CURRICULUM

OF

AEROSPACE ENGINEERING

BE/BS
ME/MS
PhD

(Revised 2015)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives & learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled "Supervision of Curricula and Textbooks and Maintenance of Standard of Education". With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

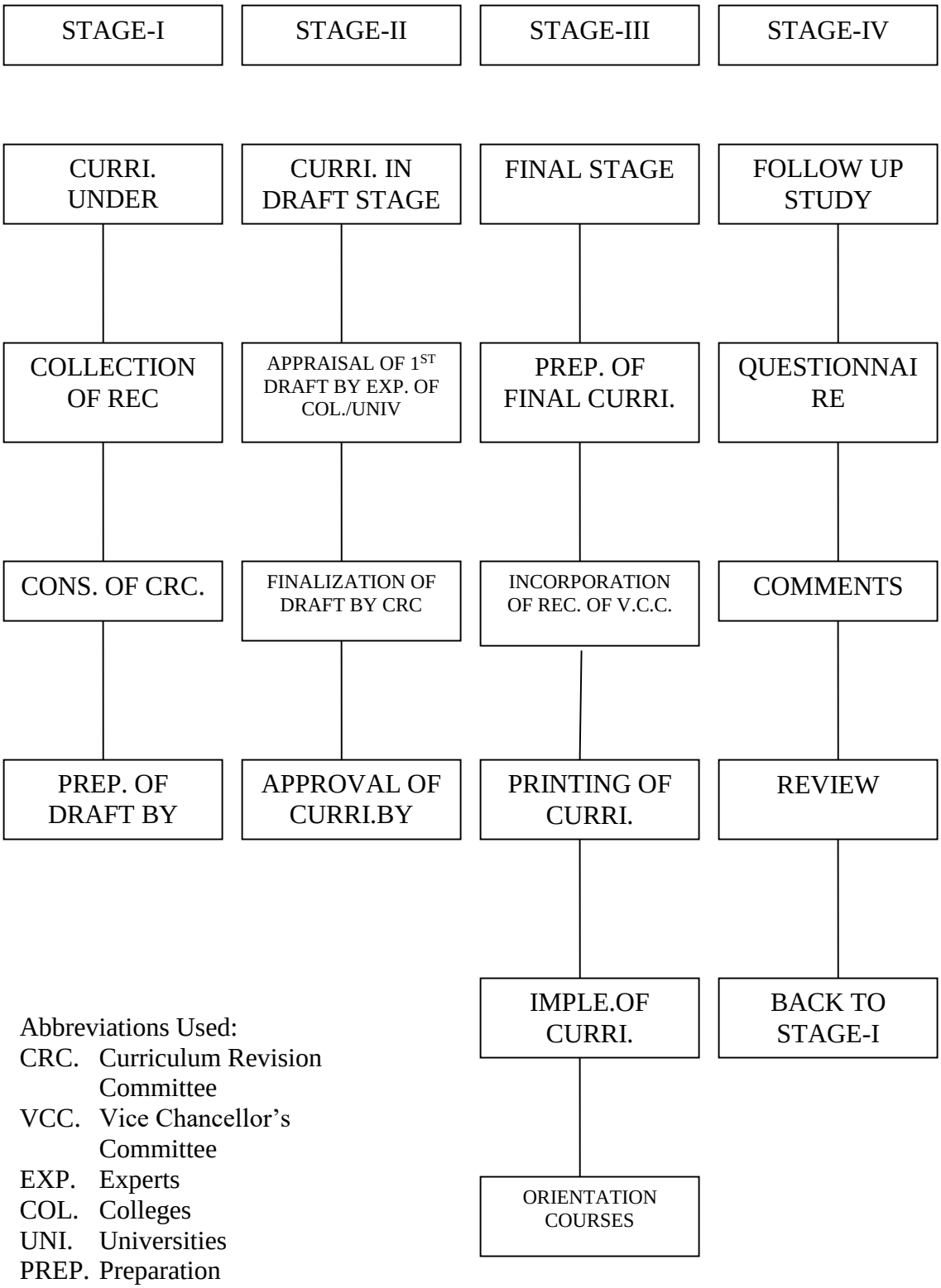
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC (www.hec.gov.pk).

(Fida Hussain)
Director General (Academics)

CURRICULUM DEVELOPMENT PROCESS



Abbreviations Used:

CRC. Curriculum Revision Committee
VCC. Vice Chancellor's Committee
EXP. Experts
COL. Colleges
UNI. Universities
PREP. Preparation

INTRODUCTION:

A three-day final meeting of the *National Curriculum Revision Committee for the Aerospace Engineering* (NCRC-Aerospace Engineering) was held from 03-05 June, 2015 to finalize the draft curricula prepared in the preliminary meeting held from 03-05 March, 2015, for the BE/BS, ME/MS, and PhD Degree Programmes. The objective of the review meeting was to review and update the curricula for Aerospace Engineering Programmes in line with the current industry needs and global trends.

BACKGROUND:

Review meeting of National Curriculum Revision Committee in Aerospace Engineering was held on 03-05 June, 2015 at HEC main office, Islamabad. The purpose of meeting was to perform review/ revision of the existing curriculum in the BE/BS, ME/MS and PhD Aerospace Engineering Programmes. Following members attended the meeting:-

1.	Dr. Abdul Munem Khan Department of Mechanical Engineering, HITEC University, Taxila.	Convener
2.	Dr. Khalid Pervaiz Professor Department of Aeronautics and Astronautics Institute of Space Technology Islamabad	Member / PEC Representative
3.	Prof. Dr. Abid Ali Khan Head of Department Department of Aeronautics and Astronautics Institute of Space Technology Islamabad	Member
4.	Dr. Khalid Mahmood Tahir Director General Institute of Avionics & Aeronautics Air University, Islamabad	Member
5.	Dr. Salim ur Rahman, Vice Chancellor, Sarhad University of Science & Information Technology, Peshawar.	Member

6. Dr. Jehanzeb Masud — Member
Associate Professor
Institute of Avionics & Aeronautics
Air University, Islamabad

7 Mr. Moazzam Ali Toor — Member
CEO Capital Engineering Corporation
Islamabad

8. Engineer Ilyas Mahmood Ahmad Qureshi — Member
Head Avionics Engineering and Aviation Technology Department
Superior University
Lahore

9. Dr. Muhammad Babar Saeed — Secretary
Dean
College of Aeronautical Engineering
NUST, Risalpur Campus

The preliminary meeting started with the recitation of Holy Quran.

Dr. Mukhtar Ahmad, Chairman HEC, inaugurated the preliminary meeting and welcomed the participants. He briefed the members of the committee about the obligation of HEC for curriculum review/revision at graduate and post graduate level. He thanked the committee members for their participation in this very important national task of up-gradation / revision of the curriculum in Aerospace Engineering. He informed the members about the procedure for the review & revision and development of curricula. He also suggested that the HEC shall be requesting the Vice Chancellors of the Universities to implement the Advance Courses suggested by the Committee in their institutions where the facilities and faculty exists. He also emphasized that the program shall be developed as a model for the students of Aerospace Engineering to gain maximum knowledge, same shall be compatible with international programs of foreign universities of high repute and shall cater the national needs and requirements. Dr. Mukhtar also stressed that realm of Aerospace Engineering must be expanded and it should contribute to national growth.

Dir Academics (HEC) Ms Ghayyur Fatima apprised the participants about the standardized format for development of curricula in the Engineering disciplines and requested the members of NCRC to review/revise the existing curriculum in Aerospace Engineering to make it more job oriented; to match the needs of the students and all stakeholders in the country. She informed that draft curriculum developed in the previous NCRC meeting was carefully drafted and now at this stage it may be reviewed to bring about further improvements.

The participants elected Dr. Abdul Munem Khan, Director Academics, Air University Islamabad as the Convener and appointed Dr Muhammad Babar Saeed, Dean College of Aeronautical Engineering, NUST (Risalpur Campus) as the Secretary of the NCRC-Aerospace Engineering.

Professor Dr. Abdul Munem Khan, Convener of the Committee, thanked HEC for their efforts and the following universities/organizations for sending their representatives and for contributing in the highly important national task.

1. Air University, Islamabad.
2. College of Aeronautical Engineering, NUST, PAF Academy, Risalpur.
3. Institute of Space Technology, Islamabad.
4. Sarhad University of Science & Information Technology, Peshawar.
5. Superior University, Lahore

Item No. 1

Vision, Objectives and Outcomes of Aerospace Engineering Education

Aerospace engineering programmes are expected to develop and groom professional aerospace engineers who not only have expertise in the respective system development principles but are also abreast with cutting edge knowledge of their theories, practices, and processes. The Program would prepare technically strong engineers who will contribute effectively towards the nation, society and aerospace industry through innovation, research, entrepreneurship, leadership, technology and healthy lifelong learning attitude.

Aerospace Engineering discipline, despite being relatively new and emerging, has enormously contributed towards technological and socio- economic advancement of communities. The research under this discipline has always been on the cutting edge and has made solid contribution in improving the quality and standards of life. The field of aeronautics has aided in transforming the world into a global village and is capable of carrying the human beings across the planets.

The Committee held detailed deliberations on the BE/BS, ME/MS and PhD curricula. It was noted that the rapidly emerging and developing area of Aerospace Engineering faces uphill challenges and is abound with newer exciting opportunities. The Committee agreed that the proposed curricula should be focussed on exploring the subject at theoretical, practical, and application levels. It must address the need to establish concepts, knowledge and practical experience in all aspects of Aerospace Engineering design cycle requirements. The program shall also include problem analysis, design, fabrication, validation, evaluation, maintenance, project planning and control aspects.

Vision Statement, Objectives and Outcomes for the Aerospace Engineering education in Pakistan are as follows:

VISION:

The Aerospace Engineering education in Pakistan will focus on imparting the Aerospace Engineering knowledge to a level that the students are successful in their professional careers, including industry, government service, and academia. The program will prepare the students for amicable application of engineering principles, processes and practices to aerospace systems, and their maintenance. The students after graduation will contribute to the creation of useful new products, or the generation of original research, by analysing and implementing solutions to relevant problems in the component disciplines of Aerospace Engineering. The students will contribute effectively when part of an integrated team, effectively communicating with team members, superiors, subordinates and clients.

The Aerospace Engineering programme will also, in addition to students' professional growth, attend to development of their personal and interpersonal skills. It will help students to enhance their ability in oral and written communication, and their adaptability to group-work environments. The program will inculcate among students a strong sense of civic, professional and ethical responsibility. The program will strive to develop a capacity for innovation and a passion for lifelong learning.

OBJECTIVES:

The following Aerospace Degree program objectives are envisaged to be accomplished through this curriculum. These objectives emphasize fundamentals in basic sciences, mathematics and the humanities. They also facilitate integration of classroom and laboratory experiences in the engineering disciplines of aerodynamics, propulsion, structural mechanics, mechanics of material, aerospace vehicle design & control, computational engineering, measurements & instrumentation, design & technical communications:

- Provide the highest quality education in state-of-the-art aerospace engineering principles and practices at undergraduate and graduate degree levels.
- To prepare students for professional practice in aerospace engineering and related engineering & scientific fields.
- Conduct research that will significantly advance the state of knowledge in the aerospace sciences and technologies.
- To prepare students for graduate education as their aptitude and professional goals may dictate.

- To provide students with an awareness of the effects of technology in a contemporary global and societal context.
- Advance aerospace engineering practice and education through publications in the engineering and educational literature and through close relations with industry, government and other academia.

OUTCOMES:

Graduates of the Aerospace Engineering Program should possess the ability:

- To apply knowledge of Aerospace Engineering in academia, research and industry.
- To design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
- To identify, formulate and solve Aerospace engineering problems.
- To function on multidisciplinary teams.
- To clearly understand the professional and ethical responsibility, and ability to communicate effectively.
- To recognize the need for, and an ability to engage in life-long learning of Aerospace Engineering issues.
- To design and conduct experiments, as well as to analyze and interpret data.

The committee expressed confidence that the curricula developed will reflect the sprit as contained in the Vision Statement and when implemented, this will satisfy the professional demands of the industry, research domains and academia. The graduates produced will be adequately equipped to exploit the opportunities and respond to the challenges offered by the faster pace of modern developments.

Item No. 2

Knowledge Areas of Aerospace Engineering Curriculum Development

The Chair expressed the need to approach the curriculum development systematically by identifying the major knowledge areas of Aerospace Engineering education.

The following major areas are considered appropriate to design the curricula of Aerospace Engineering:

1. **Non-Engineering**
   a. Humanities (English, Culture, Social Sciences)
   b. Management Sciences
   c. Natural Sciences (Mathematics, Physics, Chemistry)

2. **Engineering**
    a. Computing (Fundamentals, Programming, Design)
    b. Astronautics.
    c. Major Based Core Depth and Breadth (Space Sciences, Aerodynamics, Thermodynamics, Structures, Mechanics)
    d. Design courses and Final year project
    e. Inter-disciplinary electives

The Committee discussed and deliberated in detail, various international recommendations and standards presented to the participants, related to undergraduate and graduate programmes. The committee recognized that quality curricula should focus on building a solid foundation in the early stages of learning and gradually introducing and strengthening the core professional competencies and desired skill-sets. For BE/BS programmes, the major technical subject contents should be covered during the later years of the respective programmes. For MS/PhD programmes, the subject content should cover most modern concepts. Laboratory component should inculcate an industrious approach and practice towards problem solving among students. Good engineering practices must be nurtured all along the education programme. As the practice of Aerospace Engineering is often in the context of multi-application domains, therefore, the graduates should be provided an opportunity of reasonably broad exposure to learn and demonstrate the application of engineering practices. The Undergraduate final year design project should provide the opportunity to bring together all the knowledge gained in a wide variety of courses to solve real-life problems. MS and PhD research should contribute towards creation of knowledge and its impact on the society.

Item No. 3

Duration of Programmes

The BE/ BS Aerospace Engineering Degree Programmes would be minimum 4-year programme spread over 8 semesters. MS/ME Aerospace Engineering Degree Programmes would be of minimum 1½ years and PhD programmes would be of minimum 3 years.

Item No. 4

Eligibility and Admission Criteria

The eligibility criteria for BE/BS Aerospace Engineering was discussed. It was proposed that candidates should have an intermediate with physics, mathematics and chemistry or equivalent qualifications with at least 60% marks (requirement of PEC); however, universities may define their own admission criteria.

The eligibility criterion for admission to ME/MS Aerospace Engineering was agreed to be BE/BS Engineering or 16 years of education in a relevant field. The eligibility criteria for PhD admission is to be decided by the institutes themselves in the light of the guidelines provided by HEC.

Item No. 5

BE/BS Programme Structure

All participants agreed that the proposed program in Aerospace Engineering meets the needs of learning outcomes in terms of knowledge outcomes and ability outcomes with relevant skills. The development of curricula is expected to enhance the theoretical and practical understanding in the field of Aerospace Engineering.

Credit hours earned by a student shall be between 130-136 for the award of BE/BS degree in Aerospace Engineering. Overall distribution must conform to the criteria laid down by HEC and PEC.

Item No. 6

ME/ MS and PhD Aerospace Engineering Program Structure

The ME / MS Aerospace Engineering program was also reviewed thoroughly. It was agreed by the committee that for ME/MS minimum credit hours earned by a student shall be 30 as per following distribution:

Component	**Credit Hours**
Mandatory Courses	15
Elective Courses*	09
Thesis	06
Total	**30**

*** One of the electives should preferably be from Mathematics**

The PhD Aerospace Engineering program was also discussed thoroughly. It was agreed by the committee that for PhD minimum credit hours earned by a student shall be 48 as per following distribution:

Component	**Credit Hours**
Core Courses (of respective stream)	09
Elective Courses *	09
Thesis	30
Total	**48**

*** One of the electives should preferably be from Mathematics**

Item No. 7

Objectives of ME/ MS and PhD Aerospace Engineering

The objectives of MS/ME and PhD Aerospace Engineering program shall be to produce graduates, who:

1. Are highly valued and technically sound professionals, well prepared for their subsequent assignments, duties and responsibilities as professional aerospace engineers, in public as well as private sector organizations.
2. Have been provided core education in this program.
3. Possess detailed understanding in at least one specialty area.
4. Can apply foundational scientific concepts and sound engineering principles efficiently and effectively starting from conceptual design till final deliverables, utilizing advanced technological capabilities in the country.
5. Have experience in conducting independent analytical/ numerical/ experimental research work and document it with fact finding approaches.
6. Can professionally support and communicate technical solutions and results.
7. Continue to pursue lifelong multidisciplinary learning and aim high as professional engineers.
8. Should be able to impart Aerospace Engineering knowledge to students/researcher in respective specialities.

Contents and descriptions of courses to facilitate accomplishment of the programme objectives were deliberated in light of the ME/MS and PhD Aerospace Engineering program and found meeting all the futuristic challenges. The committee also resolved that imparting of professional training, through industrial experts' lectures or short courses be welcomed. Further, it was recommended that the elective courses taught by the institutions should preferably include one Mathematics course.

