CURRICULUM

OF

MATHEMATICS
BS/MS

(Revised 2013)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

Prof. Dr. Mukhtar Ahmed	Executive Director
Mr. Fida Hussain	Director General (Acad)
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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).

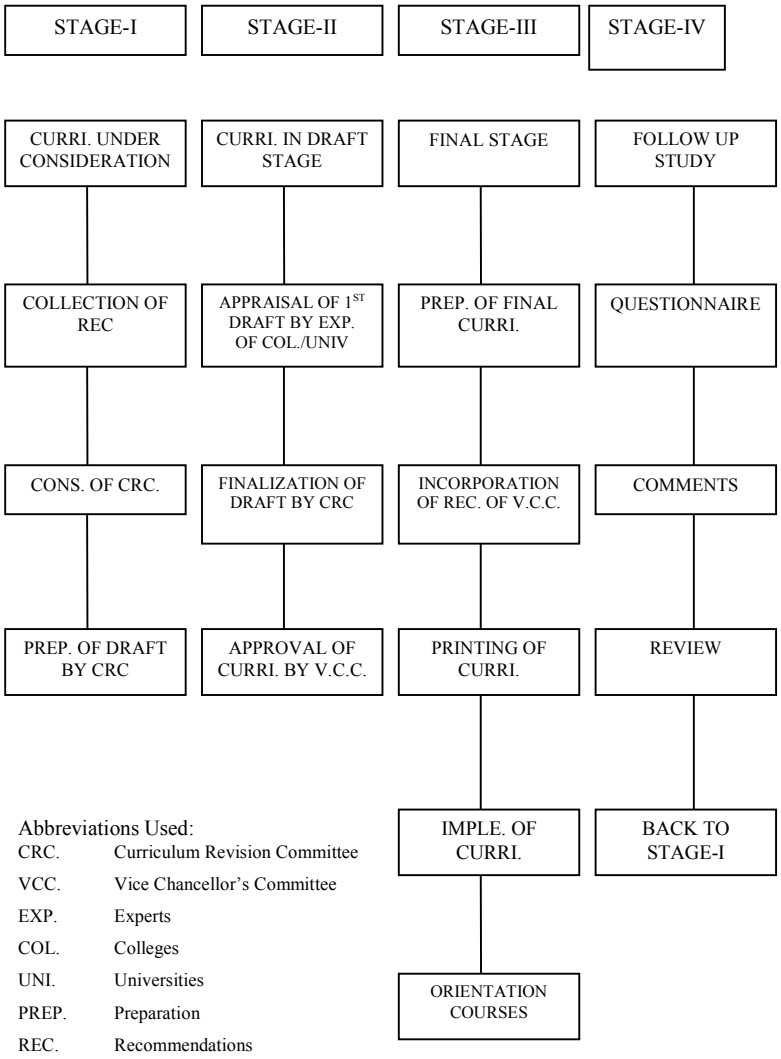
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector 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
REC.	Recommendations

MINUTES OF THE FINAL MEETING OF NCRC IN THE DISCIPLINE OF MATHEMATICS HELD ON APRIL 2-4, 2013 AT HEC REGIONAL CENTER, LAHORE

The Final Meeting of National Curriculum Revision Committee in the discipline of Mathematics was held on April 2-4, 2013 at Higher Education Commission, Regional Center, Lahore. The purpose of the meeting was to finalize the draft curriculum of Mathematics reviewed in the Preliminary meeting held on October 22-24, 2012 at the same venue. The following Members attended the meeting:

Prof. Dr. Muhammad Nawaz, Professor, Department of Mathematics, BUITEMS, Quetta.	Convener
Prof. Dr. Syed Muhammad Husnine, Professor, Department of Mathematics (Science & Humanities), FAST, Lahore.	
Prof. Dr. Nazra Sultana, Professor & Chairman, Department of Mathematics, University of Sargodha, Sargodha.	
Prof. Dr. Muhammad Aslam, Professor & Chairman, Department of Mathematics, GC University, Lahore.	
Prof. Dr. Mirza Mahmood Baig, Professor & Chairman, Department of Mathematics, NED University of Engg. & Tech, Karachi.	
Prof. Dr. Arif Rafique, Professor & Head, Department of Mathematics, Hajvery University, Lahore.	
Prof. Dr. Shahid S. Siddiqi, Professor & Chairman, Department of Mathematics, University of the Punjab, Lahore.	

Prof. Dr. Muhammad Shafique Baig,
Professor,
Department of Mathematics,
MUST, Mirpur AJK.
Prof. Dr. Sarwar Jahan Abbasi,
Professor,
Department of Mathematics,
University of Karachi, Karachi.

Prof. Dr. Ali Dino Jumani,
Professor,
Department of Mathematics,
Shah Abdul Latif University, Khairpur.
Prof. Dr. Abdullah Shah,
Associate Professor & Associate Head,
Department of Mathematics,
CIIT, Islamabad.
Dr. Rehana Naz,
Associate Professor,
Center for Mathematical and Statistical Sciences,
Lahore School of Economics,
Lahore.
Dr. Muhammad Nawaz Naeem,
Associate Professor,
Department of Mathematics,
GC University, Faisalabad.
Dr. Imrana Kousar,
Associate Professor,
Department of Mathematics,
Lahore College for Women University,
Lahore.
Dr. Sirajul Haq,
Associate Professor,
Faculty of Engineering Sciences,
GIK Institute of Engg. & Tech.,
Topi, Swabi.
Dr. Muhammad Aziz-ur-Rehman,
Assistant Professor & Chairman,
Department of Mathematics,
University of Management & Technology,
Lahore.

Dr. Muhammad Sajid Iqbal,
Assistant Professor,
Department of Mathematics and Statistics,
Virtual University, Islamabad.
Dr. Matloob Anwar, Secretary
Assistant Professor,
Department of Mathematics,
Center for Advance Math & Physics (CAMP),NUST, Islamabad.

2. The following Members could not attend the meeting due to other engagements.

Dr. Muhammad Ozair Ahmad,
Professor & Chairman,
Department of Mathematics,
University of Engineering and Technology,
Lahore.

Dr. Wasiq Hussain,
Professor & Dean,
Department of Mathematics,
Forman Christian College,
Lahore.
Dr. Allah Ditta Raza Chaudhary,
Director General,
Abdul Salam School of Mathematical Sciences, Lahore.
Prof. Dr. Malik Zawar Hussain,
Professor,
Department of Mathematics,
University of the Punjab,
Lahore.
Dr. Muhammad Sharif,
Professor,
Department of Mathematics,
University of the Punjab,
Lahore.
Dr. Arjamand Banu,
Professor,
Department of Mathematics,
Gomal University,
D.I. Khan.

Dr. Lalarukh Kamal,
Professor,
Department of Mathematics,
University of Balochistan,
Quetta.
Dr. Nasir Ali,
Assistant Professor,
Department of Mathematics & Statistics,
International Islamic University,
Islamabad.
Dr. Sadia Hina,
Assistant Professor,
Department of Mathematics,
Fatima Jinnah Women University,
Rawalpindi.
Dr. Hisham Bin Zubair,
Assistant Professor,
Department of Mathematical Sciences,
Institute of Business Administration,
Karachi.
Dr. Muhammad Farooq,
Assistant Professor,
Department of Mathematics,
University of Peshawar,
Peshawar.
Prof. Dr. Noor Ahmed Shaikh,
Director,
Institute of Mathematics & Computer Science,
University of Sindh,
Jamshoro.

3. The meeting started with the recitation of Holy Verses from the Holy Quran by Mr. Farrukh Raza, Assistant Director (Curriculum), HEC, followed by welcome address by Mr. Farman Ullah Anjum, DG (Acad), HEC. He briefed the aims and objectives of the meeting with particular focus on the revision and finalizing the curriculum of Mathematics so as to bring it in line with the international standards keeping in view the national needs. After brief introduction of participants, the DG (Acad) requested the house to elect the Convener of meeting since Dr. Allah Ditta Raza Chaudhary, Convener of the Preliminary Meeting, did not join the Final Meeting. The house unanimously elected Prof. Dr. Muhammad Nawaz, Professor, Department of Mathematics, BUITEMS, Quetta, as the Convener of meeting. The DG (Acad) then requested the Convener

and Secretary to conduct the further proceeding of the meeting for three days.

4. The Convener and Secretary of NCRC thanked the HEC for providing an opportunity to review/finalize the curriculum of Mathematics and recalled the proceeding of Preliminary Meeting. They further requested the participants to give their suggestions/inputs for the improvement of the curriculum and opened the house for discussion. After thorough and detailed deliberation, the Committee unanimously approved the curriculum of Mathematics for BS, MS/M.Phil and made the recommendations as Annexed.

5. The Convener and Secretary of the Committee thanked all the Members for sparing their valuable time and quality contribution towards finalization of the curriculum. The Committee highly admired the efforts made by the officials of HEC as well for making excellent arrangements to facilitate the smooth work by the Committee and their comfortable accommodation/stay at Lahore.

6. The meeting ended with the vote of thanks to the Chair as well as participants of the meeting.

RATIONALE

Structure, semester-wise breakdown and the contents of each course for the 4-year BS (Mathematics) curriculum are given below. Universities are free to reshuffle the courses, e.g. if a department of mathematics chooses to teach a certain course in 3rd year instead of 2nd year, the department is free to do so.

Universities also have the flexibility to modify the course contents or even to replace a certain course as long as this modification or replacement does not exceed 20% of the total contents suggested below. There is a large number of 4th year elective courses. Each institution can offer to its students 2 of these elective courses during each semester of the 4th year.

There was a strong feeling for strengthening of concepts on which foundations of Calculus are based; and at one stage possibility of inclusion of Pre-Calculus courses in the curricula for BS (Mathematics) program was also discussed. However keeping in view the limitation of credit hours and load on the student, it was resolved that the teachers may be advised to devote considerable time and effort in building concepts mentioned in the beginning of calculus courses.

