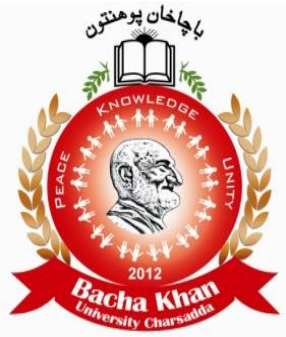
DEPARTMENT OF MATHEMATICS & STATISTICS
BACHA KHAN UNIVERSITY CHARSADDA
REVISED CURRICULUM FOR BS/AD IN MATHEMATICS & STATISTICS

Effective For BS/AD Mathematics & Statistics Program for the Student Admitted in Fall 2025 Semester and Onwards in the Department of Mathematics & Statistics Bacha Khan University Charsadda, and Affiliated Colleges.

Approved by:

9th Board of Studies of Department of Mathematics & Statistics,
12th Board of Faculty of Sciences,
15th Academic Council of BKUC
and
Final approval by 36th Syndicate of BKUC.



DEPARTMENT OF MATHEMATICS & STATISTICS
BACHA KHAN UNIVERSITY
CHARSADDA, PAKISTAN
2025

Controller of Examinations
Bacha Khan University
Charsadda

Chairman
Deptt. of Mathematics & Statistics
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Bacha Khan University Charsadda
Assistant Registrar
Academics

DEPARTMENT OF MATHEMATICS & STATISTICS
BACHA KHAN UNIVERSITY CHARSADDA

Department of Mathematics & Statistics
Bacha Khan University Charsadda
Website: www. bkuc.edu.pk

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Department of Mathematics & Statistics
Bacha Khan University, Charsadda

Brief Introduction

Department of Mathematics& Statistics Bacha Khan University, Charsadda (BKUC) started in September 2011, while it was a Campus of Abdul Wali Khan University, Mardan (AWKUM). Initially it was Department of Mathematics, but in 2016, it becomes The Department of Mathematics & Statistics. The Department offers BS (four years), M.Sc. (two years), M. Phil (two years) and PhD degree programs in Mathematics and intends to start the same programs in Statistics. These programs have been designed to produce better qualified and more competent manpower to meet the needs of the society in general, and to provide expertise in Mathematics, to solve problems in other areas such as Physics, Chemistry, Engineering, Economics, Defense, Industry etc. It has further been designed to motivate, create interest in Mathematics and thus help in creating a scientific culture in the country. Besides this the staff of the department teaches mathematics in almost all the disciplines of the university. Mathematics has been declared as a core subject for all levels in physical as well as social and management sciences by the HEC.

Mathematics has played and is playing a vital role in a rapidly changing world of science and technology. It has developed tremendously in the last century and these developments have further been accelerated by the use of information technology in every walk of life. This motivated to the discovery of varied new techniques in mathematics. Modern era of science and technology has proved that not only the natural sciences but the social and administrative sciences have also been developed to the extent that they too, need an input of mathematics.

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VISION

The Department of Mathematics & Statistics will offer courses and programs of study that will ensure that the student learner will be able to contribute to today's society. The students will obtain abilities to critically assess numerical and graphical information; learn to formulate strategies for solving problems; and acknowledge the importance of being intellectually curious throughout their adult lives. The Department, through its faculty, will continue to contribute to the body of knowledge of the discipline, whether in traditional research, applied research, or research in the teaching of Mathematics.

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MISSION

Mathematics develops computational skills, critical thinking, and problem solving skills. The theory, discipline, and techniques taught in Mathematics courses are especially important in today's society. The faculty of the Department of Mathematics & Statistics recognizes this and strives to ensure that the student learner obtains this knowledge. At the same time, the faculty contributes to the discipline by fundamental research in pure and applied Mathematics, Statistics, and Mathematics education.

