation on stability of rotational motion, attitude control of spinning and nonspinning satellites, overview of actuation mechanisms for attitude control. Rocket motion and performance: Rocket equation, multistaging, parallel staging, optimal staging, sensitivity ratios, vertical ascent trajectories, gravity turn trajectories. Special topics: Restricted 3-body problem, interplanetary trajectories, lunar transfer, gravity gradient stabilization, dual spin spacecraft, re-entry vehicles and missions.
5.	Texts/References	1. Wiesel, W. E., Spaceflight Dynamics, 2nd Ed., McGraw Hill, 1997. 2. Kaplan, M. H., Modern Spacecraft Dynamics and Control, John Wiley and Sons, London, 1976. 3. Thompson , W. T., Introduction to Space Dynamics, Dover Publications, New York, 1986. 4. Cornelisse, J. W., Rocket Propulsion and Spaceflight Dynamics, Pitman, London, 1979.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Aircraft Design** (Proposed Course Number : AE 332, existing course, contents updated)
2.	Credit Structure	3-0-0-6
3.	Prerequisite, if any	Nil
4.	Course Content	Introduction to Aircraft Design: Three phases in aircraft design, computer based aircraft design methodologies, differences between LTA and HTA aircraft, type of civil and military aircraft. Configuration and Layout: Types and comparison of wing, tail, fuselage, landing gear, wing-tail combinations, power plant (types, numbers, locations), unconventional aircraft configurations. Sizing and Constraint Analysis: Initial sizing, estimation of design gross weight, rubber engine sizing and fixed engine sizing, refined sizing method and constraint analysis. Estimation Methodologies: Lift and drag coefficient, design loads, component mass breakdown, acquisition cost, direct operating cost. Operational and Environmental Issues: Range-payload diagram, V-n diagram, noise and emission levels, special considerations such as stealth, survivability, maintainability. Advanced Concepts in Aircraft Design: Supersonic aircraft design, very large aircraft, morphing aircraft.
5.	Texts/References	1. Raymer, D. P., Aircraft Design - A Conceptual Approach, AIAA Educational Series, 4th Ed., 2006. 2. Brandt, S. A., Stiles, R. J., Bertin, J. J., Whitford, R., Introduction to Aeronautics: A Design Perspective, AIAA Educational Series, 2nd ed., 2004. 3. Jenkinson, L. R., Simpkin, P. and Rhodes, D., Civil Jet Aircraft Design, Arnold Publishers, London, 1999. 4. Fielding, J., Introduction to Aircraft Design, Cambridge Aerospace Series, Cambridge University Press, 1999.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Engineering Design Optimization** (Course Number: to be assigned)
2.	Credit Structure	2-1-0-6
3.	Prerequisite, if any	Nil
4.	Course Content	Introduction: design process; problem formulation in design, design variables, objective function, equality and inequality constraints, classification of optimization problems, local and global optima, nonlinear and linear problems. Theoretical Concepts: unconstrained optima, constrained optima, Lagrange multipliers, post optimality analysis. Linear Programming: problem definition, basic concepts and LP terminology, Simplex method, 2-phase Simplex. Gradient based Optimization Methods: Non-linear programming, steepest descent, conjugate-gradient method, Newton's methods, BFGS, SLP algorithm, CSD method. Evolutionary and other Global methods: Genetic Algorithms, Simulated Annealing, Ant Colony, Particle Swarm. Special Topics: Meta Modelling techniques, Multi-criteria Optimization, introduction to Multi-disciplinary Design Optimization.
5.	Texts/References	1. Arora, J. S., Introduction to Optimum Design, McGraw-Hill, 1989. 2. Deb, K., Optimization for Engineering Design -Algorithms and Examples, Prentice Hall India, 1995. 3. Rao, S. S., Engineering Optimization: Theory and Practice, 3rd edition, New Age International, 1998.