The committee emphasized on the important role that study of geometry plays in enhancing the capability of a student in logical and critical thinking. It was also felt that the study of geometry has not been given the due importance it deserves, while designing the curricula, and implementing it in the classroom at undergraduate level. The committee recommended familiarizing undergraduate mathematics students with the axiomatic approach to geometry from a logical and historical point of view and introducing them with the basic concepts of Affine Geometry and Euclidean Geometry.

Knowledge of statistical concepts is essential for every student of Mathematics. Sufficient know-how of computers and software packages is also required in order to deal with numerical and computational aspects of various courses. Keeping this in view, the committee recommended one course each in Statistics, Computer Programming and Software Packages in the category of General Courses. For remaining credits for general courses, the committee is of the view that the universities may choose four general courses (reflected as G1, G2, G3 and G4 in the scheme of studies) in consultation with Board of Studies of Mathematics depending upon available resources in the university. The committee, however, recommended a list of general

courses which can be extended by the universities with the consent of Board of Studies.

The committee felt that the knowledge of foreign languages is desirable for increasing employability of a mathematician and also for enabling him/her to benefit from research material available in foreign languages. The committee therefore recommended inclusion of one foreign language, in addition to English, in the scheme of studies for BS.

There was a fruitful discussion on development of Mathematics and emergence and inclusion of new trends in the discipline. Members noted that emergence of computers and extensive application of mathematics in other disciplines like biological sciences, Economics, business administration and actuarial sciences has put a significant impact on classification of mathematical concepts. The committee suggested following areas of specialization:

- Pure Mathematics
- Applied Mathematics
- Computational Mathematics
- Financial Mathematics

The committee also identified courses for each specialization; the lists can of course, be extended by universities through their boards of studies.

Pure Mathematics	**Applied Mathematics**	**Computational Mathematics**	**Financial Mathematics**
Measure Theory	Fluid Mechanics	Simulation	Business Mathematics
Algebraic Topology	Electromagnetism	Mathematical Modeling	Computational Methods in Finance
Galois Theory	Analytical Dynamics	Computational Fluid Dynamics	Stochastic Processes
Lie Groups	Quantum Mechanics	Graph Theory	Probability and Measure
Rings and Modules	General Relativity	Optimization Theory	Stochastics for Derivatives Modeling
Projective Geometry	Dynamical Systems	Statistical Inferences	Stochastic Analysis
Riemannian Geometry	Computational Fluid Dynamics	Cryptography	The Mathematics of the Black and Scholes Theory
History of Mathematics	History of Mathematics	Numerical Partial Differential Equations	The Foundations of Interest Rate and
Pointless Topology	Econometrics	Convex Analysis	
	Special Relativity	Numerical	
	Optimization Theory		
	Statistical Inferences		

Econometrics Advanced group Theory Lie Algebra Optimization Theory Axiomatic Set Theory Category Theory Statistical Inferences Convex Analysis Applied Algebra Operations Research Stochastic Processes Homological Algebra Fuzzy Set Theory	Convex Analysis Applied Algebra Bio Mathematics Operations Research Stochastic Processes Regression Models Multivariate Analysis Financial Mathematics Tensor Analysis Astronomy	Solutions of Ordinary Differential Equations Numerical Analysis Operations Research Stochastic Processes Non-Linear Programming Combinatorics Fuzzy Set Theory	Credit Risk Theory Preferences, Optimal Portfolio Choice, and Equilibrium Introduction to Markov Processes and Their Applications Quantifying Risk Modeling and Alternative Markets Forecasting Financial Time Series Quantitative Methods for Finance and Risk Analysis

The universities may choose elective courses from any of above specialization and prepare Mathematics graduate who would in turn contribute in socio-economic growth of the region in domains relevant to their specialization. The specialization “Financial Mathematics” was especially recommended by the committee for those universities who specialize in programs related with Business Administration and Management Sciences.

The committee also felt the need for a specialization for those Mathematics graduates who desire to adopt teaching of Mathematics as profession. It was proposed that courses relating to foundations of Mathematics, Axiomatic Set Theory, and History of Mathematics may be offered to the graduates aspiring for teaching profession.

For courses belonging to the categories of “Compulsory Requirements” and “General Courses” the committee recommended that the course outlines given in curricula documents of HEC prepared for this purpose; or given in curricula documents of relevant disciplines may be implemented. However if contents for some course are not available in HEC documents, the universities may design the contents for the curriculum in that particular domain in consultation with expertise

available in the University and Board of Studies of Mathematics. The same may be reported to HEC.

Admission Criterion for BS (Mathematics)

The candidate seeking admission in BS (Mathematics) Program, must meet the following eligibility criterion.

- Intermediate with Mathematics, securing at least 50% marks in aggregate.
  Or
- Any other examination of a Foreign University / Institution / Examining Body, equivalent to Intermediate with Mathematics. Equivalence and percentage of marks will be determined by IBCC.
  Or
- Diploma of Associate Engineering Examination, securing at least 60% marks in aggregate.

Scheme of Studies for BS (Mathematics)

BS (Mathematics) is a 128 credit hours program of studies spread over eight semesters. The domains and the number of courses and their credit hours assigned to these domains are as follows.

Domains	Number of Courses	Number of Credit Hours
Compulsory Requirements	9	25
General Courses	7	21
Discipline Specific Foundation Courses	10	33
Major Courses including Research Project	11 + Project	37
Elective Courses within the Major	4	12
	41 + Project	128

Details are given in the following table

Compulsory Requirements		**General Courses**	**Discipline Specific Foundation Courses**		**Major Courses including Research Project**	**Elective Courses within the Major**			
9 courses		7-8 courses	9-10 courses		11-13 courses	4 courses			
25 Credit hours		21-24 Cr. Hours	30-33 Credit hours		36-42 Credit Hours	12 Credit hours			
Title	**Cr. Hr.**	**Title**	**Cr. Hr**	**Title**	**Cr. Hr**	**Title**	**Cr. Hr**	**Title**	**Cr. Hr**
English I(Functional English)	3	Statistics	3	Algebra-I	3	Number Theory	3	E-1	3
English II (Communication Skills)	3	Computer Programming	3	Algebra-II	3	Real Analysis-I	3	E-2	3
English III (Technical Writing and Presentation skills)	3	Software Packages	3	Integral Equations	3	Real Analysis-II	3	E-3	3
Any Foreign Language	3	G-1	3	Calculus I	4	Mathe-matical Methods	3	E-4	3

Islamic Studies/Ethics	2	G-2	3	Calculus II	3	Topology	3		
Pakistan Studies	2	G-3	3	Calculus-III	4	Differen-tial Geometry	3		
Discrete Mathematics	3	G-4	3	Complex Analysis	3	Classical Mecha-nics	3		
Elements of Set theory and Mathematical Logic	3			Ordinary differential equations	3	Partial Different-ial Equations	3		
Introduction to Computers	3			Linear algebra	4	Functional Analysis	3		
				Affine and Euclidean Geometry	3	Numerical Analysis	4		
						Probability Theory	3		
						Project	3		
Total	25		21		33		37		12

Semester-Wise Breakdown

First year					
First Semester			**Second Semester**		
#	Course Title	Cr. Hr	#	Course Title	Cr. Hr.
1	Calculus-I	4	1	Calculus II	3
2	Elements of Set Theory and Mathematical Logic	3	2	Software packages	1+2
3	English I (Functional English)	3	3	Statistics	3
4	Islamic Studies/Ethics	2	4	English II (Communication Skills)	3
5	G-1	3	5	Pakistan Studies	2
6	Introduction to Computers	3	6	G-2	3
Total		18			17

Second year					
First Semester			**Second Semester**		
#	Course Title	Cr. Hr	#	Course title	Cr. Hr.
1	Algebra I (Group Theory)	3	1	Affine and Euclidean Geometry	3
2	Calculus III	4	2	Linear Algebra	3+ 1
3	G-3	3	3	G-4	3
4	English III (Technical Writing and Presentation Skills)	3	4	Discrete Mathematics	3
5	Computer Programming	2+1	5	Any Foreign Language	3
Total		16			16

Third year					
First Semester			**Second Semester**		
#	**Course Title**	**Cr. Hr**	**#**	**Course Title**	**Cr. Hr.**
1	Topology	3	1	Classical Mechanics	3
2	Differential Geometry	3	2	Partial Differential Equations	3
3	Ordinary Differential Equations	3	3	Complex Analysis	3
4	Real Analysis- I	3	4	Functional Analysis	3
5	Algebra- II (Rings and Fields)	3	5	Real Analysis-II	3
Total		15			15

Fourth year					
First Semester			**Second Semester**		
#	Course Title	Cr. Hr	#	Course title	Cr. Hr.
1	Numerical Analysis	3+1	1	Probability Theory	3
2	Number Theory	3	2	Integral Equations	3
3	E-1	3	3	E-3	3
4	E-2	3	4	E-4	3
5	Mathematical Methods	3	5	Project	3
Total		16			15

General Courses for BS Mathematics

The courses G-1, G-2, G-3 and G-4 may be chosen from following titles. This list may be extended with consent of Board of Studies keeping in view the availability of expertise in the University.