Item No. 8

Conclusion

Finally, Ms Ghayyur Fatima Director (Curriculum, HEC, Islamabad) thanked all the participants for their valuable contribution to this national cause. Dr. Abdul Munem Khan, the Convener also thanked the participants for their willing and useful contributions, especially participation from the industry. He said that

their efforts will go a long way in developing a workable, useful and comprehensive degree programs in Aerospace Engineering. He said that the entire exercise has not only been utilized by the HEC for developing Aerospace Engineering degree programs, but it also provides an opportunity to professionals and faculty from all around the country to interact for mutual benefit in professional development. He also expressed his profound gratitude to the HEC for providing an opportunity to professionals and academicians from all over the country to contribute their time, knowledge, expertise, and experience to this important activity.

The meeting concluded with vote of thanks to all participants, members and the Chair.

FRAME WORK FOR BE/BS
AEROSPACE ENGINEERING

Duration:	4 years
Number of semesters:	8
Number of weeks per semester:	16-18 (16 for teaching and 2 for examinations)
Total number of credit hours:	130-136
Max number of Cr-Hr / semester:	18
Engineering Courses:	65-70%
Non-Engineering Courses:	30-35%

Non-Engineering Domain									
Knowledge Area	**Sub Area**	**Title of Course**	**Lec CH**	**Lab CH**	**Credit Hours**	**Total Courses**	**Total Credits**	**% Area**	**% Overall**
Humanities	English	English-I	3	0	3	3	8	18.8	6.2
		English-II	3	0	3				
		English-III	2	0	2				
	Culture	Islamic Studies/	2	0	2	2	4	9.3	3.1
		Pakistan Studies	2	0	2				
	Social* Sciences	Social Sciences-I	2	0	2	3	6	13.9	4.6
		Social Sciences-II	2	0	2				
		Social Sciences -III	2	0	2				
Management Sciences	Management **	Management –I	2	0	2	2	6	13.9	4.6
		Management-II	2	0	2				
		Management-III	2	0	2				
Natural	Math	Math-I	3	0	3	3	9	20.9	6.9
		Math-II	3	0	3				
		Math-III	3	0	3				
	Physics	Engineering Physics	3	1	4	1	4	9.3	3.1
	Electives	Engineering	2	1	3	1	3	13.9	4.6
	--	Elective-I***	3	0	3	1	3		
Total				15	43	100		33.1	

* Universities may opt for two courses of 3-0 credit hours each
** Universities may opt for two courses of 3-0 credit hours each
***Math/Physics/Chemistry/Biology/Engineering Economics or related subject as appropriate for the program

Lec CH: Lecture Credit Hours, Lab CH: Laboratory Contact Hours									Engineering Domain
Knowledge Area	**Sub Area**	**Title of Course**	**Lec CH**	**Lab CH**	**Credit Hours**	**Total Courses**	**Total Credits**	**% Area**	**% Overall**
Computing	Fundamentals	Intro to Computer Programming	2	3	3	3	9	10.3	6.9
	Programming	Numerical Methods	2	3	3				
	Design	Computer Applications in Engineering Design	2	3	3				
Engineering Foundation	- -	Engineering Statics	3	0	3	10	27	31.0	20.7
		Engineering Dynamics	3	0	3				
		Materials Science and Engineering	3	0	3				
		Thermodynamics-I	3	0	3				
		Incompressible Aerodynamics	3	3	4				
		Mechanics of Materials	3	3	4				
		Introduction to Aerospace Engineering	2	0	2				
		Probability and Statistics	2	0	2				
		Engineering Drawing	0	3	1				
		Workshop Technology	1	3	2				
Major Based Core (Breadth)	- -	Compressible Aerodynamics	3	0	3	6	19	21.85	14.65
		Heat Transfer	3	3	4				
		Aero Vehicle Performance	3	0	3				
		Stability and Control	3	0	3				
		Aerospace Structures-I	3	0	3				
		Aerospace Instrumentation	2	3	3				

Major Based Core (Depth)	- -	Aerospace Vehicle Design	2	6	4	6	19	21.85	14.65
		Structural Dynamics & Aero-elasticity	3	0	3				
		Aerothermodynamics (Propulsion)	2	3	3				
		Control Systems	2	3	3				
		Structures Elective	2	3	3				
		Elective *	3	0	3				
Inter-Disciplinary Engineering Breadth(Electives)	- -	IDEE-I	3	3	4	2	7	8.1	5.4
		IDEE-II	3	0	3				
Senior Design		Senior Design Project	0	18	6	1	6	6.90	4.6
				2	87	100	66.9		

- Flight Dynamics / Space Propulsion / Thermodynamics-II / Applied Computational Methods / Turbo-machinery

Summary

Domain	Knowledge Area	Course Total	Credit Hours Total	% Overall
Non-Engineering	Humanities	8	18	33.1
	Management Sciences	3	6	
	Natural Sciences	6	19	
	Sub-Total	15	43	
Engineering	Computing	3	9	66.9
	Engineering Foundation	10	27	
	Major Based Core (Breadth)	6	19	
	Major Based Core (Depth)	6	19	
	Inter-Disciplinary Engineering Breadth(Electives)	2	7	
	Senior Design Project	1	6	
	Industrial Training(Summer)*	0	0	
	Sub-Total	28	86	
Total		43	130	100

The curriculum design is based on the concept of foundation, breadth and depth courses so that streams for different specializations can be created

within each discipline.

Foundation Courses: The foundation courses are the courses that all students in a given discipline of engineering must take. These courses provide students with the fundamental concepts and tools to pursue their studies at the higher level.

Breadth Courses: The breadth courses introduce students to different specialties in the given discipline of engineering early in their studies. Before taking the breadth courses, the students should be advised that their choices will affect taking follow-up courses because of pre-requisite requirement.

Depth Courses: The depth courses offer specialization within each engineering discipline. All depth courses must integrate a substantial design component.

The students may select electives from any of the areas of specialization with some guidelines from their respective advisors.

Industrial Training (Summer) is a mandatory non credited requirement.

PROPOSED MODEL BE/BS AEROSPACE ENGINEERING PROGRAMME

Course Title	Lec	Lab	CR	Course Title	Lec	Lab	CR
First Year (1st Semester)				**(2nd Semester)**			
English-I	3	0	3	English-II	3	0	3
Math-I	3	0	3	Engineering Mechanics-I	3	0	3
Engineering Physics	3	3	4	Math-II	3	0	3
Pakistan Studies	2	0	2	Chemistry	3	0	3
Workshop Technology	1	3	2	Engineering Drawing	0	3	1
Islamic Studies	2	0	2	IDEE-I	3	3	4
Introduction to Aerospace Engg	2	0	2				
Total	16	6	18	Total	15	6	17
First Year Credits	35						

Second Year (3rd Semester)				**(4th Semester)**			
Incompressible Aerodynamics	3	3	4	Engineering Mechanics-II	3	0	3
Intro to Comp Programming	2	3	3	Compressible	3	0	3
Math-III	3	0	3	Mechanics of materials	3	3	4
Material Science	3	0	3	Aerospace Instrumentation	2	3	3
Thermodynamics-I	3	0	3	Natural Sciences/Elective-	3	0	3
Probability and Statistics	2	0	2				
Total	16	6	18	Total	14	6	16
Second Year Credits	34						

Third Year (5th Semester) **(6th Semester)**

Numerical Methods	2	3	3	Structural Dyn &	3	0	3
Aerospace Structure-I	3	0	3	English-III	3	0	3
Control System	2	3	3	Stability & Control	3	0	3
Heat Transfer	3	3	4	Aerothermodynamics	2	3	3
Aero Vehicle Performance	3	0	3	Engineering Management	3	0	3
				Social Science I	3	0	3
Total	13	9	16	Total	17	3	18
Third Year Credits	34						

Final Year (7th Semester) **(8th Semester)**

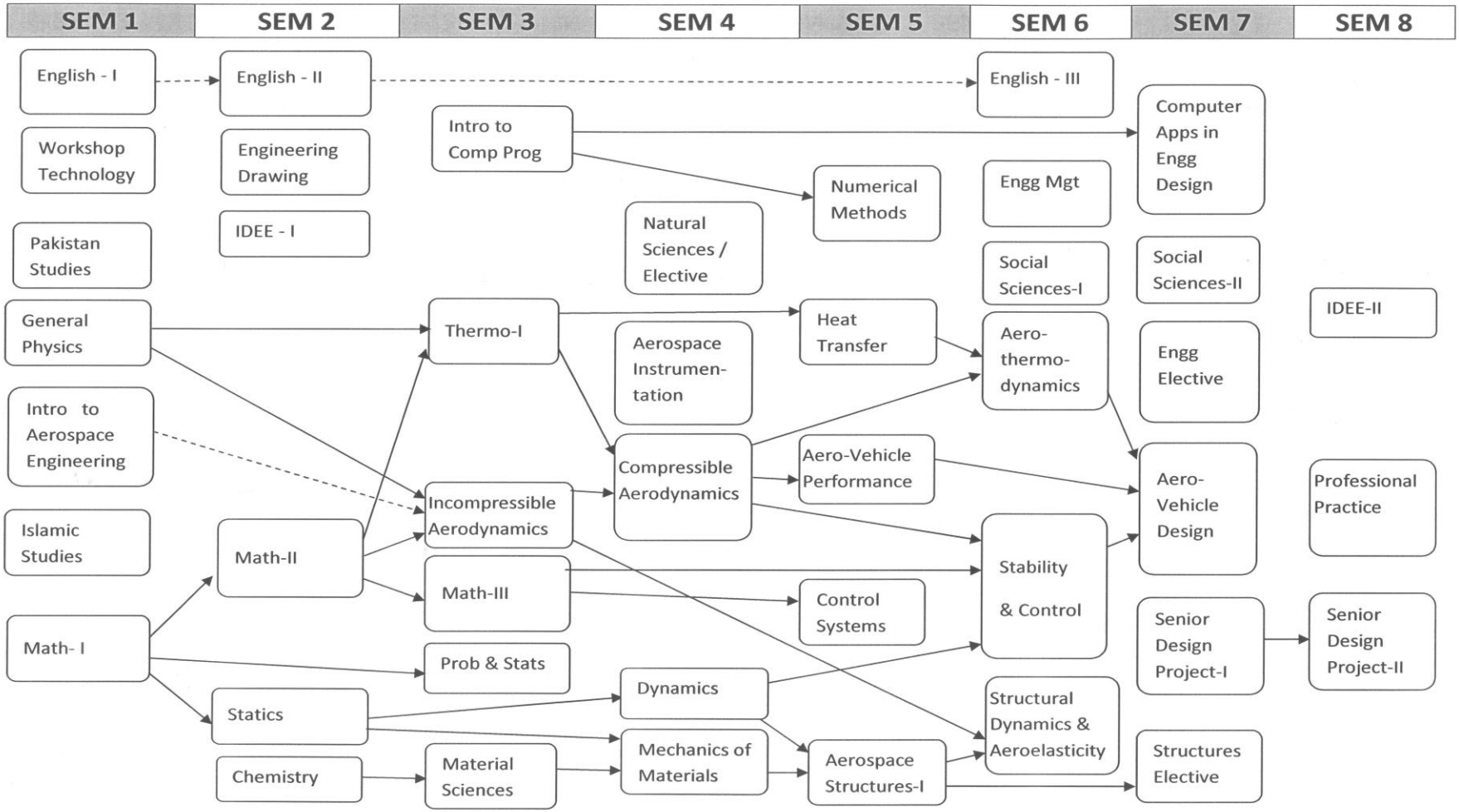
Aero Vehicle Design	1	6	3	Senior Design Project *	0	18	6
Structures Elective	2	3	3	Professional Practice	3	0	3
Engineering Elective	3	0	3	IDEE-II	3	0	3
Social Sciences-II	3	0	3				
Computer App in Engg	2	3	3				
Total	11	12	15	Total	6	18	12
Final Year Credits	27						

*. The institute may offer Senior Design Project in 7th and 8th

Total Credit Hours **130** Lec: Lecture, CR: Credit Hours

1. Number of credit hours per semester: 15-18
2. It is up to the individual universities to determine the locations of breadth and depth courses in various semesters.
3. Universities may prepare their own semester-wise program.
4. Total Credit Hours can be varied between 130 and 136 (both inclusive)
5. Subject credit hours and lab component may also be adjusted according to the subject need and institution's program
6. The Lab Credit Hours may be commensurate with the number of lab experiments in the course. However, the lab credit hours should not be less than 0.5.
7. List of electives is placed as Annex E.

Flowchart of BE / BSc Aerospace Engineering Program



Legend: Solid Arrow shows pre-requisite course, dotted arrow shows preferred knowledge

DETAIL OF COURSES
FOR BE/BS AEROSPACE ENGINEERING

Mathematics

Title of the Course: **Math - I : Applied Algebra and Calculus**

Credit Hours: 3-0

Prerequisites: Nil

Specific Objectives of course:

To provide comprehensive foundation of applied algebra and calculus with emphasis on vectors, complex numbers, matrices, limits, differentiation, integration, and coordinate systems.

Course Learning Outcomes:

After completing this course, the students will be able to:

Course Learning Outcomes:

After completing this fundamental course on Mathematics, the students will be able to:

1. Apply the concept of multiple integral to calculate the mass, volume and moment of inertia for 2D and 3D objects
2. Compute multiple integrals by applying green, stokes and gauss divergence theorems to solve complex engineering problems
3. Compute Fourier series and Fourier transforms of given piecewise continuous functions, half range expansions and complex Fourier series to develop solutions for complex engineering problems.
4. Compute integrals by applying Cauchy integrals, Cauchy integral theorem, Cauchy integral formula and Cauchy residue theorem etc for solution of complex engineering problems.

After completing the contents of Applied Algebra, students will possesses an ability to:

1. Formulate the engineering problems in terms of linear systems involving matrices and solve linear homogeneous and non-homogeneous systems of equations
2. Illustrate powerful tools for extending geometric visualization to a wide variety of mathematical problems where geometric intuition would not otherwise be available.
3. Application of the subject of linear algebra to complex engineering and science problems e.g., Vibration, Quantum Mechanics and Economics

Course Outline:

Complex numbers and De Moivre's theorem, determinants, matrices, product, inversion, rank, system of equations and Cramer's rule, synthetic division, remainder and factor theorem, roots of polynomial equations, graphical method

and transcendental equations. Limit, continuity and differentiation involving algebraic, trigonometric, hyperbolic, implicit and composite functions; application to rates and small corrections, simple Cartesian, parametric and polar curves; tangent, normal, maxima and minima, Taylor and Maclaurin series; curvature. Integration as inverse of differentiation, by substitution, by parts and partial fraction; definite integrals (Wallis formula); integral as limit for a sum, area and arc length of plane figures, volumes and surfaces of solids of revolution.

Lab Outline: Nil

Recommended Books:

1. Fisher and Zeibur*, Integrated Algebra and Trigonometry,* Prentice Hall, New Jersey, 1972
2. George B. *Thomas*, Ross L. Finney, *Calculus and Analytic Geometry 9th Ed,* Addison Wesley, England, 1995
3. S Ramachary and M B Rao*, Mathematical Methods,* BS Publishers, 2005.
4. Rees and Sparks, *College Algebra*, McGraw-Hill *Publisher,* 1985
5. Toft and Meckay, *Practical Mathematics Vol I & II,* Pitman, 1951
6. Rainville, *Unified Calculus and Analytic Geometry*, Macmillan Company *Publication*.
7. Schaum series, *Vector analysis 2nd Edition*, McGraw-Hill *Publisher*, 2009.
8. Peter Kuhfitting, *Basic Technical mathematics with Calculus*, Thomson Brooks/Cole, 1984
9. David C Lay, *Linear Algebra and its Applications 5th Edition*, Pearson, 2015.
10. George Howe, *Mathematics for Practical Man,* Cornell University Library 2014.

Title of the Course: **Math - II : Advanced Calculus & Transform**

Credit Hours: 3-0

Prerequisites: Math - I (Applied Algebra and Calculus)

Specific Objectives of course:

To provide comprehensive knowledge of basic principles, methods, and clear perception of advanced calculus used extensively in nearly all the engineering fields especially in Mechanics, Structures, Communications and Electronics.

Course Learning Outcomes:

After completing this course, the students will be able to:

1. Compute rate of change of function, area under the curve, center mass and the moment of inertia with respect to coordinate axes and problems related to the convergence.
2. Apply mathematical techniques in engineering problems
3. Estimate the extreme values of the function when used in engineering problems

Course Outline:

Analytic Solid Geometry [Equation of a line in symmetrical form, angle between two lines; Angle between two planes. Distance from a point to a plane; Distance from a point to a line. Coordinates of a point dividing a given line in a given ratio; General form reduced to normal, to find the equation of a plane passing through three points or by any set of three independent conditions; Normal form of an equation of a plane, general form of an equation of a plane; Parallel, intersecting and skew lines. The distance between two parallel planes; Shortest distance between two lines (Skew or parallel); Definition of surfaces; Spherical & Cylindrical Co-ordinates. Direction ratio's], **Partial Differentiation** [Function of several independent variables; Partial derivatives. Geometrical interpretation of partial derivatives; Equation of a tangent plane and normal line; Total Differentiation. The derivative of composite function; Partial derivative of higher order and problems; Taylors theorem for function of two variables; Maxima and minima of functions of two variables], **Infinite series** [Introduction to infinite series; Convergence by comparison test and P-series; Absolute convergence and conditional convergence; Integral test and root tests; Ratio test and power series; domain of convergence], **Multiple Integration** [Definition of double integration. Evaluate the double integral with the order of integration reversed; Using double integration find plane area in Cartesian, polar coordinates. (a) Centre of gravity of a plane figure. (b) Moment of inertia of a plane lamina; Volume and surface areas in Cartesian, cylindrical and spherical coordinate systems; Centre of gravity of volume using Cartesian, cylindrical and spherical coordinates; Moment of inertia of volume, surface area; Ratio test and power series; domain of convergence], **Fourier Series** [Introduction to Fourier Series; To evaluate Fourier Constants and write down Fourier expansions; Even and odd functions and their Fourier expansions; Half range Fourier Series; Complex Fourier Series; Fourier Integrals].