6.	Name of other Departments to whom the course is relevant	

Laboratory Courses

1.	Title of the course	**Modeling and Simulation Laboratory** (Course Number : to be assigned)
2.	Credit Structure	1.5-0-2-5
3.	Prerequisite	Nil
4.	Course Content	Introduction: Objectives, concepts and types of models. Modeling: Analytical and experimental modeling of simple mechanical, hydraulic, thermal and structural systems. Transfer function and block diagram representation. Time response: First and second order systems. System representation and simulation using MATLAB, SIMULINK and AMESim tools. Quantifying Uncertainty: Use of simulation to quantify the uncertainty in system response and performance caused by uncertainty in model parameters and inputs. Special topic: Software simulation of stiff systems and impact of integration time step on methodology and response. Lab project: Application of modelling and simulation methodologies to a complex engineering system.
5.	Texts/References	References: 1. Ogata, K., System Dynamics, 4th Ed. Pearson Education LPE, 2004. 2. Doebelin, E. O., System Dynamics: modeling, analysis, simulation, designs New York: Marcel Dekker, 1998. 3. User Manuals for the Setups and AMESim Engg. System Modelling & Simulation Software Tool
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Aerospace Measurements Laboratory** (Course Number : to be assigned)
2.	Credit Structure	1-0-2-4
3.	Prerequisite	Exposure to IC 102 Data Analysis and Interpretation
4.	Course Content	Characteristics of measuring systems: Calibration, sensitivity and error analysis. Air data measurements: Pressure altitude, airspeed Flow measurements: Hotwire anemometer, manometer, angle of attack sensor Temperature Measurements: Thermocouples, hot gas and cryogenic measurements, thermopiles Strain measurements: Strain gage types, strain gage sensitivity. Pressure measurements: Dependence of measurement dynamics on sensor construction. Inertial and GPS based sensors: Accelerometers and gyroscopes; position, velocity and time measurements. Attitude and heading reference systems: Errors in inertial sensors and characterization. Sensor interfacing: amplifiers, filters, and other signal conditioning circuits, analog and digital conditioning, ADC/DAC, synchronous and asynchronous serial communication.
5.	Texts/References	1. Doeblin, E., Measurement Systems: Application and Design, 4th Ed., McGraw-Hill, New York, 1990. 2. Grewal, M. S., Lawrence, R. and Andrews, A., GPS, INS and Integration, New York: John Wiley, 2001. 3. Collinson, R. P. G., Introduction to Avionics, Chapman and Hall, 1996. 4. Gayakwad, R. A., OPAMPs and Linear Integrated Circuits, 4th Ed., Prentice-Hall India, 2002. 5. Titterton, D. H. and Weston, J. L., Strapdown Inertial Navigation Technology, 2nd Ed., AIAA Progress in Astronautics and Aeronautics, Vol. 207, 2004. 6. Strang, G. and Borr, K., Linear Algebra, Geodesy and GPS, Wellesley-Cambridge Press, 1997. 7. Setup User Manuals and Component Data Sheets.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Control Systems Laboratory** (Proposed Course Number : AE 411, existing course, contents updated)
2.	Credit Structure	0-0-3-3
3.	Prerequisite	Exposure to Modeling and Simulation Lab
4.	Course Content	Reinforcement of basic control concepts: Proportional, integral and velocity feedback applied to simple control systems such as servo control, temperature control, gyroscope, flexible shafts. Real system effects: Effect of friction, backlash, resistance, loading and transport lag on the control system behavior. Frequency response: Experimental generation, application to closed loop system stability analysis. Lab project: Design of a control system involving simulation studies, hardware implementation and demonstration.