- Physics-I
- Physics-II
- Biology
- Economics
- Chemistry
- Accounting
- Psychology
- Sociology
- Philosophy
- Environmental Sciences

Electives for BS (Mathematics)

- Measure Theory
- Rings and Modules
- Advanced Group Theory
- Algebraic Topology
- Projective Geometry
- Graph Theory
- Galois Theory
- Riemannian Geometry
- Lie Algebra
- Fluid Mechanics
- General Relativity
- Special Relativity
- Electromagnetism
- Mathematical Modeling
- Optimization Theory
- Simulation
- Dynamical Systems
- Mathematical Physics
- Analytical Dynamics
- Computational Fluid Dynamics
- Quantum Mechanics
- History of Mathematics
- Axiomatic Set Theory
- Lie Groups
- Pointless Topology
- Category Theory
- Econometrics
- Statistical Inferences
- Convex Analysis
- Mathematical Biology
- Modules over PID

Course Contents for BS (Mathematics)

Title of the Course: Calculus-I
Credit Hours: 4
Prerequisites: Knowledge of Intermediate Calculus

Specific Objectives of course: Calculus serves as the foundation of advanced subjects in all areas of mathematics. This is the first course of Calculus. The objective of this course is to introduce students to the fundamental concepts of limit, continuity, differential and integral calculus of functions of one variable.

Course Outline:
Equations and inequalities: Solving linear and quadratic equations, linear inequalities. Division of polynomials, synthetic division. Roots of a polynomial, rational roots; Viete Relations. Descartes rule of signs. Solutions of equations with absolute value sign. Solution of linear and non-linear inequalities with absolute value sign.

Functions and graphs: Domain and range of a function. Examples: polynomial, rational, piecewise defined functions, absolute value

functions, and evaluation of such functions. Operations with functions: sum, product, quotient and composition. Graphs of functions: linear, quadratic, piecewise defined functions.

Lines and systems of equations: Equation of a straight line, slope and intercept of a line, parallel and perpendicular lines. Systems of linear equations, solution of system of linear equations. Nonlinear systems: at least one quadratic equation.

Limits and continuity: Functions, limit of a function. Graphical approach. Properties of limits. Theorems of limits. Limits of polynomials, rational and transcendental functions. Limits at infinity, infinite limits, one-sided limits. Continuity.

Derivatives: Definition, techniques of differentiation. Derivatives of polynomials and rational, exponential, logarithmic and trigonometric functions. The chain rule. Implicit differentiation. Rates of change in natural and social sciences. Related rates. Linear approximations and differentials. Higher derivatives, Leibnitz's theorem.

Applications of derivatives: Increasing and decreasing functions. Relative extrema and optimization. First derivative test for relative extrema. Convexity and point of inflection. The second derivative test for extrema. Curve sketching. Mean value theorems. Indeterminate forms and L'Hopitals rule. Inverse functions and their derivatives.

Integration: Anti derivatives and integrals. Riemann sums and the definite integral. Properties of Integral. The fundamental theorem of calculus. The substitution rule.

Recommended Books:

1. Thomas, *Calculus*, 11th Edition. Addison Wesley Publishing Company, 2005
2. H. Anton, I. Bevens, S. Davis, *Calculus*, 8th Edition, John Wiley & Sons, Inc. 2005
3. Hughes-Hallett, Gleason, McCallum, et al, *Calculus Single and Multivariable*, 3rd Edition. John Wiley & Sons, Inc. 2002.
4 Frank A. Jr, Elliott Mendelson, *Calculus*, Schaum's outlines series, 4th Edition, 1999
5. C.H. Edward and E.D Penney, *Calculus and Analytics Geometry*, Prentice Hall, Inc. 1988
6. E. W. Swokowski, *Calculus with Analytic Geometry*, PWS Publishers, Boston, Massachusetts, 1983.
7. M. Liebeck, *A Concise introduction to pure Mathematics*, CRC Press, 2011.
8. A. Kaseberg, *Intermediate Algebra*, Thomson Brooks/cole, 2004.

Title of the Course: Elements of Set Theory and Mathematical Logic
Credit Hours: 3
Prerequisites: Knowledge of Intermediate Mathematics

Specific Objectives of course: Everything mathematicians do can be reduced to statements about sets, equality and membership which are basics of set theory. This course introduces these basic concepts. The course aims at familiarizing the students with cardinals, relations and fundamentals of propositional and predicate logics.

Course Outline:
Set theory: Sets, subsets, operations with sets: union, intersection, difference, symmetric difference, Cartesian product and disjoint union. Functions: graph of a function. Composition; injections, surjections, bijections, inverse function. **Computing cardinals:** Cardinality of Cartesian product, union. Cardinality of all functions from a set to another set. Cardinality of all injective, surjective and bijective functions from a set to another set.
Infinite sets, finite sets. Countable sets, properties, examples (Z, Q). R is not countable. R, RxR, RxRxR have the same cardinal. Operations with cardinal numbers. Cantor-Bernstein theorem.
Relations: Equivalence relations, partitions, quotient set; examples, parallelism, similarity of triangles. Order relations, min, max, inf, sup; linear order. Examples: N, Z, R, $P(A)$. Well ordered sets and induction. Inductively ordered sets and Zorn's lemma.
Mathematical logic:
Propositional Calculus. Truth tables. Predicate Calculus.

Recommended Books:

1. M. Liebeck, *A Concise Introduction to Pure Mathematics*, CRC Press, 2011.
2. N. L. Biggs, *Discrete Mathematics*, Oxford University Press, 2002.
3. R. Garnier, J. Taylor, *Discrete Mathematics*, Chapters 1,3,4,5, CRC Press, 2010.
4. A.A. Fraenkal, *Abstract Set Theory*, North-Holland Publishing Company, 1966.
5. P. Suppes, *Axiomatic Set Theory*, Dover Publication, 1972.
6. P.R. Halmos, *Naive Set Theory*, New York, Van Nostrand, 1950.
7. B. Rotman, G.T. Kneebone, *The Theory of sets and Transfinite Numbers*, Oldbourne London, 1968.
8. D. Smith, M. Eggen, R.St. Andre, *A Transition to Advanced Mathematics*, Brooks/Cole, 2001.

Title of the Course: Calculus II
Credit Hours: 3
Prerequisites: Calculus I

Specific Objectives of course: This is second course of Calculus. As continuation of Calculus I, it focuses on techniques of integration and applications of integrals. The course also aims at introducing the students to infinite series, parametric curves and polar coordinates.

Course Outline:

Techniques of integration: Integrals of elementary, hyperbolic, trigonometric, logarithmic and exponential functions. Integration by parts, substitution and partial fractions. Approximate integration. Improper integrals. Gamma functions.

Applications of integrals: Area between curves, average value. Volumes. Arc length. Area of a surface of revolution. Applications to Economics, Physics, Engineering and Biology.

Infinite series: Sequences and series. Convergence and absolute convergence. Tests for convergence: divergence test, integral test, p-series test, comparison test, limit comparison test, alternating series test, ratio test, root test. Power series. Convergence of power series. Representation of functions as power series. Differentiation and integration of power series. Taylor and McLaurin series. Approximations by Taylor polynomials.

Conic section, parameterized curves and polar coordinates: Curves defined by parametric equations. Calculus with parametric curves: tangents, areas, arc length. Polar coordinates. Polar curves, tangents to polar curves. Areas and arc length in polar coordinates.

Recommended Books:

1. Thomas, *Calculus*, 11th Edition. Addison Wesley Publishing Company, 2005
2. H. Anton, I. Bevens, S. Davis, *Calculus*, 8th Edition, John Wiley & Sons, Inc. 2005
3. Hughes-Hallett, Gleason, McCallum, et al, *Calculus Single and Multivariable*, 3rd Edition. John Wiley & Sons, Inc. 2002.
4. Frank A. Jr, Elliott Mendelson, *Calculus*, Schaum's outlines series, 4th Edition, 1999
5. C.H. Edward and E.D Penney, *Calculus and Analytics Geometry*, Prentice Hall, Inc. 1988
6. E. W. Swokowski, *Calculus with Analytic Geometry*, PWS Publishers, Boston, Massachusetts, 1983.
7. M. Liebeck, *A Concise introduction to pure Mathematics*, CRC Press, 2011.
8. A. Kaseberg, *Intermediate Algebra*, Thomson Brooks/COLE, 2004.

9. J. Stewart, Calculus early transcendentals, 7th Edition, Brooks/COLE, 2008.

Title of the Course: Algebra I (Group Theory)
Credit Hours: 3
Prerequisites: Elements of Set Theory and Mathematical Logic

Specific Objectives of course: This course introduces basic concepts of groups and their homomorphisms. The main objective of this course is to prepare students for courses which require a good back ground in group theory like Rings and Modules, Linear Algebra, Group Representation, Galois Theory etc.

Course Outline:
Groups: Definition of a group, subgroup, subgroup generated by a set. The cyclic groups, cosets and Lagrange's theorem. Normalizer centralizer. The center of a group. Equivalence relation in a group, conjugacy classes. Normal subgroups, quotient group. **Group homomorphism**s: Homomorphisms and isomorphism and Automorphism. Kernel and image of homomorphism. Isomorphism theorems. Permutation groups. The cyclic decomposition of a permutation group. Cayley's theorem. Direct product of two groups and examples.

Recommended Books:

1. J. Rose, *A Course on Group Theory*, Cambridge University Press, 1978.
2. I. N. Herstein, *Topics in Algebra*, Xerox Publishing Company, 1964.
3. P. M. Cohn, *Algebra*, John Wiley and Sons, London, 1974.
4. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, *Basic Abstract Algebra*, Cambridge University Press, 1986.
5. J. B. Fraleigh, *A First Course in Abstract Algebra*, Addison-Wesley Publishing Company, 2002.
6. Vivek Sahai and Vikas Bist, *Algebra*, Narosa Publishing House, 1999.
7. D. S. Dummit and R. M. Foote, *Abstract Algebra*, 3rd Edition, Addison-Wesley Publishing Company, 2004.

Title of the Course: Calculus III
Credit Hours: 4
Prerequisites: Calculus II

Specific Objectives of course: This is third course of Calculus and builds up on the concepts learned in first two courses. The students would be introduced to the vector calculus, the calculus of multivariable functions and double and triple integrals along with their applications.