Lab Outline: Nil

Recommended Books:

1. George B. Thomas, Ross L. Finney, Calculus and Analytic Geometry 9th Edition, Addison Wesley, 1995
2. Erwin Kreyszig, *Advanced Engineering Mathematics 10th Edition*, Wiley, 2011
3. Agnew, *Analytic Geometry and Calculus with Vectors*, McGraw-Hill, 1962
4. Toft and Meckay, *Practical Mathematics Vol I & II,* Pitman, 1951
5. Hildebrand, *Advanced Calculus for Application 2nd Edition*, Prentice-Hall, 1976.
6. Bedford F W & Dwivedi, *Vector calculus,* McGraw-Hill, 1970
7. Denis G Zill & Warren S Wright, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2012.

Title of the Course: **Math - III : Differential Equations**

Credit Hours: 3-0

Prerequisites: Math - II (Advanced Calculus & Transforms)

Specific Objectives of course:

To provide detailed knowledge of basic principles, methods, and clear perception of ordinary differential equations and partial differential equations used in engineering fields especially in Mechanics, Dynamics, Structures, Communications and Electronics.

Course Learning Outcomes:

After completing this course, the students will be able to:

1. Explain the basic knowledge of differential equations
2. Apply the knowledge of differential equations arising in basic/complex engineering problems
3. Compute the solutions of differential equations using different techniques

Course Outline:

First Order Ordinary Differential Equation [Introduction to differential equation, Solution by separation of variables, Differential equations with homogeneous coefficient, Reducible to homogeneous form, Exact differential equations, Linear differential equations of order one, Solution using exact differentials, Bernoulli's differential equations, Applications of Ist order Ordinary Differential Equations, Orthogonal trajectories, Introduction to Mathematical Modelling]; **High Order Differential Equations with Constant Coefficients** [Solution of homogeneous differential equations, Non homogeneous ordinary differential equations, Method of undetermined coefficients, Cases of failure in method of undetermined coefficients, Method of variation of parameters, Cauchy Euler Equation, Solutions of System of linear ordinary differential equations by operator method, Power series method, Solutions about Singular points using the method of Frobenius, Applications of higher order ODEs]; **Partial Differential Equations [**Basic concept of partial differential equations, solution of PDE and Fundamental Theorem, Solution of homogeneous Linear Partial Differential Equation (LPDE) by operator method, Method of separating variables (Product Method). Solution of first order, 2^{nd} and higher order LPDE by Product method and examples Boundary value problems with boundary initial conditions, Derivation of one-dimensional wave equation and its solution, Derivation of one-dimensional heat equation and its solution, Heat equation with special cases when initial velocity = 0 and initial displacement $\neq 0$ and vice-versa, D' Alembert's solution of wave equation].

Lab Outline: Nil

Recommended Reading Material:

1. Erwin Kreyszig, *Advanced Engineering Mathematics 10th Edition*, Wiley, 2011.
2. Denis G Zill & Warren S Wright, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2012.
3. Toft and Meckay, *Practical Mathematics Vol I & II,* Pitman, 1951
4. Shepley Ross, *Introduction to Ordinary Differential Equations,* John Wiley & Sons Inc, 1980.
5. Sankara Rao, *Introduction to Partial Differential Equations,* PHI Learning Pvt. Ltd., 2010
6. D.G. Zill, *Differential Equations*, International Thomson Publishing, 1990.

Title of the Course: **Engineering Physics**

Credit Hours: 3-1

Prerequisites: Nil

Specific Objective of the Course:

Course Learning Outcomes:

After completing the theory part of the course, the students will be able to:

1. …
2. …
3. …

In addition, the students will also be able to perform following tasks:

1. Apply the basic knowledge of mathematics and science to the fundamental engineering problems and make relationship between various disciplines of physics and engineering
2. Arrange experimentally obtained data to produce meaningful results

Course Outline:

The course includes dimensional analysis, experimental errors; force and torque, general conditions of equilibrium work, energy and power angular motion and moment of inertia. Electric field intensity, current and resistance; kirchhoff's laws for electrical circuits, electromagnetism, thermoelectricity are also covered in this course. Simple Harmonic Motion (SHM), composition of SHM, Damped SHM, Lissajous figures, beats, doppler effect, loudness and intensity and fundamental concepts in geometrical optics, wave theories of light, dual nature of radiation and matter, interference, diffraction, polarization, double refraction and its application to optical stress analysis also form part of this course.

Recommended Reading Material:

1. Robert Resnick, *Physics 5th Edition*, David Halliday and Krane.
2. Thomas D Young and Freedman, *University Physics, 13th Edition,* Addison-Wesley, 2011.

3. Sears & Zemansky, *University Physics 13th Edition,* Addison Wesley, *2011.*
4. P Khare and A Swarup, *Engineering Physics; Fundamentals and modern Applications,* 2009, Jones and Bartlett.

Title of the Course: **Introduction to Aerospace Engineering**

Credit Hours: 2-0

Prerequisites: Nil

Specific Objective of the Course:

Course Learning Outcomes:

After completing this course, the students will have:

1. Knowledge of distinct fundamental disciplines within aerospace engineering
2. Good understanding of airframe classifications and functioning of its components
3. Ability to apply fundamental engineering skills to aerospace problems
4. An ability to design, build and fly a simple flight platform
5. An aptitude to work in teams for solution of an open ended problems

Course Outline:

This is an introductory course of Aerospace Engineering aimed at giving practical understanding of aircraft and its systems to the engineering students. It encompasses the aspects of flight controls, aircraft construction, principles of jet reaction, flight instruments, and electrical systems. The course also gives the concepts of aeronautics and astronautics.
Flight control studies deal with aerodynamics and aircraft control surfaces.

Aircraft construction includes basic structure of aircraft, landing gears, hydraulic, pneumatic and fuel systems and also the maintenance inspections. The topic 'principle of jet reaction' includes thrust and power, factors effecting thrust, compressors and jet propulsion devices. The study of aircraft instruments includes flight, engine auxiliary instruments. The electrical system deals with power supply, power generation and electrical components. In addition to the text, a few videos and visits of aircraft maintenance facilities are included to help understand course contents.

Recommended Reading Material:

1. Dava Newman, *Interactive Aerospace Engineering and Design*. McGraw-Hill, 2002.
2. Ben Senson and Jasen Ritter, *Aerospace Engineering; From the Groundup*, Delmar Cengage Learning, 2011.

3. John D Anderson, *Introduction to Flight 7th Edition*, McGraw-Hill Education 2011.

Journals / Periodicals:

Aerospace America (AIAA)
Aerospace Engineering (SAE)

Title of the course: **Introduction to Computer Programming**

Credit Hours: 2-1

Prerequisites: Nil

Specific Objective of the course:

To teach computer programming (C++ / Fortran / VB / C#)

Course Learning Outcomes:

After completing this course, the students will be able to:

1. Define and describe the elements of any commercially available programming language
2. Explain programming concepts and interpret, translate instructions into language code
3. Demonstrate skills to construct the logic and solve problems

Course Outline:

Introduction to digital computers, main components and functions; elements of programming, flow charts, high level languages (C++ / Fortran 90 / VB/ C# etc), practical training in programming using any language.

Recommended Reading Material:

1. Robert Lafore, *Object Oriented Programming in C++, 9th Edition,* Sams Publishing, 2001
2. Paul Deitel and Harvey Deitel, *C++: How to Programme, 9th Edition,* Prentice Hall, 2013

Title of the course: **Computer Applications in Engineering Design**

Credit Hours: 2-1

Prerequisites: Introduction to Computer Programming

Specific Objective of the course:

The objective of this course is to give students a 'hand on' experience of solving engineering problems (Stress Analysis, Modal Analysis, Buckling Analysis, Thermal Analyses, Fluid Flow Problems, etc) using a commercially available Computational analysis software such as ANSYS, NASTRAN / PATRAN.

Course Learning Outcomes:

After completing this course, the students will be able to:

Course Outline:
The course provides a student with insight to solid modeling features of the software being used. Students are to solve problems belonging to the structures and aerodynamics specialty.

Lab Outline:
Assignments are to be completed and submitted as per instructor's directive.

Recommended Reading Material:
1. Software manual

Title of the Course: **Mechanics of Materials**

Credit Hours: 3-0

Prerequisites: Engineering Mechanics - I (Statics)

Specific Objectives of course:
The students should be able to understand stress, strain stress-strain relation & behaviour of structures under different types of loading.

Course Learning Outcomes:
After completing this course, the students will be able to:
1. Understand the basic concepts of normal and shear stress distribution and their combined affects
2. Understand strains and deformation
3. Understand basic mechanical properties of materials
4. Calculate stress and strain distributions on beam and other structural members and analyse critical areas and point

Course Outline:
Stress, strain, Hook's law , statically determinate and indeterminate problems under axial, shear and bending loads, shear modes, shear force and bending moment diagrams, flexural and shear formula for beams, theory of torsion; thin walled pressure vessel.

Recommended Reading Material:

1. J L Meriam and L G Kraig, *Engineering Mechanics Statics, 7th Edition*, Wiley, 2011.
2. Russell C Hibbler, *Statics and Mechanics of Materials, 4th Edition*, Prentice Hall, 2013
3. Anthony M Bedford and Wallace Fowler*, Engineering Mechanics; Statics – Dynamics, 5th Edition,* Prentice Hall, 2007.
4. Russell C Hibbler, *Engineering Mechanics – Statics, 13th Edition*, Prentice Hall, 2012

Title of the Course: **Engineering Drawing**

Credit Hours: 0-1

Prerequisites: Knowledge of Basic Drawing

Specific Objectives of course:

This course consists of a series of lectures and class room exercises designed for familiarizing the students with the basic concepts of Engineering Drawing. It prepares the students for understanding of a technical drawing and its creation. The contents are covered through number of hands on exercises on drawing the various views in a typical engineering drawing.

Course Learning Outcomes:

After completing this course, the students will be able to:

1. Manually prepare engineering drawing with technical details.
2. To develop self confidence in learning basics of Engineering Drawing.
3. To read technical drawings and produce its isometric views manually.

Course Outline:

It includes a brief account of the various types of drawings with main emphasis on Orthographic Drawings which are the most widely used mode of technical communication. It includes detailed exercises on graphical geometry and then continues with progressive practice in making and understanding various types of orthographic drawings. The topics covered include Principle Views, Auxiliary Views and Sectional Views.

Recommended Reading Material:

1. R K Dhawan, *Fundamentals of Engineering Drawing,* S CHAND, 2014
2. David A Madsen and David P Madsen, *Engineering Drawing and Design*, Delmar Cengage Learning, 2011.

Title of the Course**:** **Computer Aided Drafting**

Credit Hours: 0-1

Prerequisites**: Engineering Drawing and Basic Computer Usage**

Specific Objectives of course:

This course in Computer Aided Drafting (CAD) covers the fundamentals of CAD. The course has been designed to provide students with an adequate background for understanding and using the computers to make 2-D and 3-D engineering drawings. It also prepares the students for advanced usage of computers in CAD / CAM (computer aided manufacturing) operations.

Course Outline:

The students are introduced to the computer software to be used during the course, enabling the student to prepare a draft and generate 2-D drawings with

associated manufacturing and tolerance annotations. Any suitable CAD software (CATIA, Solid Edge, SolidWorks, Pro-E, Patran, etc) may be used for the purpose of course conduct. Students are familiarized with various 2-D drawing commands including the dimensioning and advanced editing techniques and drafting of 3-D drawings using computer software. Students are also familiarized with various basic and advanced 3-D drawing commands for enabling them to generate 3-D models in a perfect, precise and efficient manner.

Course Learning Outcomes:

After completing this course, the students will be able to:

1. Independently prepare engineering drawing and models of intermediate difficulty using software.
2. Develop self confidence in learning basics of CAD software
3. Independently consult technical drawings and produce 3-D models on software.

Recommended Reading Material:

1. Software manual and tutorials
2. Electronic PCB Design software Tutorials
3. David A Madsen and David P Madsen, Engineering Drawing and Design, Delmar Cengage Learning, 2011.

Title of the Course : **Advance Thermodynamics**

Credit Hours: 3-0

Prerequisites: Math - II & Physics

Specific Objectives of course:

To familiarize Thermodynamics Laws and their application to various systems & physical properties of pure substances.

Course Outline:

This is the first course in Engineering Thermodynamics. It provides essential background and competence to the students to have basic know how and analysis ability of the fundamental concepts and basic laws of thermodynamics and their applications to various engineering systems. Study of the subject course is the pre-requisite for more advanced courses on Engineering Thermodynamics and Propulsion etc. Gas power cycle, vapour power cycle, combined power cycles, species transport, reaction thermodynamics, thermochemistry of combustion.

Course Learning Outcomes:

After completing this course, the students will be able to:

Recommended Reading Material:

1. Yunus Cengel and Michal Boles, *Thermodynamics – An Engineering Approach 8th Edition*, McGraw – Hill, 2014

2. M J Moran & H N Shapiro, *Fundamentals of Engineering Thermodynamics 8th Edition*, Wiley, 2014.
3. J B Jones/G A Hawkins, *Engineering Thermodynamics 5th Edition,* John Wiley & Sons Inc, 2006

Title of the Course: **Heat Transfer**

Credit Hours: 3-1/2

Prerequisites: Thermodynamics

Specific Objectives of course:

To familiarize the students with three basic modes of heat transfer i.e. conduction, convection and radiation, with their applications in design of thermal devices including heat exchangers under steady and unsteady conditions.

Course Outline:

This course covers basic laws of conduction, convection and radiation and their application to thermal devices including heat exchangers. The course starts with 1-D heat conduction of composite surfaces in axial and radial directions involving steady and unsteady conditions. The course extends to internal and external heat transmissions involving free and forced heat convection in laminar and turbulent regimes.

Course Learning Outcomes:

After completing this course, the students will be able to:

Recommended Reading Material:

1. Incropera and D P deWitt, *Introduction to Heat Transfer 5th Edition,* Wiley*,* 2007
2. Frank Krieth, *Principals of Heat Transfer 7th Edition,* Cengage Learning, Inc, *2011.*
3. Jack Holman, *Heat Transfer 10th Edition,* McGraw-Hill, 2009*.*

Journals / Periodicals:

Journal of Thermodynamics & Heat Transfer
Journal of Propulsion & Power

Title of the Course: I**ncompressible Aerodynamics**

Credit Hours: 3-1

Prerequisites: Math – II, Engineering Physics and knowledge of Aerospace Engineering. Fluid Mechanics.

Specific Objectives of course:

To study the basic concepts of fluid flow and to calculate forces and moments acting on solid object immersed in a fluid.

Course Outline:

The course deals with the incompressible fluid flows only, and comprises two major parts. The first part deals with the fluid statics and dynamics in which the fluid flows are analysed and the mass flow rate, forces and energy flux are calculated. This part also deals with the potential flows and their superposition. Part two consists of the dimensional analysis, boundary layer theory and comparison of ideal and real flows. It also deals with airfoil characteristics, thin airfoil theory; high lift devices, wing characteristics, Prandtl's lifting line theory and drag on lifting surfaces.

Lab Outline:

Experimental work on subsonic wind tunnel; wind tunnel calibration; model testing, data resolution and measurement of pressure distribution to calculate lift and drag.

Course Learning Outcomes:

After completing this course, the students will be able to:
Develop understanding of the basic concepts

Recommended Reading Material:

1. John D Anderson*, Fundamentals of Aerodynamics, 5th Edition,* McGraw-Hill Education, 2010*.*
2. Bruce R Munson and Alric P Rothmayer*, Fundamentals of Fluid Mechanics, 7th Edition,* Wiley, 2012*.*
3. Pope & Harper*, Low speed wind tunnel testing,* Wiley NY 1966.
4. Yunus Cengel and John Cimbala*, Fluid Mechanics Fundamentals and Applications, 3rd Edition*, McGraw-Hill Education, 2013.

Journals / Periodicals:
Journal of Fluid Mechanics

Title of the Course: **Compressible Aerodynamics**

Credit Hours: 3-0

Prerequisites: Thermodynamics, Incompressible Aerodynamics

Specific Objectives of course:

To study subsonic and supersonic flows, normal and oblique shock waves, expansion waves, Fanno line, Rayleigh line and isentropic flows through variable area channels.

Course Outline:

In the first part, wave propagation and speed of sound are covered followed by isentropic flow through variable area. It extends to study of flow through converging and converging- diverging nozzles and formation of normal shock waves and their application to wind tunnel and supersonic diffusers. Second part deals with oblique shock waves and Prandtl-Mayer flow and their application to supersonic airfoils and nozzles. In the third part, flows with friction and heat addition are discussed.