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BS Mathematics

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BS MATHEMATICS SCHEME OF STUDIES

Eligibility Criteria

a) F.Sc. (Pre-Engineering)/F.Sc. Pre-Medical/FCS/DAE/FA (Statistics, Maths, Economics) or equivalent at least 2nd Division (45% Marks)

b) The students who have not studied Mathematics at intermediate level have to pass deficiency courses (non-credits) of Mathematics (06 credits hours) in the first two semesters.
   1. Pre-Calculus-I
   2. Pre-Calculus-II

Course Work:

Sr. No.	Course Work	No. of Courses	No. of Credit Hours
1	General Education Courses	13	32
2	Majors:		
	Major Discipline Courses	25	75
3	Interdisciplinary Courses	7	21
4	Understanding of Holy Quran-I & II	2	2
5	Internship	1	3
6	Capstone Project	1	3
Total No. of Courses/Internship/Capstone Project of the Program		49	
Total Credit Hours of the Program			136

Semester-wise break up

S. No	Course Code	Course Title	Credit Hours	Category
Semester-I				
1	MATH-311	Calculus-I	3(3+0)	Major
2		Arts and Humanities	2(2+0)	General Education
3	MATH-313	Quantitative Reasoning-I	3(3+0)	General Education
4		Natural Science	3(2+1)	General Education
5	Eng-311	Functional English	3(3+0)	General Education
6	CS-311	Applications of ICT	3(2+1)	General Education

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7	QUR-300	Understanding of Holy Quran-I	1(1+0)	General Education
8	MATH-314	Pre-Calculus-I	3(3+0)	Non-Credits
Semester Credit Hours			**18**	
Semester-II				
1	MATH-321	Calculus-II	3(3+0)	Major
2	MATH-322	Discrete Mathematics	3(3+0)	Major
3	MATH-326	Quantitative Reasoning-II	3(3+0)	General Education
4	ENG-321	Expository Writing	3(3+0)	General Education
5	PS-314	Pakistan Studies	2(2+0)	General Education
6	MATH-327	Introduction to Programming	3(2+1)	Interdisciplinary
7	QUR-301	Understanding of Holy Quran-II	1(1+0)	General Education
8	MATH-323	Pre-Calculus-II	3(3+0)	Non-Credits
Semester Credit Hours			**18**	
Semester-III				
1	MATH-411	Calculus-III	3(3+0)	Major
2	MATH-412	Linear Algebra-I	3(3+0)	Major
3	MATH-413	Group Theory-I	3(3+0)	Major
4	STAT-316	Probability & Statistics	3(3+0)	Interdisciplinary
5	PS-321	Ideology & Constitution of Pakistan	2(2+0)	General Education
6	IS-312	Islamic Studies/ Ethics for Non-Muslims	2(2+0)	General Education
7		Social Science	2(2+0)	General Education
Semester Credit Hours			**18**	
Semester-IV				
1	MATH-421	Number Theory	3(3+0)	Major
2	MATH-422	Numerical Methods	3(3+0)	Major
3	MATH-423	Data Structure & Algorithms	3(3+0)	Major
4	MATH-424	Ordinary Differential Equations	3(3+0)	Major
5	SOC-313	Civics and Community Engagement	2(2+0)	General Education
6	MGT-411	Entrepreneurship	2(2+0)	General Education
Semester Credit Hours			**16**	
Semester-V				
1	MATH-511	Real Analysis-I	3(3+0)	Major
2	MATH-512	Set Topology	3(3+0)	Major
3	MATH-513	Partial Differential Equations	3(3+0)	Major
4	CS-514	Advanced Programming	3(3+0)	Interdisciplinary
5	MATH-514	Introduction to Mechanics	3(3+0)	Interdisciplinary
Semester Credit Hours			**15**	