Course Outline:

Vectors and analytic geometry in space: Coordinate system. Rectangular, cylindrical and spherical coordinates. The dot product, the cross product. Equations of lines and planes. Quadric surfaces.
Vector-valued functions: Vector-valued functions and space curves. Derivatives and integrals of vector valued functions. Arc length. Curvature, normal and binormal vectors.

Multivariable functions and partial derivatives: Functions of several variables. Limits and Continuity. Partial derivatives, Composition and chain rule. Directional derivatives and the gradient vector. Implicit function theorem for several variables. Maximum and minimum values. Optimization problems. Lagrange Multipliers.

Multiple integrals: Double integrals over rectangular domains and iterated integrals. Non-rectangular domains. Double integrals in polar coordinates. Triple integrals in rectangular, cylindrical and spherical coordinates. Applications of double and triple integrals. Change of variables in multiple integrals.
Vector calculus: Vector fields. Line integrals. Green's theorem. Curl and divergence. Surface integrals over scalar and vector fields. Divergence theorem. Stokes' theorem.

Recommended Books:

1. Thomas, *Calculus*, 11th Edition. Addison Wesley Publishing Company, 2005
2. H. Anton, I. Bevens, S. Davis, *Calculus*, 8th Edition, John Wiley & Sons, Inc. 2005
3. Hughes-Hallett, Gleason, McCallum, et al, *Calculus Single and Multivariable*, 3rd Edition. John Wiley & Sons, Inc. 2002.
4. Frank A. Jr, Elliott Mendelson, *Calculus*, Schaum's outlines series, 4th Edition, 1999
5. C.H. Edward and E.D Penney, *Calculus and Analytics Geometry*, Prentice Hall, Inc. 1988
6. E. W. Swokowski, *Calculus with Analytic Geometry*, PWS Publishers, Boston, Massachusetts, 1983.
7. M. Liebeck, *A Concise introduction to pure Mathematics*, CRC Press, 2011.
8. A. Kaseberg, *Intermediate Algebra*, Thomson Brooks/COLE, 2004.
9. J. Stewart, *Calculus early transcendentals*, 7th Edition, Brooks/COLE, 2008.

Title of the Course: Affine and Euclidean Geometry
Credit Hours: 3
Prerequisites: Calculus I

Specific Objectives of course: To familiarize mathematics students with the axiomatic approach to geometry from a logical, historical, and pedagogical point of view and introduce them with the basic concepts of Affine Geometry, Affine spaces and Platonic Ployhedra.

Course Outline:
Vector spaces and affine geometry: Collinearity of three points, ratio AB/BC. Linear combinations and linear dependent set versus affine combinations and affine dependent sets. Classical theorems in affine geometry: Thales, Menelaus, Ceva, Desargues. Affine subspaces, affine maps. Dimension of a linear subspace and of an affine subspace.

Euclidean geometry: Scalar product, Cauchy-Schwartz inequality: norm of a vector, distance between two points, angles between two non-zero vectors. Pythagoras theorem, parallelogram law, cosine and sine rules. Elementary geometric loci.
Orthogonal transformations: Isometries of plane (four types), Isometries of space (six types). Orthogonal bases.
Platonic polyhedra: Euler theorem on finite planar graphs. Classification of regular polyhedra in space. Isometries of regular polygons and regular polyhedra.

Recommended Books:
1. E. Rees, *Notes on Geometry*, Springer, 2004.
2. M. A. Armstrong, *Groups and Symmetry*, Springer, 1998.
3. H. Eves, *Fundamentals of Modern Elementary Geometry*, Jones and Bartlett Publishers International, 1992
4. S. Stahl, *The Poincare Half-Plane A Gateway to Modern Geometry*, Jones and Bartlett Publishers International, 1993.

Title of the Course: Linear Algebra
Credit Hours: 3+1
Prerequisites: Calculus I

Specific Objectives of course: Linear algebra is the study of vector spaces and linear transformations. The main objective of this course is to help students learn in rigorous manner, the tools and methods essential for studying the solution spaces of problems in mathematics, engineering, the natural sciences, and social sciences and develop mathematical skills needed to apply these to the problems arising within their field of study; and to various real world problems.

Course Outline:

System of Linear Equations: Representation in matrix form. Matrices. Operations on matrices. Echelon and reduced echelon form. Inverse of a matrix (by elementary row operations). Solution of linear system. Gauss-Jordan method. Gaussian elimination.

Determinants: Permutations of order two and three and definitions of determinants of the same order. Computing of determinants. Definition of higher order determinants. Properties. Expansion of determinants.

Vector Spaces: Definition and examples, subspaces. Linear combination and spanning set. Linearly Independent sets. Finitely generated vector spaces. Bases and dimension of a vector space. Operations on subspaces, Intersections, sums and direct sums of subspaces. Quotient Spaces.

Linear mappings: Definition and examples. Kernel and image of a linear mapping. Rank and nullity. Reflections, projections, and homotheties. Change of basis. Eigen-values and eigenvectors. Theorem of Hamilton-Cayley.

Inner product Spaces: Definition and examples. Properties, Projection. Cauchy inequality. Orthogonal and orthonormal basis. Gram Schmidt Process. Diagonalization.

Recommended Books:

1. Ch. W. Curtis, *Linear Algebra*, Springer 2004.
2. T. Apostol, *Multi Variable Calculus and Linear Algebra*, 2nd ed., John Wiley and sons, 1997.
3. H. Anton, C. Rorres , *Elementary Linear Algebra: Applications Version*, 10th Edition, John Wiley and sons, 2010.
4. S. Friedberg, A. Insel, Linear Algebra, 4th Edition, Pearson Education Canada, 2003.
5. S. I. Grossman, *Elementary Linear Algebra*, 5th Edition, Cengage Learning, 2004.

Title of the Course: Discrete Mathematics
Credit Hours: 3
Prerequisites: Mathematics at intermediate level

Specific Objectives of course: Discrete Mathematics is study of distinct, un-related topics of mathematics; it embraces topics from early stages of mathematical development and recent additions to the discipline as well. The present course restricts only to counting methods, relations and graphs. The objective of the course is to inculcate in the students the skills that are necessary for decision making in non-continuous situations.

Course Outline:

Counting methods: Basic methods: product, inclusion-exclusion formulae. Permutations and combinations. Recurrence relations and

their solutions. Generating functions. Double counting. Applications. Pigeonhole principle, applications.

Relations: Binary relations, n-ary Relations. Closures of relations. Composition of relations, inverse relation.

Graphs: Graph terminology. Representation of graphs. Graphs isomorphism. Algebraic methods: the incidence matrix. Connectivity, Eulerian and Hamiltonian paths. Shortest path problem. Trees and spanning trees. Complete graphs and bivalent graphs.

Recommended Books:

1. B. Bollobas, *Graph Theory*, Springer Verlag, New York, 1979.
2. K.R. Parthasarathy, *Basic Graph Theory*, McGraw-Hill, 1994
3. K.H. Rosen, *Discrete Mathematics and its Application*, McGraw-Hill, 6th edition, 2007.
4. B. Kolman, R.C. Busby, S.C. Ross, *Discrete Mathematical Structures*, Prentice-Hall of India, New Delhi, 5th edition, 2008.
5. A. Tucker, *Applied Combinatorics*, John Wiley and Sons, Inc New York, 2002.
6. R. Diestel, *Graph Theory*, 4th edition, Springer- Verlag, New York, 2010.
7. N.L. Brigs, *Discrete Mathematics*, Oxford University Press, 2003
8. K.A. Ross, C.R.B. Wright, *Discrete Mathematics*, Prentice Hall, New Jersey, 2003.

Title of the Course: Topology
Credit Hours: 3
Prerequisites: Calculus I

Specific Objectives of course: The aim of this course is to introduce the students to metric spaces and topological spaces. After completion of this course, they would be familiar with separation axioms, compactness and completeness. They would be able to determine whether a function defined on a metric or topological space is continuous or not and what homeomorphisms are.

Course Outline:

Topological spaces: Examples; open and closed subsets, metric spaces, neighbourhoods. Examples. Limit points and accumulation points. Interior, closure, dense subsets. Constructing new topological spaces: Cartesian products, induced topology and quotient topology. Continuous maps, open and closed maps, homeomorphisms. Examples: R, RxR, S^1, S^2, torus, cylinder. Cauchy sequences, complete metric spaces. Separation axioms. Compact spaces. Properties. Power of Compactness. Image of a compact set through a continuous map. Compactness and completeness of metric spaces.

Connected spaces, connected components. Properties. Image of a connected set through a continuous map. Path-connectedness.

Recommended Books:

1. J. Kelly, *General Topology*, Springer, 2005.
2. K. Janich, *Topology*, Springer, 1994.
3. J. Hocking, G. Young, *Topology*, Dover Publications, 1961.
4. J. R. Munkres, *Topology - A First Course*, Prentice-Hall, 2003.
5. G. Simmons, *Topology and modern analysis*, McGraw-Hill, 1963.
6. S. Lipschutz, *General Topology*, McGraw-Hill, 2004.
7. J. Dugundji, *Topology*, Allyn and Bacon, 1966.

Title of the Course: Differential Geometry and Tensor Analysis
Credit Hours: 4
Prerequisites: Calculus I

Specific Objectives of course: After having completed this course, the students would be expected to understand classical concepts in the local theory of curves and surfaces including normal, principal, mean, curvature, and geodesics. They will also learn about tensors of different ranks.

Course Outline:

Theory of Space Curves: Introduction, index notation and summation convention. Space curves, arc length, tangent, normal and binormal. Osculating, normal and rectifying planes. Curvature and torsion. The Frenet-Serret theorem. Natural equation of a curve. Involutes and evolutes, helices. Fundamental existence theorem of space curves.