Course Learning Outcomes:

After completing this course, the students will be able to:

1. Apply knowledge of shock waves and calculate aerodynamic parameters in both subsonic and supersonic compressible flows
2. Communicate easily with details involved in supersonic nozzle designs and compare between under expanded nozzles and over expanded nozzles.
3. Apply linearized potential flow theory to subsonic and supersonic flows.

Recommended Reading Material:

1. Patrick H Oosthuizian and Carscallen*, Compressible Fluid Flow, 2nd Edition,* CRC Press, 2013.

2. James E. A. John, *Gas Dynamics, 3rd Edition,* Prentice Hall, 2006

3. A H Shapiro*, Dynamics & Thermodynamics of Compressible Flow, 1st Edition,* The Ronald Press, 1954

4. B W Imrie*, Compressible Fluid Flow,* Newnes-Butterworth, 1973

5. J. D. Anderson, *Modern Compressible Flow with historical Perspective, 3rd Edition*, McGraw-Hill Education.
6. Zucrow, Gas Dynamics, M. J.& Hoffman 2013.

Title of the Course :**Aerospace Vehicle Performance**

Credit Hours: 3-0

Prerequisites: Compressible Aerodynamics

Specific Objective of course:

To study the concept of flight mechanics of aircraft/ space vehicle considered as a point mass.

Course Outline:

The course introduces basic performance characteristics of air vehicles / space vehicles. It begins with an introduction to standard atmosphere and its effects on performance of aircraft. The course then covers a steady-state analysis of performance parameters such as endurance, aircraft ceiling, range, climb, descent, glide, take-off and landing performance. Accelerated performance parameters are then evaluated using Energy State Approximation and results are compared with exact solutions. The last part of the course deals with turning

performance both instantaneous and sustained. Spacecraft: Flight Mechanics and performance evaluation may also be covered, as applicable.

Recommended Reading Material:

1. John D Anderson Jr, *Aircraft Performance and Design, 1st Edition*, McGraw-Hill, 1999
2. Antonio Filippone, *Advance Aircraft Flight Performance,* Cambridge University Press, 2012
3. James D Lang, *Aircraft Performance, Stability and Control,* Department of Aeronautics, United States Air Force Academy, 1974.
4. John D Anderson Jr, *Introduction to Flight,* McGraw-Hill.
5. Thomas R Yechout, *Introduction to Aircraft Flight Mechanics; Performance, Static Stability, Dynamic Stability and Classic Feedback,* American Institute of Aeronautics and Astronautics, 2014.

Journals/Periodicals:

Aerospace Testing International

Title of the Course: **Stability & Control**

Credit Hours: 3-0

Prerequisites: Compressible Aerodynamics, Math - III (Differential Equations)

Specific Objective of course:

To study the stability and control of aerospace vehicle under a variety of external loads and control inputs.

Course Outline:

This course gives a systematic account of stability and control of aerospace vehicle. In first part of the course, the static longitudinal, directional and lateral stability with respect to vehicle axis system are studied. Effects of various major components on static stability, critical flight conditions and controls requirement are also included in this part. In second part, dynamic stability, the axis systems, inertial and rotating axes and their transformations are studied. This part also gives treatment to linearization of vehicle equations of motion, Laplace transform, stability derivatives, transfer functions, vehicle dynamic response to external disturbances and controls.

Recommended Reading Material:

1. Bandu M Pamadi, *Performance, Stability, Dynamics and Control of Airplanes, 3rd Edition*, American Institute of Aeronautics and Astronautics, 2015.
2. Robert C Nelson, Flight Stability and Automatic Control, 2nd Edition, McGraw-Hill, 1998.
3. J Roskam, *Airplane Flight Dynamics and Automatic Flight Control Part 1 and Part 2,* Dar Corporation, 2003.

Title of the Course: **Aerospace Vehicle Design**

Credit Hours: 2-2

Prerequisites: Stability & Control, Aero-Thermodynamics and Aero-Vehicle Performance

Specific Objective of course:

To undertake conceptual, preliminary and detailed design of an Aerospace vehicle

Course Outline:

This deals with the conceptual design of various types and categories of aerospace vehicle. It consists of two major activities: design layout and design analysis. These two phases broadly cover aspects involving configuration layout, pay-load considerations, aerodynamics, propulsion, structures and loads, weights, stability and control, performance and finally trade studies. As a part of this course, the student is required to prepare and present a conceptual design of a complete aerospace vehicle based on certain given specifications. Extensive use of computers would be made to refine the designed vehicle. The study extends to preliminary and detailed design phases.

Recommended Reading Material:

1. Daniel P Raymer, *Aircraft Design: A Conceptual Approach,* 5th Edition,
2. Andras Sobester and Alexander I J Forrester, *Aircraft Aerodynamics: Design, Geometry and Optimization*.
3. Ajoy Kumar Kundu, *Aircraft Design,* 1st Edition, Cambridge Aerospace Series, 2010.

Journals / Periodicals:

Aerospace Testing International
Journal of Aircraft

Title of the Course: **Engineering Mechanics-II (Dynamics)**

Credit Hours: 3-0

Prerequisites: Engineering Mechanics - I (Statics)

Specific Objectives of course:

To study the kinematics and kinetics of particles and rigid bodies using a variety of methods.

Course Outline:

The course shall be divided into four parts. The first part, Kinematics of Particles, deals with a number of ways in which the motion of a particle is caused. Part two, Kinetics of Particles, is concerned with the three basic methods: force-mass-acceleration, work-energy, and impulse-momentum. In the third part, Kinematics

of Rigid Bodies, the equations of relative velocity and relative acceleration are encountered. Emphasis is placed jointly on solution by vector geometry and solution by vector algebra. Part four, Kinetics of Rigid Bodies, covers the basic equations, which govern all categories of plane motion. Equation of motion in rotating frames is also covered.

Recommended Reading Material:

1. J L Mariam & L G Kraig*, Engineering Mechanics (Dynamics) Vol II (S I Version), 8th Edition,* John Wiley, 2014*.*

2. R C Hibbler*, Engineering Mechanics (Dynamics*), *13th Edition*, Prentice Hall, 2012.

3. Beer & Johnston*, Dynamics, 10th Edition,* McGraw-Hill, 2012.

Title of the Course: **Aerospace Materials**

Credit Hours: 3-0

Prerequisites: Chemistry

Specific Objectives of course:

To study the properties and applications of various materials used in aerospace industry.

Course Outline:

The course shall be designed to develop fundamentals of both conventional and advanced materials being used in engineering applications with special emphasis on Aerospace applications. Course contents may include internal atomic structure, crystal structures and crystal systems in metals, structural imperfection, phase diagrams and their analysis, manufacturing processes of ferrous and non-ferrous materials and their mechanical properties, heat treatment, surface treatment and Time Temperature Transformation (TTT) diagrams. Introduction to polymers, polymer composites, types of fibre, metal matrix composites, ceramic matrix composites, inter metallic composites, powder metallurgy, conductors, magnetic materials and failure analysis of materials may also be introduced.

Recommended Reading Material:

1. Adrian P Mourtiz, *Introduction to Aerospace Materials*, American Institute of Aeronautics and Astronautics, 2012.
2. William F Smith, Foundation of Materials Science & Engineering, *2nd Edition*, McGraw-Hill, 1993
3. Brian Canter and Assender, *Aerospace Materials,* CRC Press, 2001.

Title of the Course: **Aerospace Structures I**

Credit Hours: 3-0

Prerequisites: Engineering Mechanics - II (Dynamics)

Specific Objectives of course:

The students should be able to understand the basic concepts of aerospace structural analysis.

Course Outline:

This course deals with the structural theory that is common to all types of aerospace vehicles. The emphasis is upon fundamentals that are applicable to a broad class of structural problems. The first part of the course describes the load and temperature environment of the aerospace vehicles which may be followed by an introduction to 'Theory of Elasticity'. The latter part of the course deals with the theories of bending, extension, torsion, and shear of slender beams without structural discontinuities. These theories are useful in preliminary design and for determining the basic stress systems that are used in the analysis of statically indeterminate structures. The last part of the course introduces the deflection analysis of beams. A few labs may also be included to help students in understanding fundamental concepts of the theory of structural analysis. These labs are designed to provide an opportunity to the students to measure strains on different types of structures and manipulate the acquired data to get different derived parameters from recorded strains. A few material testing experiments can also be part of this course.

Recommended Reading Material:

1. Archie Higdon, *Mechanics of Materials 4th Edition,* John Wiley, 1985
2. T H G Megson, *Introduction to Aircraft Structural Analysis 2nd Edition*
3. Butterworth-Heinemann, 2013.
4. Bruce K. Donaldson, *Analysis of Aircraft Structures 2nd Edition,* Cambridge University Press, 2012
5. Arthur P Boresi, *Advanced Mechanics of Materials, 6th Edition,* Wiley, 2009.
6. David J Peery, *Aircraft Structures,* McGraw-Hill, 2011
7. Robert M Rivello, *Theory and Analysis of Flight Structures, 5th Edition*, McGraw-Hill, 1989.
8. T H G Megson, *Aircraft Structures for Engineering Students, 5th Edition*, Butterworth-Heinemann, 2012.

Title of the Course: **Structural Dynamics and Aero-Elasticity**

Credit Hours: 3-0

Prerequisites: Incompressible Aerodynamics & Aerospace Structure – I

Specific Objectives of course:

Objective of this course is to teach different types of vibrations and their effects in aerospace vehicles.

Course Outline:

The course covers Fundamentals of vibration, discrete and continuous systems, free and forced vibratory Single Degree of Freedom (SDOF) systems, harmonic vibration, rotating unbalance, base excitation, vibration isolation, transient vibration, systems with two degrees of freedom and Multi Degree of Freedom (MDOF). The last part of the course introduces the subject of aero-elasticity.

Recommended Reading Material:

1. S.S. Rao, *Mechanical Vibration, 5th Edition,* Prentice Hall, 2010.
2. Daniel E J Inman, *Engineering Vibration 4th Edition,* Prentice Hall, 2013.
3. Dewey H Hodges, *Introduction to Structural Dynamics and Aero-elasticity, 2nd Edition,* Cambridge University Press, 2014.
4. S Graham Kelly, *Mechanical Vibrations: Theory and Applications, 1st Edition,* Cengage Learning, 2011.

Journals / Periodicals:

International Journal of Structure Stability & Dynamics
Structural Dynamics & Vibrations
Journal of Vibration and Acoustics
Journal of Fluids and Structures

Title of the Course: **Aerospace Propulsion**

Credit Hours: 3-1/2

Prerequisites: Heat Transfer and Compressible Aerodynamics

Specific Objective of course:

To teach details of propulsion units including breathing engines and rocket propulsion.

Course Outline:

The course shall deal with air breathing engines which include ramjet, turbojet, turbo-fan, and turbo-prop. The course starts with the review of basic topics in thermodynamics, which predict the performance of propulsion devices. Next, the details of turbo engine components, especially compressor and turbine, and their

matching are discussed. In the latter part of the course rocket propulsion and rocket propellants, liquid & Solid Rocket Propulsion Systems, nozzle design, rocket performance. Relevant experiments at appropriate levels are also conducted during the semester.

Recommended Reading Material:

1. Hill & Peterson, *Mechanics and Thermodynamics of Propulsion 2nd Edition,* Pearson Publishing Company, 2009
2. George P Sutton and Oscar Biblarz*, Rocket Propulsion Elements 6th Edition, John Wiley, NY, 1992*
3. S M Yahya, *Turbines Compressors and Fans,* Tata McGraw-Hill Inc, 2006.
4. Ernest H Hirschel, *Basics of Aerothermodynamics* 2nd Edition, 2015.
5. Naixing Chen, *Aerothermodynamics of Turbo Machinery: Analysis and Design,* 2010.

Journals / Periodicals:

Journal of Propulsion & Power

Title of the Course**: Control Systems**

Credit Hours: 2-1

Prerequisites: Math – III

Specific Objectives of course:

Objective of this course is to introduce fundamentals of control theory so that the students learn to model real life problems related to feedback control systems and find their solutions analytically.

Course Outline:

This course introduces the Aerospace majors to the fundamentals of linear control system. Initially the students are taught the mathematical modelling of physical systems, which include both electrical and mechanical systems. The Digital computer is introduced as a tool for solution of differential equations and linear systems, transient and steady state response. Classification of control systems and frequency response of feedback control system are taught during the later part of the course. Root locus, Routh's criterion and signal flow graphs are also covered.

Recommended Reading Material:

1. Phillips & Harbor*, Feedback Control Systems 5th Edition,* Prentice Hall, USA, 2010
2. John Joachim D'Azzo, and Constantine H. Houpis, *Linear Control System Analysis and Design : Conventional and Modern, 4th Edition,* McGraw-Hill, 1995

3. Joseph Distefano, *Schaum's Outline of Feedback and Control Systems 2nd Edition*, McGraw-Hill Education 2013.
4. Constantine H. Houpis and Sheldion, *Linear Control System Analysis and Design with MATLAB, 6th Edition,* CRC Press, 2013.

Journals / Periodicals:

IEEE Control Systems Magazine

Title of the Course: **Aerospace Instrumentation**

Credit Hours: 2-1

Prerequisites: Physics

Specific Objectives of course:

Main objective of this course is to introduce the students with the fundamentals of measurement techniques and instrumentation systems. So that they should be able to understand instrumentation systems that are being used in and for aerospace systems.

Course Outline:

Measurement and correct interpretation are necessary parts of any engineering research and development programme. Naturally, the measurements must supply reliable information and their meanings must be correctly comprehended and interpreted. This course is meant for students who have to deal with various types of test and measurement equipment at various stages of their life. It includes topics related to process of measurement standards and dimensional units of measurement, sensors, counters, displacement and dimensional measurements, and stress & strain measurement analysis, fluid flow measurement, temperature measurement and motion measurement. Experimental portion includes use of measuring instruments like autocollimator, screw pitch measuring machine, tolerator, horizontal metro scope, interference microscope, interferometer, surface roundness testing machine and Mechanical & Electronic comparators.

Lab Outline:

Besides formal lab work SPICE / MATLAB / LABVIEW based tutorial sessions can be scheduled for analysis and designing of analogue and digital instrumentation systems.

Recommended Reading Material:

1. Nagabhushana and Sudha, *Aircraft Instrumentation and Systems,* I K International Publishing House, *2010*
2. James W. Dally, William F. Riley, and Kenneth G. McConnell, *Instrumentation for Engineering Measurements,* John Wiley and Sons Ltd, 1993

3. *Alan S Morris, Measurement and Instrumentation: Theory and Applications,* Butterworth-Heinemann, *2011.*

Title of the Course: **Probability and Statistics**

Credit Hours: 2-0

Prerequisites: Math– I

Specific Objectives of course:

To enable the students to effectively analyse scientific data using various statistical tools and techniques.

Course Outline:

Representation of statistical data, measures of central tendency, variation, skewness and Kurtosis. Fundamentals of probability, discrete and continuous probability distributions i.e. binomial, Poisson, negative exponential, normal and Weibull; Sampling distributions of mean and standard deviation; Chi-square and F distributions; testing of hypothesis. Linear correlation by moments and experimental verification of laws of statistics and probability

Recommended Reading Material:

1. Ronald E Walpole and Reymond H Myres*, Probability and Statistics for Engineers and Scientists, 9th Edition,* Pearson, 2011
2. Niel A Weiss, *Introductory Statistics 9th Edition*, Pearson, 2011.
3. Jay L Devore, *Probability and Statistics for Engineering and Sciences 9th Edition,* Brooks Cole, 2015

Title of the Course: **Numerical Methods**

Credit Hours: 2-1

Prerequisites: Introduction to Computer Programming

Specific Objectives of course:

To enable students to solve complex problems of sciences and engineering using modern computers using discrete mathematical concepts.

Course Outline:

Introduction to numerical methods; polynomial, transcendental and linear systems of equations; root finding, bisection methods, Newton's methods, finite differences, interpolation, curve fitting, differentiation, integration and ordinary differential equations; errors of approximation. Practical training in application to scientific and engineering problems, introduction to Finite Element Method

Lab Outline:

Practice problems from sciences and engineering

Recommended Reading Material:

1. Burden & Faires, *Numerical Analysis, 10th Edition*, CENGAGE Learning Custom Publishing, 2015
2. Boris Obsieger*, Numerical Methods I: Basis and Fundamentals,* Create Space Independent Publishing Platform, 2015*.*
3. Anne Greenbaun and Chartier, *Numerical Methods: Design, Analysis and Computer Implementation of Algorithims,* Princeton University Press, *2012.*
4. Steven Chapra and Reymond Canale, *Numerical Methods for Engineers 7th Edition,* McGraw-Hill, 2014.

Title of the Course: Senior Design Project I & II

Credit Hours: 0-6 (To be covered in 7th & 8th Semester consecutively)

Prerequisites: Senior Standing

Specific Objectives of course:

To do a complete project independently on any aerospace topic exhibiting ability of application of knowledge in all basic aerospace subjects.

Outline:

Students are required to complete an engineering project based upon the knowledge they have gained during BE/BS studies.