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Semester-VI				
1	MATH-521	Real Analysis-II	3(3+0)	Major
2	MATH-522	Complex Analysis	3(3+0)	Major
3	MATH-	Elective-I	3(3+0)	Major
4	AI-612	Machine Learning	3(2+1)	Interdisciplinary
5	PHY-214	Introduction to Classical Mechanics	3(3+0)	Interdisciplinary
6	MATH-523	Internship	3(3+0)	
Semester Credit Hours			**18**	
Semester-VII				
1	MATH-611	Differential Geometry	3(3+0)	Major
2	MATH-612	Mathematical Methods	3(3+0)	Major
3	MATH-	Elective-II	3(3+0)	Major
4	MATH-	Elective-III	3(3+0)	Major
5	MATH-	Elective-IV	3(3+0)	Major
6	MATH-613	Scientific Writing & Research Methods	3(3+0)	Interdisciplinary
Semester Credit Hours			**18**	
Semester-VIII				
1	MATH-	Elective-V	3(3+0)	Major
2	MATH-	Elective-VI	3(3+0)	Major
3	MATH-	Elective-VII	3(3+0)	Major
4	MATH-	Elective-VIII	3(3+0)	Major
5	MATH-699	Capstone Project	3(3+0)	
Semester Credit Hours			**15**	
Total Credit Hours				**136**

Arts and Humanities (any one course from the following list)

Sr. No.	Course Code	Course Title	Credit Hours
1	IS-320	Arabic Language	2(2+0)
2	PASH-324	Pashto Language: Introduction and Development	2(2+0)
3	PHIL-311	Introduction to Philosophy	2(2+0)
4	IS-323	History of Islamic Culture and Civilization	2(2+0)

Natural Sciences (any one course from the following list)

Sr. No.	Course Code	Course Title	Credit Hours
1	PHY-313	Physics-I	3(2+1)
2	CHEM-310	Chemistry-I	3(2+1)
3	GEOL-311	Fundamental of Geology	3(2+1)

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Social Sciences (any one course from the following list)

Sr. No.	Course Code	Course Title	Credit Hours
1	EC-414	Introduction to Economics	2(2+0)
2	SOC-315	Introduction to Sociology	2(2+0)
3	POL-314	Introduction to Political Science	2(2+0)
4	PSY-311	Fundamentals of Psychology	2(2+0)

****The list of elective courses is given below:***

Sr. No.	Course Code	Course Title	Credit Hours
1	MATH-631	Measure Theory	3(3+0)
2	MATH-632	Rings and Modules	3(3+0)
3	MATH-633	Group Action	3(3+0)
4	MATH-634	Group Theory-II	3(3+0)
5	MATH-635	Graph Theory	3(3+0)
6	MATH-636	Galois Theory	3(3+0)
7	MATH-637	Fluid Mechanics	3(3+0)
8	MATH-638	Mathematical Modelling	3(3+0)
9	MATH-639	Integral Equations	3(3+0)
10	MATH-640	Ring Theory	3(3+0)
11	MATH-641	Introduction to Algebraic geometry	3(3+0)
12	MATH-642	Continuous Groups	3(3+0)
13	MATH-643	Introduction to Combinotorics	3(3+0)
14	MATH-644	Introductions to Algebraic Systems	3(3+0)
15	MATH-645	Dynamics	3(3+0)
16	MATH-646	Special Functions	3(3+0)
17	MATH-647	Quantum Mechanics	3(3+0)
18	MATH-648	Mathematical Biology	3(3+0)
19	MATH-649	Ring and Fields	3(3+0)
20	MATH-650	Operation Research	3(3+0)
21	MATH-651	Functional Analysis-I	3(3+0)
23	MATH-652	Functional Analysis-II	3(3+0)
24	MATH-653	Linear Algebra-II	3(3+0)
25	MATH-654	Numerical Analysis	3(3+0)
26	MATH-655	Optimization Theory	3(3+0)
27	MATH-656	History of Mathematics	3(3+0)
28	MATH-657	Introduction to Fractional Differential Equations	3(3+0)
29	MATH-658	Vector and Tensor Analysis	3(3+0)

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30	MATH-659	Dynamical Systems	3(3+0)

Course Outline: for BS Mathematics

S. No	Course Code	Course Title	Credit Hours	Category
Semester-I				
1	MATH-311	Calculus-I	3(3+0)	Major
2	MATH-313	Quantitative Reasoning-I	3(3+0)	General Education
3		Arts and Humanities	2(2+0)	General Education
4		Natural Science	3(2+1)	General Education
5	Eng-311	Functional English	3(3+0)	General Education
6	CS-311	Applications of ICT	3(2+1)	General Education
7	QUR-300	Understanding of Holy Quran-I	1(1+0)	
8	MATH-314	Pre-Calculus-I	3(3+0)	Non-Credits
Semester Credit Hours			**18**	

MATH-311 Calculus-I **Credit Hours: 3(3+0)**

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 ofa polynomial, rational roots; Viete Relations. Descartes rule of signs. Solutions of equations with absolute value sign. Solution of linear and on-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.