Theory of Surfaces: Coordinate transformation. Tangent plane and surface normal. The first fundamental form and the metric tensor. The second fundamental form. Principal, Gaussian, mean, geodesic and normal curvatures. Gauss and Weingarten equations. Gauss and Codazzi equations.

Tensor Analysis: Einstein summation convention. Tensors of different ranks. Contravariant, covariant and mixed tensors. Addition, subtraction, inner and outer products of tensors. Contraction theorem, quotient law. The line element and metric tensor. Christoffel symbols.

Recommended Books:

1. R. S. Millman and G. D. Parker, *Elements of Differential Geometry*, Prentice-Hall, New Jersey, 1977.
2. A. Goetz, *Introduction to Differential Geometry*, Addison-Wesley, 1970.
3. E. Kreyzig, Differential Geometry, Dover, 1991.
4. M. M. Lipschutz, *Schaum's Outline of Differential Geometry*, McGraw Hill, 1969.

5. D. Somasundaram, *Differential Geometry*, Narosa Publishing House, New Delhi. 2005.
6. M. R. Spiegel, Vector Analysis, McGraw Hill Book Company, Singapore, 1981.
7. A. W. Joshi, *Matrices and Tensors in Physics*, Wiley Eastern Limited, 1991.
8 F. Chorlton, *Vector and Tensor Methods*, Ellis Horwood Publisher, U.K., 1977.

Title of the Course: Ordinary Differential Equations
Credit Hours: 3
Prerequisites: Calculus I

Specific Objectives of course: To introduce students to the formulation, classification of differential equations and existence and uniqueness of solutions. To provide skill in solving initial value and boundary value problems. To develop understanding and skill in solving first and second order linear homogeneous and non-homogeneous differential equations and solving differential equations using power series methods.

Course Outline:
Preliminaries: Introduction and formulation, classification of differential equations, existence and uniqueness of solutions, introduction of initial value and boundary value problems

First order ordinary differential equations: Basic concepts, formation and solution of differential equations. Separable variables, Exact Equations, Homogeneous Equations, Linear equations, integrating factors. Some nonlinear first order equations with known solution, differential equations of Bernoulli and Ricaati type, Clairaut equation, modeling with first-order ODEs, Basic theory of systems of first order linear equations, Homogeneous linear system with constant coefficients, Non homogeneous linear system
Second and higher order linear differential equations: Initial value and boundary value problems, Homogeneous and non-homogeneous equations, Superposition principle, homogeneous equations with constant coefficients, Linear independence and Wronskian, Non-homogeneous equations, undetermined coefficients method, variation of parameters, Cauchy-Euler equation, Modeling.
Sturm-Liouville problems: Introduction to eigen value problem, adjoint and self adjoint operators, self adjoint differential equations, eigen values and eigen functions, Sturm-Liouville (S-L) boundary value problems, regular and singular S-L problems, properties of regular S-L problems
Series Solutions: Power series, ordinary and singular points, Existence of power series solutions, power series solutions, types of

singular points, Frobenius theorem, Existence of Frobenius series solutions, solutions about singular points, The Bessel, modified Bessel Legendre and Hermite equations and their solutions.

Recommended Books:

1. Dennis G. Zill and Michael R., Differential equations with boundary-value problems by Cullin 5th Edition Brooks/Cole, 1997.
2. William E. Boyce and Richard C. Diprima, Elementary differential equations and boundary value problems, Seventh Edition John Wiley & Sons, Inc
3. V. I. Arnold, *Ordinary Differential Equations*, Springer, 1991.
4. T. Apostol, *Multi Variable Calculus and Linear Algebra*, 2nd ed., John Wiley and sons, 1997.

Title of the Course: Analysis I
Credit Hours: 3
Prerequisites: Calculus III

Specific Objectives of course: This is the first course in analysis. It develops the fundamental ideas of analysis and is aimed at developing the students' ability in reading and writing mathematical proofs. Another objective is to provide sound understanding of the axiomatic foundations of the real number system, in particular the notions of completeness and compactness.

Course Outline:

Number Systems: Ordered fields. Rational, real and complex numbers. Archimedean property, supremum, infimum and completeness.

Topology of real numbers: Convergence, completeness, completion of real numbers. Open sets, closed sets, compact sets. Heine Borel Theorem. Connected sets.

Sequences and Series of Real Numbers: Limits of sequences, algebra of limits. Bolzano Weierstrass Theorem. Cauchy sequences, liminf, limsup. Limits of series, convergences tests, absolute and conditional convergence. Power series.

Continuity: Functions, continuity and compactness, existence of minimizers and maximizers, uniform continuity. Continuity and connectedness, Intermediate mean Value Theorem. Monotone functions and discontinuities.

Differentiation: Mean Value Theorem, L'Hopital's Rule, Taylor's Theorem.

Recommended Books:

1. S. Lang, Analysis *I*, Addison-Wesley Publ. Co., Reading, Massachusetts, 1968.
2. W. Rudin, *Principles of Mathematical Analysis*, 3rd ed., Mc.Graw-

Hill, 1976.
3. B. S. Thomson, J. B. Bruckner and A. M. Bruckner, *Elementary Real Analysis*, 2nd Ed. 2008.
4. G. Boros, V. Moll, *Irresistible Integrals: Symbolics, Analysis an Experiments in the Evaluation of Integrals*, Cambridge University Press, 2004.
5. J. Borwein, D. Bailey, R. Girgenson, *Experimentation in Mathematics: Computational Paths to discovery*, Wellesley, MA, A.K. Peters, 2004.
6. G. Bartle , R. Sherbert , *Introduction to Real Analysis,* 3rd edition, John Wiley, New York, 1999.

Title of the Course: Algebra II (Ring Theory)
Credit Hours: 3
Prerequisites: Algebra I

Specific Objectives of course: This is a course in advanced abstract algebra, which builds on the concepts learnt in Algebra I. The objectives of the course are to introduce students to the basic ideas and methods of modern algebra and enable them to understand the idea of a ring and an integral domain, and be aware of examples of these structures in mathematics; appreciate and be able to prove the basic results of ring theory; appreciate the significance of unique factorization in rings and integral domains.

Course Outline:
Rings: Definition, examples. Quadratic integer rings. Examples of non-commutative rings. The Hamilton quaternions. Polynomial rings. Matrix rings. Units, zero-divisors, nilpotents, idempotents. Subrings, Ideals. Maximal and prime Ideals. Left, right and two-sided ideals;. Operations with ideals. The ideal generated by a set. Quotient rings. Ring homomorphism. The isomorphism theorems, applications. Finitely generated ideals. Rings of fractions.
Integral Domain: The Chinese remainder theorem. Divisibility in integral domains, greatest common divisor, least common multiple. Euclidean domains. The Euclidean algorithm. Principal ideal domains. Prime and irreducible elements in an integral domain. Gauss lemma, irreducibility criteria for polynomials. Unique factorization domains. Finite fields. Polynomials in several variables. Symmetric polynomials. The fundamental theorem of symmetric polynomials.

Recommended Books:
1. J. Rose, *A Course on Group Theory*, Cambridge University Press, 1978.
2. I. N. Herstein, *Topics in Algebra*, Xerox Publishing Company, 1964.
3. P. M. Cohn, *Algebra*, John Wiley and Sons, London, 1974.

4. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, *Basic Abstract Algebra*, Cambridge University Press, 1986.
5. J. B. Fraleigh, *A First Course in Abstract Algebra*, Addison-Wesley Publishing Company, 2002.
7. Vivek Sahai and Vikas Bist, *Algebra*, Narosa Publishing House, 1999.
8. D. S. Dummit and R. M. Foote, *Abstract Algebra*, 3rd Edition, Addison-Wesley Publishing Company, 2004.

Title of the Course: Classical Mechanics
Credit Hours: 3
Prerequisites: Calculus I

Specific Objectives of course: To provide solid understanding of classical mechanics and enable the students to use this understanding while studying courses on quantum mechanics, statistical mechanics, electromagnetism, fluid dynamics, space-flight dynamics, astrodynamics and continuum mechanics.

Course Outline:
Kinematics: Rectilinear motion of particles. Uniform rectilinear motion, uniformly accelerated rectilinear motion. Curvilinear motion of particle, rectangular components of velocity and acceleration. Tangential and normal components. Radial and transverse components. Projectile motion.
Kinetics: Work, power, kinetic energy, conservative force fields. Conservation of energy, impulse, torque. Conservation of linear and angular momentum. Non-conservative forces.
Simple Harmonic Motion: The simple harmonic oscillator, period, frequency. Resonance and energy. The damped harmonic oscillator, over damped, critically damped and under damped. Motion, forces and vibrations.
Central Forces and Planetary Motion: Central force fields, equations of motion, potential energy, orbits. Kepler's law of planetary motion. Apsides and apsidal angles for nearly circular orbits. Motion in an inverse square field.
Planer Motion of Rigid Bodies: Introduction to rigid and elastic bodies, degree of freedom, translations, rotations, instantaneous axis and center of rotation, motion of the center of mass. Euler's theorem and Chasles' theorem. Rotation of a rigid body about a fixed axis, moments and products of inertia. Parallel and perpendicular axis theorem.
Motion of Rigid Bodies in Three Dimensions: General motion of rigid bodies in space. The momental ellipsoid and equimomental systems. Angular momentum vector and rotational kinetic energy. Principal axes and principal moments of inertia. Determination of

principal axes by diagonalizing the inertia matrix.
Euler Equations of Motion of a Rigid Body: Force free motion. Free rotation of a rigid body with an axis of symmetry. Free rotation of a rigid body with three different principal moments. The Eulerian angles, angular velocity and kinetic energy in terms of Euler angles. Motion of a spinning top and gyroscopes-steady precession, sleeping top.