SCHEME OF STUDIES FOR ME/MS. AEROSPACE ENGINEERING

Minimum Credits Hours = 30
Essential Credit Hours = 21
Elective Credit Hours * = 09

* One of the electives should be from Mathematics

Breakdown of 21 Credit Hours

Subjects	Credit Hours
Mathematics	3
Major related subjects	12
Thesis*	6

*Universities may follow HEC Policy regarding conduct of thesis / course work.

Following are the areas of Specialization:

- **Fluid Dynamics /Aerodynamics**
- **Solid Mechanics / Structural Design and Finite Element Analysis**
- **Thermo fluids / Propulsion**
- **Flight Dynamics and Control / Guidance, Navigation & Control**
- **Aerospace Vehicle Design**

- Student may take any four Major Courses from the Graduate Courses list or any other relevant course for completion of the theoretical part of the specialization:

SCHEME OF STUDIES FOR PhD.
AEROSPACE ENGINEERING

Minimum Credits Hours = 48
Essential Credit Hours = 36
Elective Credit Hours * = 12

* One of the electives should preferably be from Mathematics

Breakdown of 36 Credit Hours

Subjects	Credit Hours
Major related subjects	06
Thesis*	30

- Area of specializations are same as that of MS/ME
- Student may take any two Major Courses from the Graduate core courses list or any other relevant course for completion of the theoretical part of the specialization.
- Core courses and elective courses taken during MS studies will not count towards PhD coursework.
- Courses for one specialization can be considered as an elective for other specializations.

Graduate core courses list.

Major Graduate Courses	**Specialization**	**Fluid Dynamics \ Aerodynamics**	**Solid Mechanics \ Structural Design & Finite Element Analysis**	**Thermo-Fluids \ Propulsion**	**Flight Dynamics and Control / Guidance, Navigation & Control**	**Aerospace Vehicle Design**
Advanced Aerodynamics - I : Incompressible Flows		√		√		√
Advanced Aerodynamics - II : Compressible Flows		√		√		√
Computational Fluid Dynamics-1		√		√		√
*Advanced Heat Transfer		√		√		√
Viscous Flow		√		√		√
Turbulent Fluid Flow		√				√
Theory of Elasticity			√			√
Advanced Theory of Vibration			√		√	√
Finite Element Methods – I			√		√	√
Mechanics of Composite Structures			√			√
Mechanical Behaviour of Materials			√			√
Design and Analysis of Aerospace Structures			√			√
Advance Heat Transfer				√		√
Advanced Combustion				√		√
Rocket Propulsion				√		√
Advanced Aero Thermodynamics				√		√
Turbo-machinery				√		√
Research Methodology		√	√	√	√	√

LIST OF MAJOR COURSES: SPECIALIZATIONS

Major Courses	**Specialization**	**Fluid Dynamics \ Aerodynamics**	**Solid Mechanics \ Structural Design & Finite Element Analysis**	**Thermo-Fluids \ Propulsion**	**Guidance, Navigation & Control \ Flight Dynamics and Control**	**Aerospace Vehicle Design**
Advanced Aerospace Propulsion				√		
Modern Feedback Control					√	
Guidance and Navigation of Aerospace Vehicles					√	
Aerospace Vehicles Dynamics & Control					√	√
Optimal Control					√	
Design of Aerospace Vehicle					√	√
Inertial and Integrated Navigation System					√	
Advanced Flight Dynamics					√	√
Multi-disciplinary Optimization for Aerospace Vehicle Design						√

DETAIL OF COURSES FOR ME/MS and PhD
AEROSPACE ENGINEERING

Title of the course: **Advanced Aerodynamics-I: Incompressible Flows**

Credit Hours: 3-0

Prerequisites: Nil

Course Outline:

This graduate level course is first in the sequence of two advanced aerodynamics courses. The main focus of this course is on incompressible flows. Incompressible flows form a major part of aerodynamics and their analysis is broadly classified under “inviscid” and “viscous” flows. In viscous incompressible flows, further subdivisions are made on the basis of flow Reynolds number (Re) i.e. Laminar boundary layer (High Re), Stokes flow (low Re) and turbulent flow (Very high Re). The basic governing equations of fluid/aerodynamics i.e. Navier Stokes equations are introduced and their various analytical solution techniques are explained in detail. Two-dimensional incompressible and inviscid flows are solved using complex analysis treatment.

Recommended Reading Material:

1. Panton, Ronald L., Incompressible Flow 2nd Edition, Wiley-Interscience, NY, 1996
2. Frank M. White, *Viscous Fluid Flow 2nd Ed*, McGraw-Hill, NY, 1990
3. John Anderson, *Modern Compressible Flow 2nd Ed.*, McGraw-Hill, Singapore, 1990

Title of the course: **Advanced Aerodynamics-II: Compressible Flows**

Credit Hours: 3-0

Prerequisites: Nil

Course Outline:

This graduate level course is second in the sequence of two advanced aerodynamics courses. The main focus of this course is on compressible flow. Compressible flows form a major part of aerodynamics and their analysis is broadly classified under “inviscid” and “viscous” flows. Inviscid compressible flows include analysis of properties across shocks/expansion waves, variable area flows, linearized 2-D flow, part of hypersonic flow and unsteady wave motion. Viscous compressible flows involve solution of the complete system of

governing equations including Navier-Stokes equations. Various examples of viscous compressible flow are illustrated.

Recommended Reading Material:

1. John Anderson, *Modern Compressible Flow 2nd Ed.*, McGraw-Hill, Singapore, 1990
2. Frank M. White, *Viscous Fluid Flow 2nd Ed*, McGraw-Hill, NY, 1990

Title of the Course: **Computational Fluid Dynamics-I**

Credit Hours: 3-0

Prerequisites: Nil

Course Outline:

This is the first course in Computational Fluid Dynamics (CFD). This includes introduction to finite difference and finite volume methods used in modern engineering. Basic concepts of discretization, consistency and stability are also introduced. Applications of numerical methods to selected model partial differential equations are carried out

Recommended Reading Material:

1. John Anderson, *Computational Fluid Mechanics and Heat Transfer,* Tanehill & Pletcher Hemisphere Pub, NY 1984

Title of the Course: **Advanced Heat Transfer**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

This graduate level course in heat transfer is designed to cover material beyond the undergraduate level. Different modes of heat transfer, i.e. Conduction, Convection and Radiation are broadly discussed. The main focus of this course is on Conduction and Convection with some introductory material on Radiation towards the end of the course. In Conduction 2-D steady and 1-D unsteady problems are introduced and their solution methods discussed. In Convection the equations of motion, energy and mass conservation are reviewed and problems involving forced and free convection are discussed with reference to various flow regimes

Recommended Reading Material:

1. Ozisik, *Heat Conduction 2nd Ed,* John Wiley & Sons, 1993
2. Louis Burmeister, *Convective Heat Transfer 2nd Ed,* John Wiley & Sons,
3. 1993

4. Siegel & Howell, *Thermal Radiation Heat Transfer 2nd Ed,* McGraw-Hill, 1972

Title of the Course: **Viscous Flow**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Laminar boundary-layer theory, three-dimensional and compressible boundary layers, Laminar-flow instability theory, transition, Introduction to the mechanics of turbulence, turbulent free shear flows and boundary layers, Computational and general solution methods, Stability of laminar flows, transition and turbulent flow.

Recommended Reading Material:

1. John Anderson, *Modern Compressible Flow 2nd Ed.*, McGraw-Hill, Singapore, 1990
2. Frank M. White, *Viscous Fluid Flow 2nd Ed*, McGraw-Hill, NY, 1990

Title of the Course: **Turbulent Fluid Flow**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Description of turbulent flow, Flow equations, vorticity dynamics, Reynolds-averaged equations, engineering turbulence models, Theory of homogeneous turbulence, spectral dynamics, Shear flow turbulence, mean and fluctuating structure of free and wall-bounded turbulent flows Qualitative features of turbulence, Statistical and spectral representation of turbulent velocity fields, averages, moments, correlations, length and time scales and the energy cascade, Averaged equations of motion, closure requirements, Reynolds stress, dissipation rate. Isotropic turbulence, homogeneous shear flows, free shear flows, and wall bounded flows. Scalar transport, particulate transport.

Recommended Reading Material:

1. Paul. A. Libby, *Introduction to turbulence*, CRC Press, 1996,
2. S. B. Pope, *Turbulent Flows*, Cambridge University Press, 2000
3. P. A. Durbin, *Statistical theory and modelling of turbulent flows*, Wiley publishers, 2001,

Title of the Course: **Theory of Elasticity**

Credit Hours: 3-0

Prerequisites: Nil

Course Outline:

This is the first course in Structures, which in its broad aspect deals with the study of elastic bodies. When the elementary methods of strength of materials are inadequate to furnish satisfactory information regarding stress distribution in engineering structures, then a resort is made to the more powerful methods of theory of elasticity. Basic equations of the theory of elasticity in different co-ordinate system, solution to plane stress and plane strain problems, Fourier transformation method and St. Venant's principle is also introduced in the course. Solution to plates of various profiles and end conditions along with the most commonly used numerical energy methods are explained to strengthen the concepts of student to undertake the advanced courses in structures in the future semesters.

Recommended Reading Material:

1. Timoshenko & Goodier, *Theory of Elasticity*, 3rd Ed, McGraw-Hill, NY, 1970
2. Martin H. Sadd, *Elasticity, Theory Application and Numerics*, Elsevier Science, 2005,

Title of the Course: **Advanced Theory of Vibrations**

Credit Hours: 3-0

Prerequisites: Nil

Course Outline:

The purpose of this course is to cover comprehensive fundamental principles of vibration theory. It begins with an introduction to some basic concepts, discussion about spring, mass and damper elements, and introduction to harmonic motion and its analysis. The course then covers Free and Forced vibration of single degree of freedom (SDOF) system, damped and un-damped system. After thoroughly covering SDOF system two and multi-degrees of freedom system are covered. Special additional topics are covered at the end of the course.

Recommended Reading Material:

1. Singiresu S Rao*, Mechanical Vibrations 3rd Ed,* Addison-Wesley Massachusetts, 2003

Title of the Course: **Finite Element Methods – I**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

The course covers Finite Element Method as applied to one & two-dimensional problems of structures, heat transfer & fluid flow. One-dimensional and two-dimensional, static & dynamic problems are solved by using FEM.

Recommended Reading Material:

1. J N Reddy, *An Introduction to the Finite Element Method 2nd Ed,* McGraw-Hill, NY, 1993
2. K. A. J. Bathe, *Finite element procedures*, Elsevier Science, 1982

Title of the Course: **Mechanics of Composite Structures**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Composite material and their constituents, Unidirectional composites behaviour of laminated composite plates under various loading conditions, classical lamination theory, effective stiffness properties of composites, Constitutive description of laminated plates, Laminated plate theory, Edge effects in laminates, Nonlinear theory of generally laminated plates, Governing equations in the Von Karman sense, Laminated plates with moderately large deflections, Postbuckling and nonlinear vibration of laminated plates, Failure theories and experimental results for laminates.

Recommended Reading Material:

1. *Mechanics of Composite Materials by Agarwal*
2. Robert M. Jones*, Composite Materials 2nd Revised Edition,* CRC press, 1998

Title of the Course: **Mechanical Behaviour of Materials**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Types of stresses and strains, elastic and plastic deformation, defects and

imperfections in single and polycrystalline materials, classification of defects, tensile, compression, torsion, bend, impact and fracture, toughness testing of materials. Effect of strain rate on flow properties of materials, fracture mechanics, fatigue, creep and stress rupture of materials, Griffth and Orwan theory of fracture of materials, factors affecting fatigue, stress rupture test, Nabaroo-Herring and coble creep, embrittlement and its types, materials' selection and failure analysis, case studies.

Recommended Reading Material:

1. R. K. Dowling*, Mechanical Behaviour of Materials*, Pearson Education Limited

Title of the Course: **Design and Analysis of Aerospace Structures**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Structural design requirements for aerospace applications, Structural design of launch vehicle, aircraft and spacecraft. Analysis of thin walled structures under bending torsion and shear. Buckling of thin plates, columns, shear panels, compression panels and thin walled circular and conical cylinders. Stresses in flat and curved plates, stresses in rotating sections, Composite materials for aerospace applications.

Recommended Reading Material:

1. Bruce K. Donaldson, *Analysis of Aircraft Structures 1st Edition* , Cambridge
2. University Press,1993
3. Arthur P Boresi, *Advanced Mechanics of Materials 6th Edition*, John Wiley, 2002
4. Peery and Azar, *Aircraft Structures 2nd Edition,* McGraw-Hill, 1982
5. Robert M Rivello, *Theory and Analysis of Flight Structures*, McGraw-Hill
6. T H G Megson, *Aircraft Structures for Engineering Students,* Butterworth-Heinemann

Title of the Course: **Design and Analysis of Aerospace Structures**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Structural design requirements for aerospace applications, Structural design of launch vehicle, aircraft and spacecraft. Analysis of thin walled structures under bending torsion and shear. Buckling of thin plates, columns, shear panels,

compression panels and thin walled circular and conical cylinders. Stresses in flat and curved plates, stresses in rotating sections, Composite materials for aerospace applications.

Recommended Reading Material:

1. Bruce K. Donaldson, *Analysis of Aircraft Structures 1st Edition* , Cambridge University Press,1993
2. Arthur P Boresi, *Advanced Mechanics of Materials 6th Edition*, John Wiley, 2002
3. Peery and Azar, *Aircraft Structures 2nd Edition,* McGraw-Hill, 1982
4. Robert M Rivello, *Theory and Analysis of Flight Structures*, McGraw-Hill
5. T H G Megson, *Aircraft Structures for Engineering Students,* Butterworth-Heinemann.

Title of the Course: **Advanced Heat Transfer**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

This graduate level course in heat transfer is designed to cover material beyond the undergraduate level. Different modes of heat transfer, i.e. Conduction, Convection and Radiation are broadly discussed. The main focus of this course is on Conduction and Convection with some introductory material on Radiation towards the end of the course. In Conduction 2-D steady and 1-D unsteady problems are introduced and their solution methods discussed. In Convection the equations of motion, energy and mass conservation are reviewed and problems involving forced and free convection are discussed with reference to various flow regimes

Recommended Reading Material:

1. Ozisik, *Heat Conduction 2nd Ed,* John Wiley & Sons, 1993
2. Louis Burmeister, *Convective Heat Transfer 2nd Ed,* John Wiley & Sons, 1993
3. Siegel & Howell, *Thermal Radiation Heat Transfer 2nd Ed,* McGraw-Hill, 1972

Title of the Course: **Advanced Combustion**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Fundamentals of combustion systems, fire and explosion phenomena, Thermo-chemistry, chemical kinetics, laminar flame propagation, detonations and explosions, flammability and ignition, spray combustion, and the use of computer techniques in combustion problems, Thermodynamics of gas mixtures, chemical kinetics, conservation equations for multi-component reacting gas mixtures, deflagration and detonation waves. Nozzle flows and boundary layers with reaction and diffusion.

Recommended Reading Material:

1. Felix Jiri Weinberg, *Advanced Combustion Methods*, Academic Press,1086.
2. J. Warntaz and Ulrich Maas, *Combustion*, Springer, Robert W. Dibble, 2001,
3. Kenneth K. Kuo, *Principles of combustion*, John Wiley & Sons

Title of the Course: **Rocket Propulsion**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Analysis of liquid and solid propellant rocket power plants, propellant thermo-chemistry, heat transfer, system considerations. Low-thrust rockets, multi-stage rockets, trajectories in powered flight, electric propulsion, Space Propulsion and Power Systems, Analysis and performance of chemical and nuclear rockets, electric propulsion systems, Introduction to solar, chemical, thermoelectric, and nuclear power sources, Aerothermo-chemistry of Advanced Propulsion Systems, Physics and chemistry needed to analyze high performance rocket propulsion systems including reacting high temperature radiating gas and plasma flows.

Recommended Reading Material:

1. Sutton, *Rocket Propulsion Elements* (*Latest Ed)*, John Wiley, NY

Title of the Course: **Advanced Aerothermodynamics**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Aerothermodynamics of Aerospace vehicles,(missiles, space planes, air-breathers), flight dynamics (trajectory, range, stability), aerothermo-dynamics (fluid dynamics, thermodynamics, aerodynamics, heating), and propulsion systems (scramjets, combined cycles).

Recommended Reading Material:

1. Hill & Peterson, *Mechanics and Thermodynamics of Propulsion 2nd Ed*, Pearson Publishing Company, 2009
2. George P Sutton & Oscar Biblarz, *Rocket Propulsion Elements 6thEd*., John Wiley, NY, 1992
3. S M Yahya & Tata Mac-Graw, Turbines *Compressors and Fan,* Hill Inc, 2006.
4. H Cohan, G F C Rogers & H I H Saravanamut too, *Gas Turbine Theory*, John Wiley & Sons Inc.
5. S L Dixon, *Fluid Mechanics, Thermodynamics of Turbomachinery,* Pergamon Press, 1966

Title of the Course: **Turbo-machinery**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

This course includes the theories of cascades, performance analysis of axial and radial flow compressor, pumps and turbines at design and off-design conditions.