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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.
9. Calculus by James Stewart

Course Code: MATH-313 Quantitative Reasoning-I Credit Hours: 3(3+0)

Course Objectives: This course aims to develop the basic mathematical skills which ultimately enhance problem solving skills using inductive and deductive reasoning, Polya's strategy, and sets. The basic concepts will be develop with applications form the real world such as algebraic models with equations, rates, ratios, and percentages will be discussed. Students will also explore linear models, including rectangular-coordinates, functions, empowering them to analyze real-world problems with logical precision. By the course's end, students will have honed problem-solving, logical reasoning, and mathematical modeling abilities to tackle diverse challenges confidently.

Course Outline:

1. Numerical Literacy: Number system and basic arithmetic operations, Units and their conversions, dimension, area, perimeter and volume**,** Rates, ratios, proportions and percentage Types and sources of data**,** Measurements scales**,** Tabular and graphical presentation of data**,** Quantitative reasoning exercise using number knowledge

2. Fundamental Mathematical Concepts: Basic of geometry (lines, angles, circles, polygons etc.)**,** Sets and their operations**,** Relation, function and their graphs**,** Exponents, factoring and simplyfing

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algebraic expressions**,** Algebraic and graphical solutions of linear and quadratic equation and inequalities**,** Quantitative reasoning exercises using fundamental mathematical concepts.

3. Fundamental Statistical Concepts: Population and sample**,** Measures of central tendency, dispersion and data interpretation**,** Rules of counting (multiplicative, permutation and combination)**,** Basic probability theory**,** Introduction to random variables and their probability distributions**,** Quantitative reasoning exercises using fundamental statistical concepts.

Recommended Books:

1. "Quantitative Reasoning: Tools for Today's Informed Citizen" by Bernard L. Madison, Lynn and Arthur Steen.
2. "Quantitative Reasoning for the Information Age" by Bernard L. Madison and David M. Bressoud.
3. "Fundamentals of Mathematics" by Wade Ellis.
4. "Quantitative Reasoning: Thinking in Numbers" by Eric Zaslow.
5. "Thinking Clearly with Data: A Guide to Quantitative Reasoning and Analysis" by Ethan Bueno de Mesquita and Anthony Fowler.
6. "Using and Understanding Mathematics: A Quantitative Reasoning Approach" by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
7. "Discrete Mathematics and its Applications" by Kenneth H. Rosen.
8. "Statistics for Technology: A Course in Applied Statistics" by Chatfield, C.
9. "Statistics: Unlocking the Power of Data" by Robin H. Lock, Patti Frazer Lock, Kari Lock Morgan, and Eric F. Lock.

PASH-423 Pashto Language: Introduction and Development Credit Hours: 2(2+0)

پښتو ژبه: پېژندګلو او پرمختګ

Pashto Language: Introduction and Development

Objectives	1. دا کورس د پښتو زده کونکيو تر څنګ د نورو څانګو د پاره مه دے څکه پکښې د پښتو تعارف په لږ کښې ابتدايي مواد شامل دي چې دوي د پښتو د ابتدايي نقوشو نه خبر شي 2. زده کونکي د پښتو د ليک دود سره اشنا کول 3. زده کونکي د پښتو ژبې او قام په اساسي نظرياتو خبرول 4. زده کونکي د پښتو ادب او پښتو نومورو شاعرانو د ژوند او شاعری نه خبرول
Course Outline:	• املاء او رسم الخط کښې فرق • د رسم الخط مختلف قسمونو بيان • د پښتو املاء ارتقاء • پښتو املاء کښې روښانې اختراعات • پښتو املاء ته د خوشحال خان خټک بخښنې • د باړه ګلی سيمنارونه او پښتو املاء • د پښتو د املاء او رسم الخط په لږ کښې انفرادي کوششونه • د پښتو ژبې په اړه بېلابېلې نظريې