Recommended Books:

1. E. DiBenedetto, *Classical Mechanics. Theory and Mathematical Modeling*, ISBN: 978-0-8176-4526-7, Birkhauser Boston, 2011.
2. John R. Taylor, *Classical Mechanics*, ISBN: 978-1-891389-22-1, University of Colorado, 2005.
3. H. Goldstein, *Classical Mechanics*, Addison-Wesley Publishing Co., 1980.
4. C. F. Chorlton, *Text Book of Dynamics*, Ellis Horwood, 1983.
5. M. R. Spiegel, *Theoretical Mechanics*, 3rd Edition, Addison-Wesley Publishing Company, 2004.
6. G. R. Fowles and G. L. Cassiday, *Analytical Mechanics,* 7th edition, Thomson Brooks/COLE, USA, 2005.

Title of the Course: Partial Differential Equations
Credit Hours: 3
Prerequisites: Ordinary Differential Equations

Specific Objectives of course: Partial Differential Equations (PDEs) are at the heart of applied mathematics and many other scientific disciplines. The course aims at developing understanding about fundamental concepts of PDEs theory, identification and classification of their different types, how they arise in applications, and analytical methods for solving them. Special emphasis would be on wave, heat and Laplace equations.

Course Outline:
First order PDEs: Introduction, formation of PDEs, solutions of PDEs of first order, The Cauchy's problem for quasilinear first order PDEs, First order nonlinear equations, Special types of first order equations
Second order PDEs: Basic concepts and definitions, Mathematical problems, Linear operators, Superposition, Mathematical models: The classical equations, the vibrating string, the vibrating membrane, conduction of heat solids, canonical forms and variable, PDEs of second order in two independent variables with constant and variable coefficients, Cauchy's problem for second order PDEs in two independent variables
Methods of separation of variables: Solutions of elliptic, parabolic and hyperbolic PDEs in Cartesian and cylindrical coordinates
Laplace transform: Introduction and properties of Laplace transform,

transforms of elementary functions, periodic functions, error function and Dirac delta function, inverse Laplace transform, convolution theorem, solution of PDEs by Laplace transform, Diffusion and wave equations

Fourier transforms: Fourier integral representation, Fourier sine and cosine representation, Fourier transform pair, transform of elementary functions and Dirac delta function, finite Fourier transforms, solutions of heat, wave and Laplace equations by Fourier transforms.

Recommended Books:

1. Myint UT, *Partial Differential Equations for Scientists and Engineers*, 3rd edition, North Holland, Amsterdam, 1987.
2. Dennis G. Zill, Michael R. Cullen, *Differential equations with boundary value problems,* Brooks Cole, 2008.
3. John Polking, Al Boggess, *Differential Equations with Boundary Value Problems*, 2nd Edition, Pearson,July 28, 2005.
4. J. Wloka, *Partial Differential Equations*, Cambridge University press, 1987.

Title of the Course: Complex Analysis
Credit Hours: 3
Prerequisites: Analysis I

Specific Objectives of course: This is an introductory course in complex analysis, giving the basics of the theory along with applications, with an emphasis on applications of complex analysis and especially conformal mappings. Students should have a background in real analysis (as in the course Real Analysis I), including the ability to write a simple proof in an analysis context.

Course Outline:

Introduction: The algebra of complex numbers, Geometric representation of complex numbers, Powers and roots of complex numbers.

Functions of Complex Variables: Definition, limit and continuity, Branches of functions, Differentiable and analytic functions. The Cauchy-Riemann equations, Entire functions, Harmonic functions, Elementary functions: The exponential, Trigonometric, Hyperbolic, Logarithmic and Inverse elementary functions, Open mapping theorem. Maximum modulus theorem.

Complex Integrals: Contours and contour integrals, Cauchy-Goursat theorem, Cauchy integral formula, Lioville's theorem, Morerea's theorem.

Series: Power series, Radius of convergence and analyticity, Taylor's and Laurent's series, Integration and differentiation of power series.

Singularities, Poles and residues: Zero, singularities, Poles and

Residues, Types of singular points, Calculus of residues, contour integration, Cauchy's residue theorem with applications.
Mobius transforms, Conformal mappings and transformations.

Recommended Books:

1. R. V. Churchill, J. W. Brown, *Complex Variables and Applications ,* 5th edition, McGraw Hill, New York, 1989.
2. J. H. Mathews and R. W. Howell, *Complex Analysis for Mathematics and Engineering*, 2006.
3. S. Lang, *Complex Analysis*, Springer-Verlag, 1999.
4. R. Remmert, *Theory of Complex Functions*, Springer-Verlag, 1991.
5. W. Rudin, *Real and Complex Analysis*, McGraw-Hill, 1987.

Title of the Course: Functional Analysis
Credit Hours: 3
Prerequisites: Analysis I

Specific Objectives of course: This course extends methods of linear algebra and analysis to spaces of functions, in which the interaction between algebra and analysis allows powerful methods to be developed. The course will be mathematically sophisticated and will use ideas both from linear algebra and analysis.

Course Outline:
Metric Space: Review of metric spaces, Convergence in metric spaces, Complete metric spaces, Dense sets and separable spaces, No-where dense sets, Baire category theorem.
Normed Spaces: Normed linear spaces, Banach spaces, Equivalent norms, Linear operator, Finite dimensional normed spaces, Continuous and bounded linear operators, Dual spaces.
Inner Product Spaces: Definition and examples, Orthonormal sets and bases, Annihilators, projections, Linear functionals on Hilbert spaces. Reflexivity of Hilbert spaces.

Recommended Books:

1. A. V. Balakrishnan, *Applied Functional Analysis*, 2nd edition, Springer-Verlag, Berlin, 1981.
2. J. B. Conway, *A Course in Functional Analysis*, 2nd ed., Springer-Verlag,Berlin,1997.
3. K. Yosida, *Functional Analysis*, 5th ed., Springer-Verlag, Berlin, 1995.
4. E. Kreyszig, *Introduction to Functional Analysis with Applications*, John Wiley and Sons, 2004.

Title of the Course: Analysis II
Credit Hours: 3
Prerequisites: Analysis I

Specific Objectives of course: A continuation of Real Analysis I, this course will continue to cover the fundamentals of real analysis, concentrating on the Riemann-Stieltjes integrals, Functions of Bounded Variation, Improper Integrals, and convergence of series. Emphasis would be on proofs of main results.

Course Outline:
The Riemann-Stieltjes Integrals: Definition and existence of integrals. Properties of integrals. Fundamental theorem of calculus and its applications. Change of variable theorem. Integration by parts.
Functions of Bounded Variation: Definition and examples. Properties of functions of bounded variation.
Improper Integrals: Types of improper integrals, tests for convergence of improper integrals. Beta and gamma functions. Absolute and conditional convergence of improper integrals.
Sequences and Series of Functions: Power series, definition of point-wise and uniform convergence. Uniform convergence and continuity. Uniform convergence and differentiation. Examples of uniform convergence.

Recommended Books:

1. S. Lang, *Analysis I, II*, Addison-Wesley Publ. Co., Reading,Massachusetts,1968,1969.
2. W. Rudin, *Principles of Mathematical Analysis*, 3rd Ed., McGraw-Hill, 1976.
3. K. R. Davidson and A. P. Donsig, *Real Analysis with Real Applications*, Prentice Hall Inc., Upper Saddle River, 2002.
4. G. B. Folland, *Real Analysis*, 2nd Edition, John Wiley and Sons, New York, 1999.
5. E. Hewitt and K. Stromberg, *Real and Abstract Analysis*, Springer-Verlag, Berlin Heidelberg New York, 1965.
6. H. L. Royden, *Real Analysis*, 3rd Edition, Macmillan, New York, 1988.
7. G. Bartle , R. Sherbert , *Introduction to Real Analysis,* 3rd edition, John Wiley, New York, 1999.

Title of the Course: Numerical Analysis I
Credit Hours: 3+1
Prerequisites: Calculus I, Linear Algebra

Specific Objectives of course: This course is designed to teach the students about numerical methods and their theoretical bases. The course aims at inculcating in the students the skill to apply various

techniques in numerical analysis, understand and do calculations about errors that can occur in numerical methods and understand and be able to use the basics of matrix analysis.

Course Outline:

Error analysis: Floating point arithmetic, approximations and errors.

Methods for the solution of nonlinear equations: Bisection method, regula-falsi method, fixed point iteration method, Newton-Raphson method, secant method, error analysis for iterative methods.

Interpolation and polynomial approximation: Lagrange interpolation, Newton's divided difference formula, forward, backward and centered difference formulae, interpolation with a cubic spline, Hermite interpolation, least squares approximation.

Numerical differentiation: Forward, backward and central difference formulae, Richardson's extrapolation.

Numerical integration: Rectangular rule, trapezoidal rule, Simpson's 1/3 and 3/8 rules, Boole's and Weddle's rules, Newton-Cotes formulae, Gaussian quadrature.

Numerical solution of a system of linear equations: Direct methods: Gaussian elimination method, Gauss-Jordan method; matrix inversion; LU-factorization; Doolittle's, Crout's and Cholesky's methods, Iterative methods: Jacobi, Gauss-Seidel and SOR.

The use of software packages/programming languages for above mentioned topics is recommended.