Recommended Reading Material:

1. S L Dixon, *Fluid Mechanics, Thermodynamics of Turbomachinery,* Pergamon Press, 1966

Title of the Course: **Advanced Aerospace Propulsion**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

This course includes the theory of rocket propulsion, flight dynamics of rocket, solid rocket, liquid rocket, heat transfer in rocket motor, and component design. Advance propulsion topics on hypersonic airbreathing propulsion (HAP), Rocket Based Combined Cycle (RBCC) engines, Turbine Based Combined Cycle (TBCC) engines.

Recommended Reading Material:

1. Hill & Peterson, *Mechanics and Thermodynamics of Propulsion 2nd Ed*, Pearson Publishing Company, 2009
2. George P Sutton & Oscar Biblarz, *Rocket Propulsion Elements 6thEd*., John Wiley, NY, 1992

Title of the Course: **Modern Feedback Control Theory**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Applications of modern feedback control theory to flight control, Controller design based on optimal control techniques. Nonlinear system theory applications, typical aerospace control methods such as model following, load alleviation, and flutter suppression, recent advances in aerospace vehicle control.

Recommended Reading Material:

1. Richard Dorf, Robert Bishop, *Modern control system11th edition*, Pearson education

Title of the Course: **Guidance and Navigation of Aerospace Vehicles**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Principles of guidance systems for spacecraft, launch vehicles, homing and ballistic missiles. Optimal guidance, Interplanetary transfer guidance with low thrust, Principles of inertial navigation, theory and applications of the Global Positioning

System, Celestial navigation procedures, application of Kalman filtering to recursive navigation theory.

Recommended Reading Material:

1. Peter H. Zipfel, *Modeling and Simulation of Aerospace Vehicle Dynamics*, AIAA, 2001.
2. Schwarz KP and M Wei2000.,*INS/GPS Integration for Geodetic Applications*, Springer.

Title of the Course: **Aerospace Vehicle Dynamics and Control**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Six degree of freedom motion of aerospace vehicle, ascent and re-entry of launch vehicle and space craft, attitude control of spacecraft, transfer of orbit, types of spacecraft orbits, Methods of Coordinate Transformation, Equation of Motion for Flight over Flat Earth, Equation of Motion for Flight over Spherical Earth, Equation of Motion for Flight over Ellipsoidal Earth, Flight Dynamics of launch vehicle and Spacecraft.

Recommended Reading Material:

1. Bong Wie, *Space vehicle dynamics and control 2nd edition*, AIAA, 2008

Title of the Course: **Optimal Control**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

The optimal control problem, Variational approach, Pontryagin's principle, Hamilton-Jacobi equation, Dynamic programming, Time-optimal, minimum fuel, minimum energy control systems, the regulator problem, Structures and properties of optimal controls.

Recommended Reading Material:

1. Gearing Hans P., *Optimal control with engineering applications,* Springer,2007

Title of the Course:**: Design of Aerospace Vehicles**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

System engineering, Mission analysis and design, Trajectories, determination of main design parameters, configuration and structural design, mass analysis, performance analysis

Recommended Reading Material:

1. Jose A Cambereos & David J. Moorhouse, *Exergy analysis and design optimization of aerospace vehicle systems*, AIAA, 2011

Title of the Course: **Inertial & Integrated Navigation System**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Principles of inertial navigation and its integration with GPS; coordinate frames, modelling linear motion and rotational motion, mechanization of inertial navigation sensor measurements, space state representation of system errors and linear state equations.

Recommended Reading Material:

1. Schwarz KP and M Wei 2000., *INS/GPS Integration for Geodetic Applications*, Springer

Title of the Course: **Advanced Flight Dynamics**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

The course includes dynamics and control of aircraft, Linear systems theory, state equations, transfer functions, stability, time and frequency response, Aircraft longitudinal and lateral flight dynamics

Recommended Reading Material:

1. M. V. Cook, *Flight dynamics and principles*, Butterworth Heinemann, 2007.

Title of the Course: **Multi-disciplinary Optimization for Aerospace Vehicle Design**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

Applications of unconstrained and constrained parameter optimization, dynamic programming, and optimal control theory to problems in aerodynamics, aerospace structures, flight dynamics and control, and aerospace design, numerical methods of optimization.

Recommended Reading Material:

1. P. Venkataraman, *Applied optimization with MATLAB programming 2nd edition*, John Wiley & Sons
2. Compressible Fluid Dynamics (Contents given above)
3. Advanced Propulsion Systems (Contents given above)

Title of the Course: **Advanced Engineering Mathematics**

Credit Hours:3-0

Prerequisites: Nil

Course Outline:

The course includes Vector Calculus, Tensors, Kronecker tensor, Livi-Civita tensor, differential operators in tensor form, Calculus of Variations, Brachistochrone problem, Euler-Lagrange Equations for several variables, optimization, Fibonicci Procedure, method of Lagrange multipliers, kuhn-Tucker Conditions.

Recommended Reading Material:

1. Bernard Kolman, *Introductory Linear Algebra with Applications 6th Ed*, Printice Hall, USA, 1997
2. Tune Myint-U & Lokenath Debnath, *Partial Differential Equations for Scientists and Engineers 3rd Ed*, PTR Prentice Hall N J
3. Erwin Kreysig, *Advanced Engineering Mathematics 8th Ed*, John Wiley, Singapore, 1999
4. C Roy Wylie, *Advanced Engineering Mathematics5thEd*, McGraw-Hill, London, 1982
5. Robert Weinstock, *Calculus of Variations*, McGraw-Hill, 1952

List of MS/ME Electives is placed as Annex "F"

Annexure - A

COMPULSORY COURSES
IN ENGLISH FOR BE/BSc IN ENGINEERING DISCIPLINE

Semester – I

Functional English

Objectives: To enhance language skills and develop critical thinking

Course Contents:

Basics of Grammar
Parts of speech and use of articles
Sentence structure, Active and passive voice
Practice in unified sentence
Analysis of phrase, clause and sentence structure
Transitive and intransitive verbs
Punctuation and spelling

Comprehension
Answers to questions on a given text

Discussion
General topics and every day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening
To be improved by showing documentaries/films carefully selected by subject teachers)

Translation skills
Urdu to English

Paragraph writing
Topics to be chosen at the discretion of the teacher

Presentation skills
Introduction

Note: Extensive reading is required for vocabulary building

Recommended Reading Material:

1. Functional English

a) Grammar

1. A.J. Thomson and A.V. Martinet, "*Practical English Grammar Exercises 1"*.Third Edition. Oxford University Press. 1997. ISBN 0194313492
2. A.J. Thomson and A.V. Martinet, "*Practical English Grammar Exercises 1"*.Third Edition. Oxford University Press. 1997.. ISBN 0194313506

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet.*"Oxford Supplementary Skills. Fourth Impression"*, 1993, ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

1. Reading. Upper Intermediate. Brian Tomlinson and Rod Ellis. "*Oxford Supplementary Skills"*. Third Impression 1992.ISBN0 19 453402 2.

d) Speaking

Semester II

Communication Skills

Objectives:
To enable the students to meet their real life communication needs

Course Contents:

Paragraph writing
Practice in writing a good, unified and coherent paragraph

Essay writing
Introduction

CV and job application

Translation skills
Urdu to English

Study skills
Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills
Letter / memo writing and minutes of the meeting, use of library and internet recourses

Presentation skills
Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended Reading Material:

Communication Skills

a) Grammar
   1. A.J. Thomson and A.V. Martinet, *Practical English Grammar. Exercises 1*.Third Edition. Oxford University Press. 1986.ISBN 0 19 431350 6.

b) Writing

   1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. "*Oxford Supplementary Skills"*. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
   2. Writing. Upper-Intermediate by Rob Nolasco. "*Oxford Supplementary Skills".* Fourth Impression 1992. ISBN 019435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading
   1. Reading. Advanced. Brian Tomlinson and Rod Ellis. "*Oxford Supplementary Skills"*. Third Impression 1991. ISBN 019453403 0.
   2. John Langan *,"Reading And Study Skills"* McGraw-Hill Higher Education,2012
   3. Richard Yorky*,"Study Skills",* McGraw-Hill, 1982

Semester III

Technical Writing and Presentation Skills

Objectives:

To enable the students to write a research paper / technical report in a succinct manner according to a specified format.

Course Contents:

Presentation skills

Essay writing
Descriptive, narrative, discursive, argumentative

Academic writing
How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Note: Extensive reading is required for vocabulary building

Recommended Reading Material:
Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing
   1. Writing. Advanced by Ron White. *Oxford Supplementary Skills*. Third Impression 1992.ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).

   2. John Langan,"College Writing Skills". McGraw-Hill Higher Education. 2004.
   3. Laurie G. Kirszner and Stephen R. Mandell ,*"Patterns of College Writing"*,(4th edition) by. St. Martin's Press.

b) Presentation Skills
c) Reading
   The Mercury Reader. A Custom Publication. Compiled by northern Illinois University. General Editors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

ISLAMIC STUDIES

(Compulsory)

Objectives:

This course is aimed at:

1 To provide Basic information about Islamic Studies
2 To enhance understanding of the students regarding Islamic Civilization
3 To improve Students skill to perform prayers and other worships
4 To enhance the skill of the students for understanding of issues related to faith and religious life.

Detail of Courses:

UNIT NO.1: **INTRODUCTION TO QURANIC STUDIES**

1) Basic Concepts of Quran
2) History of Quran
3) Uloom-ul -Quran

UNIT No.2 :STUDY OF SELLECTED TEXT OF HOLLY QURAN

1) Verses of Surah Al-Baqra Related to Faith(Verse No-284-286)
2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
5) Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)

UNIT No.3 :STUDY OF SELLECTED TEXT OF HOLLY QURAN

1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

UNIT NO.4: SEERAT OF HOLY PROPHET (S.A.W) I

1) Life of Muhammad Bin Abdullah (Before Prophet Hood)
2) Life of Holy Prophet (S.A.W) in Makkah
3) Important Lessons Derived from the life of Holy Prophet in Makkah

UNIT NO.5: SEERAT OF HOLY PROPHET (S.A.W) II

1) Life of Holy Prophet (S.A.W) in Madina
2) Important Events of Life Holy Prophet in Madina
3) Important Lessons Derived from the life of Holy Prophet in Madina

UNIT NO.6:INTRODUCTION TO SUNNAH

1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith
4) Uloom –ul-Hadith
5) Sunnah& Hadith
6) Legal Position of Sunnah

UNIT NO.7:SELLECTED STUDY FROM TEXT OF HADITH

UNIT NO.8: INTRODUCTION TO ISLAMIC LAW & JURISPRUDENCE

1) Basic Concepts of Islamic Law & Jurisprudence
2) History & Importance of Islamic Law & Jurisprudence
3) Sources of Islamic Law & Jurisprudence
4) Nature of Differences in Islamic Law
5) Islam and Sectarianism

UNIT NO.9: **ISLAMIC CULTURE & CIVILIZATION**

1) Basic Concepts of Islamic Culture & Civilization
2) Historical Development of Islamic Culture & Civilization
3) Characteristics of Islamic Culture & Civilization
4) Islamic Culture & Civilization and Contemporary Issues

UNIT NO.10:**ISLAM& SCIENCE**

1) Basic Concepts of Islam & Science
2) Contributions of Muslims in the Development of Science
3) Quranic& Science

UNIT NO.11:ISLAMIC ECONOMIC SYSTEM

1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade & Commerce

UNIT NO.12: **POLITICAL SYSTEM OF ISLAM**

1) Basic Concepts of Islamic Political System
2) Islamic Concept of Sovereignty
3) Basic Institutions of Govt. in Islam

UNIT NO.13: **ISLAMIC HISTORY**

1) PERIOD OF KHILAFAT-E-RASHIDA
2) PERIOD OF UMMAYADS
3) PERIOD OF ABBASIDS

UNITNO.14:SOCIAL SYSTEM OF ISLAM

1) BASIC CONCEPTS OF SOCIAL SYSTEM OF ISLAM
2) ELEMENTS OF FAMILY
3) ETHICAL VALUES OF ISLAM

REFERENCE READING MATERIAL:

1) Hameed ullah Muhammad, “Emergence of Islam”, IRI, Adam Publishers, Delhi, India.
2) Hameed ullah Muhammad, “Muslim Conduct of State”, Adam Publishers, Delhi, India
3) Hameed ullah Muhammad, ‘Introduction to Islam’ Adam Publishers, Delhi, India
4) Mulana Muhammad Yousaf Islahi,”
5) Hussain Hamid Hassan, *“An Introduction to the Study of Islamic Law”* Leaf Publication Islamabad, Pakistan.
6) Ahmad Hassan, *“Principles of Islamic Jurisprudence”* Islamic Research Institute, international Islamic University, Islamabad (1993)
7) Mir Waliullah*, “Muslim Jurisprudence and the Quranic Law of* Crimes” Islamic Book Service (1982)
8) H.S. Bhatia, *“Studies in Islamic Law, Religion and Society”* Deep & Deep Publications New Delhi (1989)
9) Dr. Muhammad Zia-ul-Haq*, “Introduction to Al Sharia Al Islamia”* AllamaIqbal Open University, Islamabad (2001)

Annex "C"

Pakistan Studies (Compulsory)

(As Compulsory Subject for Degree Students)

Introduction / Objectives:

The course has been designed as a compulsory subject for the students studying for Bachelor's degree, general or professional. The course is of 2 credit hours carrying 100 marks (recommended). The teaching work is comprised of three dimensions: Historical Perspective (20%); Government and Politics (40%); and Contemporary Pakistan (40%).

The course framework is issue-oriented. It has many dimensions, the historical and ideological background of Pakistan, the process of governance and national development as well as the issues arising in the modern, age and posing challenges to Pakistan. The course has been designed with a vision that Pakistan Studies should open a window to future.

Course Outline:

1. Historical Perspective:

a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i-Azam Muhammad Ali Jinnah.
b. Factors leading to Muslim separatism
c. People and Land
    i. Indus Civilization
    ii. Muslim advent
    iii. Location and Geo-Physical features.

2. Government and Politics in Pakistan

Political and constitutional phases:

a. 1947-58
b. 1958-71
c. 1971-77
d. 1977-88
e. 1988-99
f. 1999 onward

3. Contemporary Pakistan

a. Economic institutions and issues
b. Society and social structure
c. Ethnicity
d. Foreign policy of Pakistan and challenges
e. Futuristic outlook of Pakistan

Books Recommended:

1. Burki, Shahid Javed."*State & Society in Pakistan",* The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. "*Issue in Pakistan's Economy".* Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. "*Pakistan's Foreign policy: A Historical Analysis"*. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar."*Pakistan Political Roots & Development. Lahore*", 1994.
5. Wilcox, Wayne. "*The Emergence of Bangladesh",* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. "*Pakistan Kayyun Toota",* Lahore: Idara-e-Saqafat-e-Islamia, Club Road.
7. Amin, Tahir. "*Ethno -National Movement in Pakistan",* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence". *Enigma of Political Development".* Kent England: Wm Dawson& Sons Ltd, 1980.
9. Zahid, Ansar. "*History & Culture of Sindh".* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. "*Political Parties in Pakistan",* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. "*The Political System of Pakistan".* Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, "Politics in Pakistan",* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, "*Pakistan Under Martial Law"*, Lahore: Vanguard, 1987.
14. Haq, Noor ul. "*Making of Pakistan: The Military Perspective"* Islamabad: National Commission on Historical and Cultural Research, 1993.

Annex "D"

COURSES OF SOCIAL SCIENCE

Sociology and Development

(For Engineers)

Objectives: The main objective of this course is to apprise potential engineers about social factors that contribute towards enhancing their professional performance for the good of society and the country. This course is culture specific and has to be taught within the context of local and national socio-economic environment. The engineers are expected to supervise several people in different capacities and their understanding about human behaviour is critical for their optimum performance. Modification of human behaviour or getting work done from sub-ordinates and seniors remain a major challenge for all the professional engineers. This course will enhance understanding about the determinants of human behaviour, which ultimately will result in improved individual efficiency.