5.	Texts/References	1. Ogata, K., Modern Control Engineering, 4th Ed. Prentice Hall India, 2006. 2. User Manuals of the various experimental setups
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Aircraft Propulsion Laboratory** (Proposed Course Number : AE 316, existing course, contents updated)
2.	Credit Structure	1-0-3-5
3.	Prerequisite	Exposure to Propulsion
4.	Course Content	Study of aircraft engine models, basic measurement techniques in thermal, mechanical and fluid systems. Experimentation related to aerodynamics and performance of turbomachinery (in axial flow fan set-up and in two-dimensional compressor/turbine cascades), fuel systems, combustion and heat transfer (convective heat transfer to geometries typical of aerospace propulsion applications) in aerospace propulsion systems. Experiments on performance characteristics of gas turbine/jet propulsion systems.
5.	Texts/References	1. Hill, P. G. and Peterson, C., Mechanics and Thermodynamics of Propulsion, 2nd Ed., Prentice Hall, 1991. 2. Laboratory Manual, Propulsion Laboratory, Department of Aerospace Engineering, IIT Bombay, 2007.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Aerodynamics Laboratory** (Proposed Course Number : AE 312, existing course, contents updated)
2.	Credit Structure	1-0-3-5
3.	Prerequisite	Exposure to Fluid Mechanics, and Aerodynamics.
4.	Course Content	Types of wind tunnels and their characteristics, wind tunnel corrections Flow past bluff and a streamlined bodies and measurement of pressure drag. Wall shear flows, free shear flows, development of boundary layer on flat plate with and without pressure gradient, free shear layer in a jet, estimation of drag by wake survey method. Flow in a variable area duct and experimental determination of mass flow coefficient. Flow visualisation methods, surface flow methods and colour die injection method. Measurement of unsteady flow using hot-wire and laser Doppler velocimeter.
5.	Texts/References	1. Goldstein , R. J., Fluid Mechanics Measurements, Taylor and Francis, 1996.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Aircraft Structures Laboratory** (Proposed Course Number : AE 314, existing course, contents updated)
2.	Credit Structure	1-0-3-5
3.	Prerequisite	Nil
4.	Course Content	The aerospace structures laboratory includes experiments related to material aspects as well as structural mechanics. These experiments are largely based upon the syllabus covered in the courses on solid mechanics and aerospace structures. A couple of experiments on vibrations and structural dynamics are also included for exposure. The experiments in this laboratory course cover the following. Fabrication of fibre reinforced composite laminate; tension, compression, interlaminar shear, impact and hardness testing for determination of elastic moduli and strength of material; coefficient of thermal expansion; strain measurement; inverse methods for material property determination (Poisson's ratio and Youngs Modulus) using measured static and dynamic structural response in conjunction with simple structural models; shear centre of open section thin-walled beam, displacement and strain distribution in bending and torsion of twin-walled open and closed section beams; Buckling of beams/plates; measurement of natural frequency, natural modes and modal damping of beams.
5.	Texts/References	Laboratory Manual, Aircraft Structures Lab., Dept. of Aerospace Engineering, IIT Bombay, 2007.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**Aircraft Design Laboratory** (Course Number : to be assigned)
2.	Credit Structure	1-0-2-4
3.	Prerequisite	Exposure to AE 332, Aircraft Design
4.	Course Content	As part of the Aircraft Design Laboratory, the students are required to complete a group project involving conceptual design studies of an aircraft, meeting some stated requirements. The group project is aimed to achieve the following learning goals for the students: 1. To provide hands-on experience related to Aircraft Design, 2. To be able to plan and execute a multi-disciplinary design task, 3. To be able to successfully present the results of the design task verbally and in the form of a report and drawings, 4.To learn to work efficiently in a group and as a member of the group.
5.	Texts/References	1. Raymer , D. R., User Manual for RDS-Professional, Software for Aircraft Design, Analysis & Optimization, Version 5.2, Conceptual Research Corporation, California, USA 2007. 2. Roskam , J., User Manual for Advanced Aircraft Analysis (AAA) Software, Version 3.1, Design, Analysis and Research Corporation, Kansas, USA, August 2006.
6.	Name of other Departments to whom the course is relevant	