Recommended Books:

1. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, Singapore, 2005.
2. R. L. Burden and J. D. Faires: Numerical Analysis, latest edition, PWS Pub. Co.
3. J.H. Mathews, Numerical Methods for Mathematics, latest Edition, Prentice Hall International.
4. S. C. Chapra and R. P. Canale: Numerical Methods for Engineers, 6th edition, McGraw Hill.
5. W. E. Boyce, R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, John Wiley \& Sons, Inc., 2001.
6. L. Debnath, Nonlinear Partial Differential Equations for Scientists and Engineers, Birkhauser-Boston, 2005.
7. Alexander Komech, Andrew Komech, Principles of Partial Differential Equations, Springer-New York, 2009.
8. H. Richard, Elementary Applied Partial Differential Equations, Prentice-Hall International, Inc., London 1987.
9. Weinberger, Hans F., A First Course in Partial Differential Equations with Complex Variables and Transform Methods, Dover Publications, Inc., 1995.
10. R. Kent Nagle, Edward B. Saff, Arthur David Snider, Fundamentals

of Differential Equations, Addison Wesley Longman, Inc., 2000.

Title of the Course: Number Theory
Credit Hours: 3
Prerequisites: Linear Algebra

Specific Objectives of course: The focus of the course is on study of the fundamental properties of integers and develops ability to prove basic theorems. The specific objectives include study of division algorithm, prime numbers and their distributions, Diophantine equations, and the theory of congruences.

Course Outline:
Preliminaries: Well-ordering principle. Principle of finite induction.
Divisibility theory: The division algorithms. Basis representation theorem. Prime and composite numbers. Canonical decomposition. The greatest common divisor. The Euclidean algorithm. The fundamental theorem of arithmetic. Least common multiple.
Linear Diophantine equations: Congruences. Linear congruences. System of linear congruences. The Chinese remainder theorem. Divisibility tests. Solving polynomial congruences. Fermat's and Euler's theorems. Wilson's theorem.
Arithmetic functions: Euler's phi-function. The functions of J and sigma. The Mobius function. The sieve of Eratosthenes. Perfect numbers. Fermat and Mersenne primes.
Primitive Roots and Indices: The order of an integer mod n. Primitive roots for primes. Composite numbers having primitive roots.
Quadratic residues: Legendre symbols and its properties. The quadratic reciprocity law.
Quadratic congruences with composite moduli. Pythagorean triples. Representing numbers as sum of two squares.

Recommended Books:

1. D.M. Burton, *Elementary Number Theory*, McGraw-Hill, 2007.
2. W.J. Leveque, *Topics in Number Theory*, vols. I and II, Addison- Wesley, 1956.
3. S.B. Malik , *Basic Number Theory*, Vikas Publishing house, 1995.
4. K.H. Rosen, *Elementary Number Theory and its Applications*, 5th edition, Addison-Wesley, 2005.
5. I. Niven, H.S. Zuckerman, H.L. Montgomery, *An Introduction to the theory of Numbers*, John Wiley and Sons, 1991.
6. A. Adler, J.E. Coury, *The Theory of Numbers*, Jones and Bartlett Publishers, 1995.

Title of the Course: Mathematical Methods
Credit Hours: 3
Prerequisites: Calculus III

Specific Objectives of course: The main objective of this course is to provide the students with a range of mathematical methods that are essential to the solution of advanced problems encountered in the fields of applied physics and engineering. In addition this course is intended to prepare the students with mathematical tools and techniques that are required in advanced courses offered in the applied physics and engineering programs.

Course Outline:
Fourier Methods: The Fourier transforms. Fourier analysis of the generalized functions. The Laplace transforms. Hankel transforms for the solution of PDEs and their application to boundary value problems.
Green's Functions and Transform Methods: Expansion for Green's functions. Transform methods. Closed form Green's functions.
Perturbation Techniques: Perturbation methods for algebraic equations. Perturbation methods for differential equations.
Variational Methods: Euler-Lagrange equations. Integrand involving one, two, three and n variables. Special cases of Euler-Lagrange's equations. Necessary conditions for existence of an extremum of a functional. Constrained maxima and minima.

Recommended Books:

1. D. L. Powers, *Boundary Value Problems and Partial Differential Equations*, 5th edition, Academic Press, 2005.
2. W. E. Boyce, *Elementary Differential Equations*, 8th edition, John Wiley and Sons, 2005.
3. M. L. Krasnov, G. I. Makarenko and A. I. Kiselev, *Problems and Exercises in the Calculus of Variations*, Imported Publications, Inc., 1985.
4. J. W. Brown and R. V. Churchil, Fourier Series and Boundary Value Problems, McGraw Hill, 2006.
5. A. D. Snider, *Partial Differential Equations: Sources and Solutions*, Prentice Hall Inc., 1999.

Title of the Course: Probability Theory
Credit Hours: 3
Prerequisites: Statistics

Specific Objectives of course: A prime objective of the course is to introduce the students to the fundamentals of probability theory and present techniques and basic results of the theory and illustrate these concepts with applications. This course will also present the basic principles of random variables and random processes needed in

applications.

Course Outline:

Finite probability spaces: Basic concept, probability and related frequency, combination of events, examples, Independence, Random variables, Expected value. Standard deviation and Chebyshev's inequality. Independence of random variables. Multiplicativity of the expected value. Additivity of the variance, Discrete probability distribution.

Probability as a continuous set function: sigma-algebras, examples. Continuous random variables, Expectation and variance. Normal random variables and continuous probability distribution.

Applications: de Moivre-Laplace limit theorem, weak and strong law of large numbers.

The central limit theorem, Markov chains and continuous Markov process.

Recommended Books:

1. M. Capinski, E. Kopp, *Measure, Integral and Probability*, Springer-Verlag, 1998.
2. R. M. Dudley, *Real Analysis and Probability*, Cambridge University Press, 2004.
3. S. I. Resnick, *A Probability Path*, Birkhauser, 1999.
4. S. Ross, *A first Course in Probability Theory*, 5th ed., Prentice Hall, 1998.
5. Robert B. Ash, *Basic Probability Theory*, Dover. B, 2008.

Title of the Course: Integral Equations
Credit Hours: 3
Prerequisites: Ordinary Differential Equations

Specific Objectives of course: Many physical problems that are usually solved by differential equation methods can be solved more effectively by integral equation methods. This course will help students gain insight into the application of advanced mathematics and guide them through derivation of appropriate integral equations governing the behavior of several standard physical problems.

Course Outline:

Linear integral equations of the first kind, Linear integral equations of the second kind. Relationship between differential equation and Volterra integral equation. Neumann series. Fredholm Integral equation of the second kind with separable Kernels. Eigenvalues and eigenvectors. Iterated functions. Quadrature methods. Least square methods. Homogeneous integral equations of the second kind. Fredholm integral equations of the first kind. Fredholm integral equations of the second kind. Abel's integral equations. Hilbert Schmidt theory of integral equations with symmetric Kernels.

Regularization and filtering techniques.

Recommended Books:

1. C. T. H. Baker, *Integral Equations*, Clarendon Press, 1977.
2. F. Smithies, *Integral Equations*, Cambridge University Press, 1989.
3. A. M. Wazwaz, *A first Course in Integral Equations*, World Scientific Pub., 1989.
4. W. V. Lovitt, *Linear Integral Equations*, Dover Publications, 2005.

MS (MATHEMATICS) PROGRAMME

The MS degree in Mathematics focuses on strengthening of the ability of a student in Mathematical reasoning and logical thinking. Students in this program prepare themselves either for their further development in the field of Mathematics or for jobs in academic, industrial, business and government organizations.

The program offers a flexible frame work including scheme of courses covering major areas of Mathematics like Algebra, Analysis, Topology, Computational Mathematics, Foundations of Mathematics and Financial Mathematics. An institution may design its own MS program within this frame work considering available resources, demand of students and approval by statutory bodies.

Admission Criterion

- The applicants must have completed 4-year BS (Mathematics) with CGPA 2.0 out of 4.0; or MA/M Sc in Mathematics with at least 2nd Division or equivalent grade.
- GAT-General conducted by the National Testing Service with a minimum cumulative score of 50% or GRE (International) Subject Test with 50 % percentile score or GAT subject test with 60 % marks will be required at the time of admission.

The Program

i) The student must complete 24 CH course work with CGPA $\geq$ 2.5.

ii) Having obtained CGPA $\geq$ 2.5 in course work, the MS student will complete a 6 credit hour thesis and will successfully defend it in order to qualify for the award of MS degree.

iii) Thesis evaluation and viva voce will be conducted by one external examiner (from a university in Pakistan other than university of enrollment) and one internal examiner.

Semester-Wise Breakdown

First year					
First Semester			Second Semester		
#	Course Title	Cr. Hr	#	Course Title	Cr. Hr.
1	Core-1	3	1	Optional-1	3
2	Core-2	3	2	Optional-2	3
3	Core-3	3	3	Optional-3	3
4	Core-4	3	4	Optional-4	3
Total		12			12

Second year	
MS Thesis	6 Credit Hours

The Committee suggested following core courses for the MS program. A university may add more courses to the list of core courses, keeping in view the available human resources, with approval of Board of Studies and other statutory bodies of the university.

Core Courses
Riemannian Geometry
Mathematical Techniques
Integral Equations
Functional Analysis
ODEs and Computational Linear Algebra
Partial Differential Equations
Group Theory
Advanced Mathematical Physics

Lists of optional courses are given below from domains of Pure Mathematics, Applied Mathematics and Computational Mathematics. These lists may be extended with consent of Board of Studies of Mathematics in the university.

Optional Courses

Pure Mathematics	Applied Mathematics	Computational Mathematics
Rings and Modules	General Relativity-I	Theory of Spline Functions I
Operator Theory	General Relativity-II	

Topological Groups	Cosmology	Theory of Spline Functions II
General Topology	Classical Field Theory	Theory of Spline Functions III
Banach Algebra	Electrodynamics-I	Graph Theory
Homotopy Theory	Electrodynamics-II	Mathematical Modeling I
Advanced Group Theory	Plasma Physics	Mathematical Modeling II
Topological Vector Spaces	Advanced course in Plasma Physics	Numerical Solutions of PDEs
Algebraic Number Theory	Quantum Field Theory	Design Theory
Field Extension and Galois Theory	Symmetry Methods for Differential Equations	Minimal Surfaces

More courses are given below for enriching lists given above subject to availability of faculty to teach these courses. Experts in the Department of Mathematics of a university may extend this list further. Consent of Board of Studies is advised.