1. Introduction to Sociology

- 1.1 What is sociology?
- 1.2 Nature, Scope, and Importance of Sociology
- 1.3 Social Interactions
- 1.4 Social Groups
- 1.5 Social Institutions

2. Culture and Related Concepts

- 2.1 Definition of Culture
- 2.2 Types of Culture
- 2.3 Elements of Culture
- 2.4 Role of Culture in Organization
- 2.5 Socialization and Personality

3. Interpersonal Relations

- 3.1 Interpersonal Behaviour
- 3.2 Formation of Personal Attitudes
- 3.3 Language and Communication
- 3.4 Motivations and Emotions
- 3.5 Public Opinion

4. Social Stratification

- 4.1 Factors of Social Stratification
- 4.2 Caste and class
- 4.3 Power, Prestige, and Authority
- 4.4 Social Mobility
- 4.5 Migration

5. Human Ecology

- 5.1 Ecological Processes
- 5.2 Ecosystem and energy

5.3 Ecosystem and Physical Environment
5.4 Solid Waste Disposal
5.5 Pollution

6. Population Dynamics

6.1 World Population Growth and Distribution
6.2 Population Dynamics in Pakistan
6.3 Causes and Consequences of Urbanization
6.4 Population Policy in Pakistan
6.5 Population and Development

7. Community Development

7.1 Meaning, Scope, and Subject Matter of Community Development
7.2 Processes of Community Development
7.3 Community Development Programs in Pakistan
7.4 Community Organization and Related Services
7.5 Cooperation and Conflict in Community Development

8. Deviance and Crime

8.1 Crime as a Social and Cultural Phenomenon
8.2 Crime and Social Organization
8.3 Organized Crime
8.4 Culture Based Crime
8.5 Economics of Crime

9. Sociology of Change and Development

9.1 What is Social Change and Development?
9.2 Dynamics of Social Change
9.3 Role of NGOs in Development
9.4 World System and Development
9.5 Gender and Development

Recommended Readings:

1. Allport, G. W. *"The Historical Background of Modern Social Psychology". (1985). New York, Random House.*
2. Bernard, A. and T. Burgess *"Sociology", (2004)* Cambridge University Press.
3. DuBrin, A. J., "*Human Relations: Interpersonal Job Oriented Skills".(2004)* New York, Prentice Hall.
4. Gardezi, H. N., Ed. "*Understanding Pakistan: The Colonial Factor in Societal Development".* (1991). Lahore, Maktaba Fikr-o-Danish.
5. Hafeez, S. "*Changing Pakistan Society*" (1991*),* Karachi, Royal Book Company. Gardezi, H. N., Ed. (1991).
6. Jones, G. W. (2005). *"Why are Population and Development Issues not Given Priority?"* Asia-Pacific Population Journal **20**(1).
7. Macionis, J. J., "*Sociology 7th Edition",*. (1999), National Book Foundation, Islamabad

8. Maser, C. "*Sustainable Community Development: Principles and Concepts".* (1997).Plorida St. Lucie Press.
9. Nelson, N. and S. Wright "*Power and Participatory Development: Theory and Practice".1995,*London, Intermediate Technology Publications.
10. Syed, S. H. "*The State of Migration and Multiculturalism in Pakistan: The Need for Policy and Strategy"*. (2003). Islamabad, UNESCO**:** 1-30.
11. Utton, A. E. "*Human Ecology"*,1957 West View Press.
12. Webster, A*.. "Introduction to Sociology of Development*. London",1990, Macmillan Education Ltd.
13. Weiss, A. M. *" Power and civil society in Pakistan",* 2001, Oxford University Press.

SOCIAL ANTHROPOLOGY
(For Engineers)

Objectives: The students are expected to learn anthropological skills for application by professional engineers and other related practitioners. Societal growth needs are to be understood within our own cultural environment. Such a body of applied knowledge will result in improving the professional performance of would-be engineers. As culture and society play an important role towards all human activities, this course will help students relate technical skills to the societal needs and requirements.

I Introduction

1. Anthropology and Social Anthropology
2. Fields of Anthropology
3. Anthropological Research Methods
4. Social Anthropology and other Social Sciences
5. Significance of Social Anthropology

II Culture

1. Definition, Properties and Taxomony
2. Evolution of Growth and Culture
3. Evolution of Man: Religious and Modern Perspectives
4. Evolution of Culture
5. Culture and Personality

III Evolution and Growth of Culture

1. Evolution of Man
2. Schools of Thought in Cultural Anthropology
3. Acculturation
4. Enculturation
5. Ethnocentrism and Xenocentrism

IV Language and Culture

1. Communication
2. Structural Linguistics
3. Historical Linguistics
4. Relationship between Language and Culture
5. Ethnography

V Economic System

1. Global Economic System
2. The Allocation of Resources
3. The Conversion of Resources
4. The Distribution of Goods and Services
5. Poverty and Inequality

VII Marriage and Family

1. Marriage and Mate Selection
2. The Family: Types and Functions
3. Kinship System
4. Structure and Function of Family
5. Gender Relations

VIII Political Organization

1. Political Sociology
2. Origin of Political Organization and Organizational System
3. Types of Political Organizations
4. Power Politics and Factionalism in Pakistan
5. Resolution of Conflict

IX Religion and Magic

1. The Universality of Religion
2. Comparative Religions
3. Religion and Society
4. Religious Beliefs and Practices
5. Witchcraft and Sorcery

XI Culture Change

1. Forms of Art
2. Expressive Culture
3. Process of Cultural Change
4. Cultural Change in the Modern World
5. Cultural Change in Pakistani society

Recommended Books:

1. Ahmad, Akbar S. "*Pakistani Society*",1990. Karachi, Royal Books Co.

2. Bernard, H. Russel. ”*Research Methods in Anthropology, Qualitative and Quantitative Approaches.*”1994. London: Sage Publications
3. Bodley, John H. “*Cultural Anthropology*”,1994. California: Mayfield Publishing Co.
4. Brogger, Jan. “*Social Anthropology and the Lonely Crowd.”*1993. New Delhi: Reliance Publishing
5. Ember, Carol R. & Ember Melvin. “*Anthropology, 11th ed”*, 2005.. Englewood Cliffs: Prentice Hall, Ince. Harper and Row
6. Harris Marvin. “*Cultural Anthropology*”.1987. New York: Harper and Row
7. Harris Marvin.. Culture, People, nature; “*An Introduction to General Anthropology*” 1985London: Harper and Row
8. Haviland, W. A.. “*Anthropology: The Human Challenge*”. 2005, New York, Thomson Learning Inc.
9. Hertzler J. O. ”*The Social Structure of Islam*”. 1981 Cambridge: Cambridge University Press.
10. Keesing, Roger M .,”*Cultural Anthropology: A contemporary perspective. 3rded.*” 1998 New York: Harcourt Brace College Publishers.
11. Kottak, Conard Phillip. ”*Anthropology: The Exploration of Human Diversity. 9th ed.”* 2002, Boston: McGraw-Hill Higher Education.
12. Kennedy, Charles H.” *Pakistan London*”, 1992, Westview Press,.
13. Marron, Stanley. *“Pakistani Society and Culture”*. 1957 New Heaven
14. Wilson, Richard A.. “*Human Rights, Culture and Context: Anthropological Perspective”* 1996*.* London: Pluto Press.

Psychology courses
for B.S /B.E in Engineering Programmes

Course-I: **Understanding Psychology and Human Behaviour** 3 Cr. hrs

- What is Psychology?
- Nature, Scope and Application with Special Reference to Pakistan
- Different Schools of Psychology
- Methods of Psychology
- Learning
- Intelligence and Artificial Intelligence
- Personality and its Assessment
- Understanding Maladjustive Behaviour
- Positive Emotional States and Processes
- Stress Management and Anger Management

Recommended Books:

1. Atkinson R.C., & Smith E. E., ”*Introduction to Psychology (13th ed.)*”,(2000), Harcourt Brace College Publishers.
2. Fernald, L.D., & Fernald, P.S.,” *Introduction to Psychology*”, (2005), USA: WMC Brown Publishers.

3. Hergenhahn, B.R." *An Introduction to the History of Psychology*",(2001), New York: Wadsworth.
4. Goodwin, C.J, *Research in Psychology: Methods and Design, (3rd ed.)*", (2000), New York: John Wiley & Sons.
5. Synder, C.R., & Lopez, S.J. "*Positive Psychology"*,(2007), USA, Sage Publications.
6. Allen, B.P.," *Personality Theories: Development, Growth and Diversity, (2nd Ed.)*", (1997), Boston: Allyn & Bacon.
7. Cohen, R.J., & Swerdlik, M. E. "*Psychological Testing & Assessment (6th ed.)*", (2005). New York: McGraw-Hill.
8. Corcini, R.,. "*Current Psychotherapies*".(2000). London: Thompson & Co Publishers.
9. Comer, R.J. "*Abnormal Psychology*", (2004), USA: Freeman & Company.
10. Schwartz, B., Wassermann, E., & Robbins, S.," *Psychology of Learning and Behaviour, 5th Ed."*(2002). Norton and Company.

Course II Professional Psychology 3 credit hrs

- Introduction to Professional Psychology
- Psychological Testing
- Educational Psychology
- Industrial/Organizational Psychology
- Social Psychology
- Health Psychology
- Clinical Psychology
- Positive Psychology
- Legal, Ethical, and Professional Issues.

Recommended Books:

1. Crow, L., & Crow, A. "*Educational Psychology"*, (2000) New Delhi: Eurosia Publishing House Ltd.
2. Spiegel, P.K., & Koocher, G. P., "*Ethics in Psychology"*,1992 New York: Oxford University Press
3. Snyder, C.R., & Lopes, S.J., *Handbook of Positive Psychology 2000*, New York: Oxford University Press.
4. Compton, W.C*., "Introduction to Positive Psychology "2005*, USA, Thomson Wadsworth.
5. Debra, L.N. & James Campbell Quick, *Organizational Behaviour (3rded*) 2000, Cincinnati: South Western.
6. Fred Luthans, Alexander, D.S. & Edwin, A. Locke (Eds), "*Handbook of Principles of Organizational Behaviour"*, 2005 London: Blackwell.
7. Brannon, L.& Reist, J., "*Health Psychology: An Introduction to Behaviour and Health (4th ed.")*. (2000), USA Wadsworth.

8. Donohue, W. & Ferguson, K. (Eds), "*Handbook of Professional Ethics for Psychologists; Issues, Questions and Controversies"*,(2003) London: Sage Publications.
9. Meyers, D.," *Social Psychology"*, (2005) 8th Ed. McGraw-Hill Inc.
10. Cooper, J. & Hogg, M. "*Handbook of Social Psychology "*(2003), Sage Publications
11. Halgin, R.P., Whitbourne, S.K., & Halgin, R.," *Abnormal Psychology: Clinical Perspectives on Psychological Disorders*", (2004) New York: McGraw Hill.
12. Thorndike R.L., & Hage, E.P.," *Measurement and Evaluation in Psychology and Education (4th Ed)*", (1995), New York, MacMillan.

PROFESSIONAL PRACTICE

Course Description:

Prerequisite: None

This course introduce contemporary and controversial ethical issues facing the business community. Topics include moral reasoning, moral dilemmas, law and morality, equity, justice and fairness, ethical standards, and moral development. Upon completion, students should be able to demonstrate an understanding of their moral responsibilities and obligations as members of the workforce and society.

Course Objectives:

At the completion of the course requirements, the student will be able to:

a. Define business ethics
b. Describe the evolution of business ethics
c. Describe major ethical perspectives
d. Understand and apply n ethical decision-making framework
e. Understand social responsibility from several dimensions
f. Understand how the organization influences ethical decision-making
g. Examine how significant others influence ethical decision-making
h. Develop an effective ethics programme.
i. Understand international business ethics.

Course Outline:

An Overview of Business Ethics: Business Ethics Defined, Social Responsibility, and Business Ethics, The Development of Business Ethics, Why study Business Ethics?, Framework for Studying Business Ethics.

Ethical issues in Business: Foundation of Ethical Conflict, Classifications of Ethical, Issues, Ethical Issues Related to Participants and Functional Areas of Business, Recognizing an Ethical Issue.

Applying Moral Philosophies to Business Ethics: Moral Philosophy Defined, Moral Philosophy Perspectives.

Social Responsibility: The Economic Dimension, The legal Dimension, The Ethical Dimension, the Philanthropic Dimension.

An Ethical Decision-Making Framework: Ethical Issue Intensity, Individual Factors: Stages of Cognitive Moral Development, Corporate Culture, Significant others, Opportunity, Business Ethics Evaluations and Intentions, Using the Ethical Decision-Making Framework to Improve Ethical Decisions.

How the Organization Influences Ethical Decision Making: Organizational Structure and Business Ethics, the role of Corporate Culture in Ethical Decision-Making, Group Dimensions of Organizational Structure and Culture, Implications of Organizational Relationships for Ethical Decisions.

The Role of Opportunity and Conflict: Opportunity, Conflict.

Development of an Effective Ethics Programme: An Effective Ethical Compliance, Programme, Codes of Ethics and Compliance Standards, High-Level Manager's Responsibility for Ethical Compliance Programme and the Delegation of Authority, Effective Communication of Ethical Standards, Establishing Systems to Monitor, Audit, and Enforce Ethical Standards, Continuous Improvement of the Ethical Compliance Programme, The Influence of Personal Values in Business Ethics Programmes, The Ethical Compliance Audit.

International Business Ethics: Ethical Perceptions and International Business, Culture As a Factor in Business, Adapting Ethical Systems to a Global Framework: Cultural Relativism, the Multinational Corporation, A universal Set of Ethics, Ethical Issues Around the Globe.

Text Books:

1. Ferrell, O.C., and Fraedrich, John, "*Ethical Decision Making and Cases"*, New York: Houghton Mifflin.

ORGANIZATIONAL BEHAVIOUR 3 Credit Hrs

- Introduction to Organizational Behaviour
  - Organizational Disciplines and topics
  - Psychological Perspective
  - Social-Psychological Perspectives

- Structure and Control in Organization
  - Introduction
  - Bureaucracy
  - Managerial Work
  - Contingency theory

- Organizational Design

- Individual and Work Learning
  - Learning Theories
  - Learning and Work

- Stress
  - Types of Stress and Work
  - Occupational Stress Management

- Individual Differences
  - Personality and its factors
  - Personality dimensions and social learning
  - Intelligence

- Motivation and Job Satisfaction
  - Needs at Work
  - Theories of Motivation and job satisfaction
  - Correlates of Job satisfaction
  - Correlates of Job satisfaction

- Group and Work
  - Social Interaction
  - Dramaturgy and impression Management
  - Social Skill

- Group and Inter group Behaviour
  - Group Structure & Norms
  - Group Processes
  - How throne Studies

- Leadership
  - Leadership as an attribute
  - Leadership Style

- Patterns of Work
  - Work-the classical approach
  - Marx, Weber, & The critique of labor
  - Foucault & Disciplinary Power

- Conflict and Consent in Work
  - The labor Process debate
  - Work place control and resistance
  - Industrial conflict and industrial relations

- Organizational culture
  - Organizational culture and strategic management
  - Exploring organizational culture

- Evaluating concept of culture

Recommended Books:

1. Finchan, R., & Rhodes, P. (2003), "*Principles of Organizational Behaviou*r", 3rdEdition,Oxford University.
2. Noe, R., Hollenbeck, J. Gerhart, B., & Wright, P. (2006), Human Resource Management, 5th ed., McGraw-Hill.
3. Newstrom John W. (2007), Organizational Behaviour, (12th Ed), McGraw-Hill.
4. Luthan Fred, (2005), Organizational Behaviour, McGraw-Hill Inc.
5. Robins, Stephen, (2005), Organizational Behaviour, McGraw-Hill Inc.

INTRODUCTION TO SOCIOLOGY

3 Credit Hrs

- The Nature of Sociology
  - The study of social life
  - Exploring the global village
  - Sociology as a science
  - The Sociological imagination
  - The development of Sociology
  - Pioneers of Sociology
  - Nature, scope and subject matter of Sociology
  - Brief historical development of Sociology
  - Society and community
  - Relationship with other social sciences
  - Social Interaction Processes

- Social groups
  - Definition and functions
  - Types of social groups

- Social institutions
  - Definition
  - Structure and function of social institutions
  - Inter-relationships among various social institutions

- Culture and related concepts
  - Definition and aspects of culture
  - Elements of culture
  - Organization of culture
  - Other concepts, cultural relativism, sub cultures, ethnocentrism, culture lag

- Socialization and personality
  - Role and status
  - Socialization

- Culture and personality

- Deviance and social control
  - Definition and types of deviance
  - Juvenile delinquency
  - Formal and information methods of social control

- Social stratification
  - Approach to study social stratification
  - Caste class and race as basics of social stratification

- Major perspectives in Sociology
  - Functionalist perspective
  - Conflict perspective
  - Interactionistic perspective

- Social Control and deviance
  - Agencies of social control

- Social stratification
  - Determinants of social stratification
  - Social mobility, types and definition
  - Dynamics of social mobility

- Concept of social movement
  - Theories of social movement
  - Social and cultural change

- Social and cultural change
  - Definition of social change
  - Dynamics of social change
  - Impact of globalization on society and culture
  - Resistance to change

- Collective behaviour
  - Definition
  - Characteristics
  - Causes
  - Types
  - Social movements
  - Mob and crowd behaviour

Recommended Books:

1. Neulreck, Kenneth, J. 2005, "*Sociology: Diversity, Conflict and Change"*, Boston
2. Barnard, Andy. 2004."*Sociology"*, Cambridge University Press
3. Giddens, Anthony, 2004, "*Sociology 4th edition"*, Cambridge Polity Press
4. Albrow, Martin, 2003, "*Sociology"*, London Routledge.

5. Richard, T. Schaefer, 2003*, "Sociology 5th edition"*, McGraw-Hill College
6. Kendall, Diana, 2004. "*Sociology in our Times"*, 4th ed, Wadsworth
7. Tyler Melissa, Wallace Claire & Abbott Pamela, 2005,*"An Introduction to Sociology"*, 3rd ed. Routledge.