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(سامي النسل نظريه ـ اريايي نظريه ـــ پښتانه بني اسرائيل دي؟ ـــ پښتانه اريا دي؟) • د نومورو پښتو شاعرانو د ژوند احوال: (خوشحال خان خټک ـــ رحمان بابا ـــ حميد بابا ـــ کاظم خان شېدا ـــ حمزه بابا ـــ غني خان ـــ اجمل خټک ـــ قلندرمومند) • د لاندينو شاعرانو د ورکړو شوو غزلونو تشريحات: ○ توره چې تېريوي خو گزار لره کنه خوشحال خان خټک ○ په شه خوي له بد خواهانو بې پروا يم رحمان بابا ○ د ستا د شونډو په څېر کله دي د گل رنگ حميد بابا ○ د يارانو د هجران له جور و جرمه علي خان ○ ستا غمونه به ختمېږي هم که نه حمزه بابا ○ پوهه مي او زده کړه مي د مينې له آئينه ده ډاکټر محمد اعظم اعظم • د لاندينو افسانه نگارانو د لاندينو دوو افسانو فني او فکري جايزه ○ قلندر مومند: گجري ○ زيتون بانو: ژوندي غمونه	

مجوزه کتابونه:

1. ليکوالي املا او انشاء ، از گل باچا الفت
2. د خيرالبيان ليک دود ، مشموله خېرالبيان،کابل چاپ،پوهاند عبدالشکور رشاد ، مخ ۵۵ تا ۸۰ پورې
3. پښتو ليک دود ، از پرېشان خټک
4. پښتو املاء ، پروفېسر ډاکټر راج ولي شاه خټک
5. پښتو ليک دود ، از خان شهيد عندالصمدخان
6. معياري پښتو ، ډاکټر عبدالرزاق پالوال
7. پښتو ليک دود ـــــــــــــــــــــــــــ ډاکټر نصرالله جان ـــــــــــ پښتو اکېډيمي
8. ساهو پښتو ـــــــــــــــــــــــــــــــــــــــ مشتاق مجروح
9. پښتانه ليکوال ـــــــ همېش خليل
10. د ياد شوو شاعرانو د شاعرۍ دواوين/شعري ټولگي
11. گجري ـــــــــــــــــــــــــــــــــــــــ قلندر مومند
12. ژوندي غمونه ـــــــــــــــــــــــــــــــــــ زيتون بانو

IS-320 Arabic Language **Credit Hours: 2(2+0)**

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Objectives of the Course	ا۔ طلباء کو عربی زبان کی اہمیت سے آگاہ کرنا۔ ب۔ طلباء کو علم صرف اور نحو کے بنیادی قواعد سے آگاہ کرنا تاکہ اسلامی علوم سے کماحقہ استفادہ کیا جاسکے۔ ت۔ طلباء کو علم صرف کے بنیادی اصولوں سے آگاہ کرنا۔