More Courses

Combinatorics
Advanced Number Theory
Advanced Measure Theory
Harmonic analysis
Spectral Theory in Hilbert Spaces
BCK Algebra
BCI Algebra
Lattice Theory
Homology Theory
Lie Algebra & Lie Groups
Hilbert Space Methods
Optimization Theory
Perturbation Methods
Fixed point Theory and Application
Approximation Theory and application
Integral Inequalities
Time Series Analysis and Forecasting
Linear Statistical Models
Advanced Topics in Graph Theory
Geometric Function Theory
Advanced Convex Analysis
Representation Theory of Finite Groups
Fluid and Thermodynamics
Group Theoretic Methods
Advanced Analytical Dynamics

Numerical Methods for Variational Inequalities
Simple Linear Regression Models
Multiple Linear Regression Models
Category Theory
Pointless Topology
Sheaf Theory
Topos Theory
Topological Groups
Special Functions
Geometric Functions
Mathematical Biology
Symmetries and Exact solution of ODE
Symmetries and Exact solution of PDE
Operation Research
Simulation and Modeling
Fuzzy Logic and Neural Networks
Financial Modeling and Risk Management
Probability and Stochastic Processes
Monte Carlo Techniques for Simulations

COMPULSORY COURSES

1. English I
2. English II
3. Pakistan Studies
4. Islamic Studies/Ethics
5. Mathematics-I
6. Computer Application.
7. Mathematics-II / Biostatistics

DETAILS OF COURSES

(ENGLISH –I) Functional English

CREDIT Hours: (0+3)

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 Books:

1. Functional English

a) Grammar
   1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492
   2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. 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. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

d) Speaking

(ENGLISH –II) Communication Skills

Credit Hours: (0+3)

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 Books:

Communication Skills

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. 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 0 19 435406 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 0 19 453403 0.
2. Reading and Study Skills by John Langan
3. Study Skills by Richard Y

(Optional) ENGLISH-II

Technical Writing and Presentation Skills

Objectives: To enhance language skills and develop critical thinking

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

Progress report writing

Note: Extensive reading is required for vocabulary building

Recommended Books:

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. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. 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).

Pakistan Studies (Compulsory)

Credit Hours: (0+2)

(As Compulsory Subject for Degree Students)

Introduction / Objectives

Objectives

- To develop vision of Historical Perspective, Government, Politics, Contemporary Pakistan, ideological background of Pakistan.
- To study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline

1. **Historical Perspective**
   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-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

Recommended Books:

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: An 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, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson & 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.

ISLAMIC STUDIES (Compulsory)

Credit Hours: (0+2)

Objectives: To learn about Islam and its application in day to day life.

Content detail:

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

INTRODUCTION TO QURANIC STUDIES

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

STUDY OF SELECTED 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)

STUDY OF SELECTED 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)

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

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

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

SELECTED STUDY FROM TEXT OF HADITH

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

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

ISLAM & SCIENCE

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

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

POLITICAL SYSTEM OF ISLAM

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

ISLAMIC HISTORY

1) Period of Khlaft-e-Rashida
2) Period of Ummayyads
3) Period of Abbasids

SOCIAL SYSTEM OF ISLAM

1) Basic Concepts of Social System Of Islam
2) Elements of Family
3) Ethical values of Islam

REFERENCE BOOKS:

1) Hameed ullah Muhammad, "**Emergence of Islam**" , IRI, Isb.
2) Hameed ullah Muhammad, "**Muslim Conduct of State**"
3) Hameed ullah Muhammad, '**Introduction to Islam**
4) Mulana Muhammad Yousaf Islahi,"
5) Hussain Hamid Hassan, **"An Introduction to the Study of Islamic Law"** leaf Publication Islamabad, Pakistan.
6) Ahmad Hasan, **"Principles of Islamic Jurisprudence"** Islamic Research Institute, International Islamic University, Isb. (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"** Allama Iqbal Open University, Islamabad (2001).

MATHEMATICS - I

Credit hours: (0+3)

Objectives:

This is the first course of the basic sequence, Calculus I-III, serving as the foundation of advanced subjects in all areas of mathematics. The sequence, equally, emphasizes basic concepts and skills needed for mathematical manipulation. Calculus I & II focus on the study of functions of a single variable.

Course Detail:

- Limits and continuity.
- Derivative of a function and its applications.
- Optimization problems.
- Mean value theorem (Taylor's theorem and the infinite Taylor series with applications) & curve sketching; anti-derivative & integral.
- Definite integral and applications.
- The fundamental theorem of Calculus.

- Inverse functions (Chapters 1-6 of the text)

Recommended Books:

1. Anton H, *Calculus: A New Horizon* (6th edition), 1999. John Wiley, New York.
2. Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text)
3. Thomas G. B, Finney A. R., *Calculus* (10th edition), 2002. Addison-Wesley, Reading, Ma, U.S.A.
4. Anton, H., 1999. *Calculus: A New Horizon,* 6th Edition, John Wiley, New York.
5. Stewart J, 1995. *Calculus* ,3rd Edition, Brooks/Cole
6. Thomas, G. B. and Finney, A. R, 2002. *Calculus* 10th Edition, Addison-Wesley, Reading, Ma, U.S.A.

COMPUTER APPLICATIONS

CREDIT HOURS: (2 +1)

OBJECTIVES:

Courses Detail:

- Introduction to Computer and Window 98/2000.
- Word processing (Microsoft Word).
- Spread Sheets (Microsoft Excel) and other related software packages (at least two).
- Internet access and different data bases available on the internet.

BIO-STATISTICS

CREDIT HOURS: (3+0)

OBJECTIVES:

- It will help the students to analyze data pertaining to their research work
- To assess the significance of their experimental designs. Without statistical analysis research articles are not accepted for publication by the scientific journals.
- Students must have sound knowledge of the statistical programs.

Course Detail

- Introduction to Biostatistics and its scope in Microbiology.
- Collection of Primary and Secondary data.

- Editing of data.
- Presentation of data: Tabulation, Classification, Visual Presentation (Diagrams and Graphs).
- Measures of Central Tendency: Arithmetic Mean by direct and short-cut method, Geometric Mean, Harmonic Mean, Mode, Median, ED_{50} (LD_{50} in detail), Quantile.
- Measures of Dispersion: Range, Quartile Deviation, Mean Deviation, Standard Deviation by direct and short-cut method, Variance, and their Coefficient.
- Correlation: Simple Correlation Table, Rank Correlation, Partial and Multiple Correlation.
- Regression and method of least square.
- Probability: Concept of Probability, Laws of Probability.
- Permutation and Combination.
- Probability distributions: Binomial distribution, Poisson distribution and their fitting to observed data, Normal distribution.
- Sampling and Basic Design
- Hypothesis Testing.
- Chi-square test, Student's t-test, Analysis of variance.
- Laboratory Experiments pertaining to the course.

Recommended Books:

1. Stanton, A.G., 2001. Primer of Biostatistics. McGraw-Hill.
2. Jekel, J., Elmore, J.G., Katz, D.L., 2001. Epidimiology, biostatistics and preventive medicine. W. B. Saunders.
3. Quinn, G., 2002. Experimental Design and Data Analysis for Biologists. Cambridge University Press.
4. Fernholz L.T, Morgenlhaler, S., Stahel, W., 2000. Statistics in Genetics and in Environmental Sciences, Birkhauser Verlag.
5. Kuzma J. W. and Bohnenblust, S. E. 2001, Basis Statistics for the Health Sciences, McGraw-Hill International Education.

RECOMMENDATIONS OF THE NATIONAL CURRICULUM REVISION COMMITTEE FOR MATHEAMTICS

Meetings Held on October 22-24, 2012 and April 2-4, 2013

1) The committee observed that the employment agencies of the country are not very well versed in universal nomenclature of degrees and are tempted to prefer MSc (2-year degree after 14-year education) over BS (4-year degree after 12-year education). Same is the case with MPhil and MS; MPhil is preferred over MS. The committee recommended that HEC should take effective measures for creating awareness among public and private sector employers about nomenclatures like BS and MS and their equivalence with conventional degrees.

2) The committee recommended that every university should print the implemented Grade Points/Letter Grades scheme on the back of the transcripts.

3) HEC may constitute a forum of mathematicians for improving problem solving skills of school teachers. A school teacher may contact the forum (or a member of the forum) for solutions of problems faced by the teacher in classroom teaching.

4) HEC may launch a Mathematics journal of its own and should also promote journals published by Pakistani universities. The committee emphasized that mathematicians should contribute their quality research for journals published by Pakistani universities. It was remarked that Mathematics journals do not have as high impact factor in general as is the cases with other sciences because of abstract nature of the subject and limited readership.

5) Members also commented on role and responsibility of editors of a journal. Editing and reviewing is laborious task and carries a very heavy and subtle responsibility. Similar is the case with refereeing research articles in Mathematics. It was also observed that Mathematics journals in Pakistan do not manage to raise sufficient funds for paying to editors, reviewers and referees for their effort and contribution. The committee proposed that HEC may allocate sufficient funds for approved Pakistani journals in order to enable these journals to meet the reviewing and refereeing expenditure. This is very essential for improving the quality of Pakistani journals.

6) Role of professional societies is crucial in promoting research culture and addressing issues related with university life of mathematicians, members of the committee noted during discussion. There was consensus among the members that HEC can play catalytic role in establishing a society for mathematicians which can help bring mathematics teachers at one platform and create harmony. This society will also provide forum for conduct of conferences, seminars, symposia and even monitor quality of teaching of Mathematics in the country.