CRITICAL THINKING **3 Credit Hrs**

- The Power of Critical Thinking
  - Claims and Reasons
  - Reasons and Arguments
  - Arguments in the Rough
- The Environment of Critical Thinking
  - Perils of Haunted Mind
  - Self and the Power of the Group
  - Subjective and Social Relativism
  - Skepticism

- Making Sense of Arguments
  - Arguments Basics
  - Patterns
  - Diagramming Arguments
  - Assessing Long Arguments

- Reasons for Belief and Doubt
  - Conflict Experts and Evidence
  - Personal Experience
  - Fooling Ourselves
  - Claims in the News

- Faulty Reasoning
  - Irrelevant Premises
  - Genetic Fallacy, Composition, Division
  - Appeal to the Person, Equivocation, Appeal to Popularity
  - Appeal to Tradition, Appeal to Ignorance, Appeal to Emotion
  - Red Herring, Straw Man

- Unacceptable Premises
  - Begging the Question, False Dilemma
  - Slippery Slope, Hasty Generalization
  - Faulty Analogy

- Deductive Reasoning: Propositional Logic
  - Connectives and Truth Values
  - Conjunction, Disjunction, Negation
  - Conditional, Checking for Validity
  - Simple Arguments, Tricky Arguments
  - Streamlined Evaluation

- Deductive Reasoning: Categorical Logic
  - Statements and Classes
  - Translations and Standard Form
  - Terms, Quantifiers
  - Diagramming Categorical Statements
  - Sizing up Categorical Syllogisms

- Inductive Reasons
  - Enumerative Induction
  - Sample Size, Representativeness, Opinion Polls
  - Analogical Induction
  - Casual Arguments, Testing for Causes
  - Casual Confusions

- Inference to the Best Explanation
  - Explanations and Inference
  - Theories and Consistency
  - Theories and Criteria
  - Testability, Fruitfulness, Scope, Simplicity
  - Conservatism

- Judging Scientific Theories
  - Science and Not Science
  - The Scientific method, Testing Scientific Theories
  - Judging Scientific Theories
  - Copernicus versus Ptolemy, Evolution Versus Creationism
  - Science and Weird Theories
  - Making Weird Mistakes
  - Leaping to the Weirdest Theory, Mixing What Seems with What is
  - Misunderstanding the Possibilities
  - Judging Weird Theories
  - Crop Circles, Talking with the Dead

RECOMMENDED BOOKS:

1. Vaughn Lewis, 2005, "*The Power of Critical Thinking"*, Oxford University Press.
2. Paulsen David W., Cederblom Jerry:2000, "*Critical Reasoning",* Wadsworth
3. Restall Greg. 2005,"*Logic: An Introduction"*, Routledge

INTRODUCTION TO PHILOSOPY 3 Credit Hrs

- Definition and Nature of Philosophy
- Theory of Knowledge
  - Opinion and Knowledge

- Plato, the Republic Selection
- Knowledge through Reason
- Descartes Meditation on First Philosophy
- Knowledge through Experience
- Hume an Inquiry concerning Human Understanding (Selection)
- Experience Structured by the Mind
- Kant Critique of Pure Reason (Selection
- Knowing and Doing
- James Pragmatism (Selection)
- Knowledge and Emotion
- Jaggar Love and Knowledge (Selection)

- Philosophy of Religion
  - Proving that Existence of God
  - Anselm, Aquinas, Paley, Dawkins (Selection)
  - Justifying Religious Beliefs
  - Pascal Pensees (Selection)
  - James The will to Believe Selection
  - Freud the Future of An Illusion (Selection)
  - Confronting the Problems of Evil
  - Mackie Evil and Omnipotence (Complete)
  - Hick Philosophy of Religion (Selection)

- Metaphysics
  - Idealism and Materialism
  - Berkeley Three Dialogues Between Hylas and Pholonous (Selection)
  - Armstrong Naturalism, Materialism and First Philosophy (Selection)
  - The Mid-Body Problem
  - Descartes Meditations on First Philosophy (Selection)
  - O'Hear Introduction to the Philosophy of Science (Selection)
  - Dennett The Origins of Selves (Complete)
  - Pali Canon (Selection)
  - Penelhum Religion and Rationality (Selection)

- Freedom to Choose
  - Libertarianism
  - James The Dilemma of Determinism (Selection)
  - Taylor Metaphysics (Selection)
  - Determinism
  - Hospers Meaning and Free Will (Selection)
  - Skinner Walden Two (Selection)
  - Compatibilism
  - Stace Religion and the Modern Mind (Selection)
  - Radhakrishnan Indian Philosophy (Selection)

- Ethics
  - Fulfilling Human Nature
  - Aristotle Nicomachean Ethics (selection)
  - Loving God
  - Augustine The Morals of the Catholic Church and the City of God (Selection)
  - Following Natural Law
  - Aquinas Summa Theologiae (Selection)
  - Doing One's Duty
  - Kant Fundamental Principles of the Metaphysics of Morals (Selection)
  - Maximizing Utility
  - Mill Utilitarianism (Selection)
  - Turning Values of Upside Down
  - Nietzsche Human, All too Human and Beyond Good and Evil (Selection)
  - Creating Ourselves
  - Sartre Existentialism is a Humanism (Selection)
  - Hearing the Feminine Voice
  - Gilligan In a Different Voice (Selection)
  - Baier What do Women Want in a Moral Theory (Selection)

- Political and Social Philosophy
  - The State as Natural
  - Plato the Republic (Selection)
  - Aristotle Politics (Selection)
  - The State as a Social Contract
  - Hobbes Philosophical Rudiments Concerning Government and Society (Selection)
  - Locke the Second Treatise of Government (Selection)
  - Liberty of the Individual
  - Mill On Liberty (Selection)
  - Alienation in Capitalism
  - Marx Economic and Philosophic Manuscripts of 1844 (Selection)
  - Justice and Social Trust
  - Rawls A Theory of Justice (Selection)
  - Nozick Anarchy, State, and Utopia (Selection)
  - Held Rights and Goods (Selection)
  - Women in Society
  - Wollstonecraft A Vindication of the Rights of Women (Selection)
  - De Behaviour The Second Sex (Selection)
  - The Value of Philosophy
  - Russel The Problems of Philosophy (Selection)
  - Midgley Philosophical Plumbing (Selection)

RECOMMENDED BOOKS:

1. Abel Donald C., Stumpf Samuel Enoch, 2002. *Elements of Philosophy: An Introduction*, 4th Ed. McGraw-Hill.
2. Scruton Roger, 2001. *A Short History of Modern Philosophy*, 2nd ed. Routledge.

MANAGEMENT COURSES

ENTREPRENEURSHIP

Course Objective:

Entrepreneurship is an important component in the process of economic development. The purpose of this course is to analyse the theories of entrepreneurship and to go for case studies of successful entrepreneurs.

Course Contents:

Introduction: The concept of entrepreneurship, The economist view of entrepreneurship, The sociologist view, Behavioural approach, Entrepreneurship and Management

The Practice of Entrepreneurship: The process of entrepreneurship, Entrepreneurial Management, The entrepreneurial business, Entrepreneurship in service institutions, The new venture

Entrepreneurship and Innovation: The innovation concepts, Importance of innovation for entrepreneurship, Sources of innovative opportunities, The innovation process, Risks involved in innovation

Developing Entrepreneur: Entrepreneurial profile, Trait approach to understanding entrepreneurship, Factors influencing entrepreneurship, The environment, Socio cultural factors, Support systems

Entrepreneurship Organization: Team work, Networking organization, Motivation and compensation, Value system

Entrepreneurship and SMEs: Defining SMEs, Scope of SMEs, Entrepreneurial, managers of SME, Financial and marketing problems of SMEs.

Entrepreneurial Marketing: Framework for developing entrepreneurial marketing, Devising entrepreneurial marketing plan, Entrepreneurial marketing strategies, Product quality and design

Entrepreneurship and Economic Development: Role of entrepreneur in the economic development generation of services, Employment creation and training, Ideas, knowledge and skill development, The Japanese experience

Case Studies of Successful Entrepreneurs

Text Books:

- Paul Burns and Jim Dew Hurst: *Small Business and Entrepreneurship*
- P.N. Singh: *Entrepreneurship for Economic Growth*
- Peter F. Drucker: *Innovation and Entrepreneurship* Peter F. Drucker
- John B. Miner: *Entrepreneurial Success*

PRINCIPLES OF MANAGEMENT

Course Objectives:

This is a rudimentary course for the students of business administration. The focus of attention will be given to learning fundamental principles of management and of managing people and organization in a historical as well as contemporary world. Students are expected to develop analytical and conceptual framework of how people are managed in small, medium and large public and private national and international organizations.

Course Contents:

- Introduction, overview and scope of discipline
- The evolution and emergence of management thought
- Management functions
- Planning concepts, objectives, strategies and policies
- Decision making
- Organizing; departmentalization, line/staff authority, commitments and group decision making
- Staffing: principles of selection, performance, career planning
- Leading: Motivation, leadership, communication
- Controlling: the system and process and techniques of controlling
- Management and Society: future perspective

Text Books:

- Stephen P. Robins, Mary Coulter: Management
- H. Koontz Odonnel and H. Weihrich: Management
- McFarland: Management: Foundation and Practice
- Robert M. Fulmer: The New Management.

Title of the Course: Engineering Management **Credit Hours: 3**

Introduction to organization, planning and decision aids, project planning techniques, organization structure, human resource management, leadership, total quality management, project management techniques, managing information system, managing operation, PERT, CPM, tools.

Title of the Course: Total Quality Management

Fundamental principles; standards; techniques for quality analysis and improvements; statistical methods and SPC. Acceptance sampling, QFD, value engineering, cross-functional management and bench marking; ISO-9000 application, clauses and implementation issues

ANNEX "E"

LIST OF ELECTIVE COURSES – BE/BS AEROSPACE

Course	IDEE	Engg	Structures
Computational Fluid Dynamics		√	
Turbulent Fluid Flow		√	
Rotorcraft Dynamics		√	
Applied/ Industrial Aerodynamics		√	
Finite Element Methods		√	√
Aero Vehicle Loading and Structural Analysis		√	√
Advanced Mechanics of Materials		√	√
Engineering Mechanics of Composite Structures		√	√
Mechanical Behavior of Materials		√	√
Structures and Machine Design		√	√
Orbital Mechanics	√	√	
Spacecraft Dynamics and Control	√	√	
Inertial Navigation	√	√	
Guidance and Navigation of Aerospace Vehicles	√	√	
Celestial Mechanics	√	√	

Digital Control System	√	√	
Systems Engineering and Analysis	√	√	
Space Astronomy	√	√	
Space Propulsion	√	√	
Heating ventilation and Air Conditioning	√	√	
Turbo Machinery		√	
Digital logic design and PLC's	√	√	
Fuzzy Logic and Control	√	√	
Engineering Circuit Analysis – DC Circuits	√	√	
Analogue and Digital Circuits	√	√	
Professional Communication Skills	√		
Electrical Circuits and Machines	√	√	
Electronic Warfare	√	√	
Wind Tunnel Testing		√	
Statistical Quality Control	√		
Engineering Economy	√		
Space Mission Design & Analysis	√	√	
Rotorcraft Dynamics		√	
Advance Engineering Chemistry	√		
Industrial Control Electronics	√	√	
Automation and Robotics	√	√	
Mechanics of Machines		√	√
Instrumentation and Sensors	√	√	
Modern Control Theory	√	√	
Manufacturing Processes and CNC Machines	√		
Joining Technology for Modern Materials	√		
Flexible Manufacturing	√		
Introduction to Industrial Engineering	√		
Production Management and Control	√		

Character Building and Leadership	√		
Computer Aided Drafting	√		
Product Design and Development	√		
Satellite Systems and Engineering	√		
Aeroelasticity		√	√
Aeroacoustics		√	
Decelerator Aerodynamics		√	
Hovercraft Design		√	
Astronautics	√		
Spacecraft Design	√		
Tribology		√	

ANNEX "F"

LIST OF ELECTIVES FOR MS/ME and PhD

- Engineering Management
- Turbulent Fluid Flow
- Advanced Computational Fluid Dynamics
- Measurement Techniques in Fluid and Thermal Engineering
- Muti-phase Fluid Dynamics
- Hypersonic/High Temperature Gas Dynamics
- Industrial Management & System Engineering
- Unsteady Aerodynamics
- Fourier and Wavelet Analysis
- Advanced Energy Conversion for Aerospace Systems
- Gas Turbine Combustion
- Gas Turbine Performance
- Space Propulsion and Power Systems
- Electric Propulsion
- Aero thermo chemistry of Advanced Propulsion Systems
- Combustion & Flow in Rocket Engines
- Liquid Propellant Rocket Engine System Engineering
- Process Simulation and CAD of Rocket Engine
- Advanced Stress Analysis & Thermal Strength of Structures
- Aero-elasticity
- Theory of Plasticity
- Fracture Mechanics
- Mathematical modelling and Simulation
- Experimental Stress Analysis
- Experimental Methods in Structural Dynamics
- Non-destructive Evaluation of Structures and Materials
- Smart Structures
- Structural Design of Launch Vehicle &Re-entry Vehicles
- Optimization Techniques in Structural Design
- Non-linear Finite Element Methods
- Aircraft Preliminary Design and Performance
- Advanced Aerodynamics
- Experimental Techniques in Fluid & Thermal Engineering
- Advanced Materials in Engineering
- Systems Engineering and Analysis
- Aerospace System Design and Management
- Numerical Analysis
- Partial Differential Equations
- Methods of Optimization
- Real and Complex Analysis

- Matrix Applications
- Spectral Analysis
- Stochastic Processes
- Design of Experiments
- Integral Equations
- Advance Methods of Mathematical Physics
- Reliability Engineering
- Automatic Control of Flight Vehicles
- GPS and its Applications
- Applied Nonlinear Control of Aerospace Vehicles
- Interplanetary Navigation and Guidance
- Spacecraft Navigation
- Flight and Trajectory Optimization
- Atmospheric Flight Control
- Computer Applications in Guidance and Control
- Intelligent and Adaptive Control System
- Inertial & Integrated Navigation System
- Flight Vehicle Guidance, Control &Navigation
- Orbit and Attitude Control of Spacecraft
- Orbital Mechanics
- Linear Feedback Control Systems
- Multivariable Controls
- Aerospace Medicines
- Continuum Mechanics
- Renewable Energy
- Perturbation Theory
- MEMS-I
- Computer Integrated Manufacturing
- Continuum Mechanics
- Launch Vehicle and Ballistic Missile Design
- Hypersonic Aerothermodynamics
- Computational Intelligence.

The required courses of one major area can be offered as electives in other areas of specialization

RECOMMENDATIONS

The NCRC discussed different aspects of the curriculum of Aerospace Engineering at length and agreed upon the recommendations given here under:-

1. In non-engineering domain the courses in the domain of social sciences and management are very important for overall grooming and personality growth of students. Keeping in view significance of these domains, a detailed discussion on subjects, contents and theme of these courses was done. The committee member agreed that it will be a good option if universalities / institutes are permitted to offer 3 courses of 2 credit hours each or 02 courses of 03 credit hours each. Both ways the total credit hours remains within the prescribed limit of 06. However in case offering 03 courses more variety and interests can be addressed without going into unnecessary depth of these courses.

2. Similarly discussion on courses related to Management Group also concluded that option may be granted to universities to offer 03 courses of 02 credit hours or to offer 02 courses of 03 credit hours each. More knowledge areas and interests will be covered in this option.

3. The committee agreed that Engineering drawing is a fundamental course for Aerospace Engineering. They also agreed that conventional pencil engineering drawing course may be followed with a computer based drafting course.

4. In the domain of Computing Languages newer option such as Python and MATLAB may be added as options. These courses may be offered with application based methodology, so that students may develop basic computing skills.

5. Universities may look into the possibility to teach a 03 Credit Hour course focusing on Aerospace Instrumentation to replace Computer Based Instrumentation course.

6. Universities may offer optional stream of Astrodynamics and focus on Space Vehicle Design instead of Aerospace Vehicle Design in this newly proposed scheme.

7. Interdisciplinary courses may be preferably taught by specialist faculty from other departments such as Electrical, Avionics, Communication and Materials Engineering.

8. With the introduction of Outcome Based Education by PEC in realm of Engineering Education in Pakistan, it is requisite that Course Objectives and Course Learning Outcome may be penned down for all prescribed courses of Aerospace Engineering. CAE and IST have already gone through this exercise for the courses offered in their respective areas. It is recommended that a committee containing suitably qualified faculty from CAE and IST may carry out this exercise in April 2016. It will facilitate in standardization of course contents being offered in different universities.

9. The committee also recommended that universities / institutes offering Aerospace Engineering Degrees must lay special emphasis on Faculty Development Programmes. As trained human resource in the area of Aerospace Engineering is already less, therefore it is very essential that a comprehensive Faculty Development Programme may be chalked out by respective universities in collaboration with HEC.

10. As Aerospace Engineering is always on the cutting edge of technological advancements, therefore it is very essential for Aerospace Engineers to keep themselves updated in all relevant fields. Therefore Academia and industry linked with Aerospace Engineering must collaborate to hold workshop, conferences, short courses and training sessions for Aerospace Engineers.

11. It is recommended that Universities and Institutes must submit a yearly review of their respective curriculums highlighting its weaknesses and strengths. They must share their experiences with each other and reciprocal visits may be planned to increase collaboration in research, teaching and other co-curricular activities.

12. It is recommended by the Committee that Universities / Labs must lay emphasis to enhance their laboratories and infrastructure. Essential research for Aerospace Engineering tools such as Wind Tunnels, Flow Visualization apparatus and high power computational platforms must be constantly upgraded.

13. As per PEC policy the Aerospace curriculum must contain experimental / laboratory based work. In terms of Credit Hours a ratio of 80 : 20 (Theory : Practical) is recommended for a well balanced curriculum.