Course Description

S.No	Topic	Description
1.	عربی زبان کا تعارف و اہمیت	ا۔ عربی زبان کا آغاز اور ارتقاء۔ ب۔ عربی زبان کی اہمیت اور علوم اسلامیہ کے فہم میں عربی زبان کا کردار۔
2.	مفرد کی تعریف اقسام اور علامات	الف۔ مفرد، اسم، فعل اور حرف کی تعریف اور اقسام ب۔ اسم، فعل اور حرف کی علامات
3.	مرکب، اسم معرفہ	الف۔ مرکب کی تعریف اور اس کے اقسام ب۔ اسم معرفہ اور نکرہ کی تعریف اور اقسام
4.	ماضی اور مضارع	۔ فعل ماضی اور مضارع کا تعارف اقسام اور گردانیں ت۔ فعل ماضی اور مضارع کے بنیادی صرفی قواعد۔
5.	فعل امر و نہی	ا۔ فعل امر و نہی کا تعارف، اقسام اور گردانیں۔ ب۔ فعل امر و نہی کے بنیادی صرفی قواعد۔
6.	اسماء۔1	ا۔ اسم فاعل کا تعارف اور صرفی قواعد۔ ب۔ اسم مفعول کا تعارف اور صرفی قواعد۔
7.	اسماء۔2	ا۔ اسم تفضیل اور اسم آلہ کا تعارف اور صرفی قواعد۔ ب۔ اسم ظرف (زمان و مکان) کا تعارف اور صرفی قواعد۔
8.	اسماء۔3	ا۔ اسم اشارہ (قریب اور بعید)۔ ب۔ اسم موصول اور جملہ موصولہ کا تعارف۔
9.	معرب و مبنی	ا۔ اسم معرب کا تعارف اور اس کی اقسام۔ ب۔ اسماء مبنی کا تعارف اور ان کی اقسام۔
10.	حروف	ا۔ حرف نداء اور حروف جوازم مضارع۔ ب۔ حروف نواصب مضارع۔
11.	ثلاثی مجرد	ا۔ فعل ثلاثی مجرد کا تعارف۔ ب۔ فعل ثلاثی مجرد کے ابواب۔
12.	ثلاثی مزید فیہ (۱)	ا۔ فعل ثلاثی مزید فیہ کا تعارف۔ ب۔ فعل ثلاثی مزید فیہ کے ابواب۔
13.	ثلاثی مزید فیہ (۲)	ا۔ ثلاثی مزید فیہ کے ابواب کا تفصیلی مطالعہ۔
14.	ہفت اقسام (۱)	ا۔ صحیح اور مثال (واوی۔یائی) ب۔ مضاعف اور لفیف (مفروق اور مقرون)

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15.	ہفت اقسام(ب)	ا۔ناقص(واوی۔یائی) ب۔مہموز(الفاءوالدین واللام)اوراجوف۔
16.	ضمائر،اسم تصغیراور اسم منسوب	الف۔ضمائر تعریف اور کی اقسام ب۔اسم تصغیراور منسوب

نصابی کتب

نمبر شمار	نام مصنف	نام کتاب
1.	عبدالستار	عربی کا معلم۔(چاروں حصّے)
2.	معیناللہ ندوی۔	۔تمرین صرف
3.	محمد مصطفیٰ ندوی۔	۔تمرین نحوا
4.	مولانا عبدالماجد ندوی۔	۔معلم الانشاء
5.	مولانا مختار احمد۔	۔مختار النحو

حوالہ جاتی کتب

نمبر شمار	نام مصنف	نام کتاب
1.	علی جارم۔	النحوالواضح
2.	نعیم الرحمن۔	اساس عربی
3.	رشید الشرطوتی۔	۔مبادی العربیہ فی الصرف النحو
4.	عبدالرحمن امر تسری۔	۔کتاب النحو
5.	محمد مصطفیٰ ندوی۔	۔تمرین النحو
6.	عبدالرحمن طاہر۔	۔قواعد القرآن
7.	جامعۃ الملک السعود،ریاض۔	۔اللغۃ العربیۃ لغیر الناطقین بھا
8.	ڈاکٹر ابراہیم سورتی۔	۔قرانی عربیک

PHIL-311 Introduction to Philosophy Credit Hours: 2(2+0)

Course Objectives:

- Understanding basic concepts of philosophy in the fields of metaphysics, axiology, and epistemology.
- Understanding of philosophical terms.

Course Outline::

- A review of the history of philosophy.
- A discussion on the major problems and methods of philosophy.
- Plato
- Aristotle

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- Renaissance Philosophers Machiavelli
- Hobbes, Spinoza, Leibniz, Locke, Berkeley, Hume, Kant.
- Idealists: Fichte, Schelling, Schiller, Hegel.
- Utilitarian Philosophers: Jeremy Bentham, J.S. Mill.
- Romantic Reactionaries: Rousseau, Schopenhauer, Kierkegaard.
- Materialist Philosophers: Feuerbach, Marx.
- The Irrational Philosophers: Bergson, Freud.
- Phenomenologists and Existentialists: Husserl, Heidegger, Sartre, Camus, Fanon.
- Marxist Philosophers:Lukacs, Gramsci, Croce, Althusser.
- Linguists, Semiotician, Structuralist, and Deconstructionists: Saussure, Levi-Strauss, Lacan, Barthe, Foucault, Derrida.

Recommended Books:

1. Adorno, T.W., Aesthetic Theory. Tr. By C. Lenhardt. London: Routledge & Kegan Paul, 1984 2. Ahmad, Absar, Concept of Self and Self-Identity in Contemporary Philosophy. Lahore: Iqbal Academy, 1986
3. Aldrich, Virgil. Philosophy of Art, New Jersey: Prentice Hall, 1963
4. Anne, Bruce, Metaphysics: The Elements. Oxford: Basil Blackwell, 1986

IS-323 History of Islamic Culture and Civilization Credit Hours: 2(2+0)

Course Outline:

S.No.	Title	Description
.1	تہذیب وتمدن اور ثقافت کا تعارف۔I	ا۔ تہذیب وتمدن کا مفہوم ۲۔ ثقافت کا مفہوم
.2	تہذیب وتمدن کا تعارف۔II	ا۔ تہذیب وتمدن کی بنیاد ۲۔ تہذیب وتمدن کے ارکان اور اہمیت
.3	دور نبوی سے قبل اہم تہذیبیں۔I	ا۔ قبل از اسلام کی جاہلی تہذیب ۲۔ یونانی ورومی تہذیب
.4	دور نبوی سے قبل اہم تہذیبیں۔II	ا۔ مصری تہذیب ۲۔ ہندوستانی تہذیب
.5	اسلامی تہذیب کے اصول ومبادئ	ا۔ اسلامی تہذیب کی بنیادیں

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۲۔اسلامی تہذیب کے عناصر وارکان		
ا۔عہد نبوی ﷺ وخلافت راشدہ میں اسلامی تہذیب کے ارتقاء کے اسباب ۲۔خلافت راشدہ میں اسلامی تہذیب کے مظاہر	عہد نبوی ودور خلافت راشدہ میں اسلامی تہذیب	.6
ا۔دور بنوامیہ کا تعارف ۲۔دور بنوامیہ میں علمی ترقی اور علمی مراکز	دور بنوامیہ میں اسلامی تہذیب۔I	.7
ا۔دور بنوامیہ کے تہذیبی ترقی کے اسباب ۲۔دور بنوامیہ کی تہذیبی ترقی کے نتائج	دور بنوامیہ میں اسلامی تہذیب۔II	.8
ا۔دور بنوامیہ کی معاشرتی ترقی ۲۔دور بنوامیہ کی معاشی ترقی	دور بنوامیہ میں اسلامی تہذیب۔III	.9
ا۔عباسی تہذیب کا آغاز ۲۔دور عباسی کی علمی تحریکیں اور علمی مراکز	دور بنوعباس میں اسلامی تہذیب۔I	.10
ا۔دور بنوعباس میں تہذیبی ترقی ۲۔دور بنوعباس میں معاشرتی ترقی	دور بنوعباس میں اسلامی تہذیب۔II	.11
ا۔دور بنوعباس میں اسلامی تہذیب کا دوسری تہذیبوں سے مکالمہ ۲۔عباسیوں کے زوال کے اسباب اور اس کے اسلامی تہذیب پر اثرات	دور بنوعباس میں اسلامی تہذیب۔III	.12
ا۔صلیبی جنگیں اور تاتاری حملے ا۔صلیبی جنگوں اور تاتاری حملوں کے اسلامی تہذیب کے اثرات	دور بنوعباس میں اسلامی تہذیب۔IV	.13
ا۔اسپین میں اسلامی تہذیب کی اشاعت کے اسباب ۲۔اسپین میں اسلامی تہذیب کے مظاہر اور یورپی تہذیب پر اثرات	اسپین میں اسلامی تہذیب	.14
ا۔برصغیر پاک وہند میں اسلامی تہذیب کا ارتقاء ۲۔برصغیر پاک وہند میں اسلامی تہذیبی کارنامے	برصغیر پاک وہند میں اسلامی تہذیب وتمدن۔I	.15
ا۔برصغیر پاک وہند میں اسلامی تہذیب کی اشاعت کے اسباب ۲۔برصغیر پاک وہند میں اسلامی تہذیب کی اشاعت کے اثرات دوسری تہذیبوں پر	برصغیر پاک وہند میں اسلامی تہذیب وتمدن۔II	.16

نصابی کتب

نمبر	نام مصنف	نام کتاب
1	شاہ معین الدین ندوی	تاریخ تمدن اسلامی

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2	اکبر شاہ نجیب آبادی	تاریخ اسلام
3	حسن ابراہیم حسن	تاریخ الاسلام السیاسی
4	ابن کثیر	البدایۃ النھایۃ
5	مصطفی سباعی	اسلامی تہذیب کے درخشاں پہلو

حوالہ جاتی کتب

نمبر	نام مصنف	نام کتاب
1	ابن اثیر	الکامل
2	ڈاکٹر یسین مظہر صدیقی	تاریخ تہذیب اسلامی (چاروں حصے)
3	ثروت صولت	ملت اسلامیہ کی مختصر تاریخ
4	H.W Hazard	An Atlas of Islamic History
5	S.F.Mehmood	A Short History of Islam

PHY-313 Physics-I Credit Hours: 3(3+0)

Course Objectives: The main objectives of this course are: to provide students with a thorough understanding of the basic concepts of physics and the methods scientists use to explore natural phenomena, including observation, hypothesis development, measurement and data collection, experimentation, evaluation of evidence, and employment of mathematical analysis. To instruct students of the fundamental laws of physics and the application of scientific data, concepts, and models for use in the natural sciences and real world situations. To provide students with problem solving skills by an approach that describes physical phenomena with relevant mathematical models and formulae.

Course Outline:

Vector: Vector notation, vector addition, vectors in the Cartesian coordinate system, scalar product (of two vectors) vector product (of two vectors), scalar of triple product, vector triple product, gradient of a scalar, divergence of a vector, divergence theorem and Stock's theorem; conservation of energy: concept of conservation laws, conservation of energy, worked and kinetic energy, power, conservation forces, rotational energy, potential energy in an electric and gravitational field; dynamics of rigid bodies, center of mass, conservation of angular momentum, equation of motion of rotating body, moment of inertia, perpendicular axes and parallel axis theorems; calculation of moment of inertia for a disc and solid sphere; Euler's theorem, Gyroscope coriolis forces; Inverse Square Law of forces: Newton laws, forces, Newton law of Universal Gravitation b/w point mass and solid spheres, Kepler's laws, satellite in circular orbit escape velocity.

Recommended Books

1. Fundamental of Physics by Jearl Walker, Holiday & Resnick, 10th Edition, Wiley

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2. Physics I Practice Problems For Dummies (+ Free Online Practice) by Consumer Dummies. 2015. ISBN 978-1-188-85327-6.
3. Physics I: For BPUT by Dr. Mani Naidu. Pearson Education India, 2011. ISBN813179878X, 9788131798782.

CHEM-310 Chemistry-I Credit Hours: 3(2+1)

Course Objectives:

- Students will acquire knowledge about the key introductory concepts of chemical bonding, acid-base chemistry and chemical equilibrium.

Course Outline::

- **Chemical Bonding**
  Types of chemical bonding, ionic and covalent bonding, localized bond approach, theories of chemical bonding, valence bond theory (VBT), hybridization and resonance, prediction of molecular shapes using Valence Shell Electron Pair Repulsion (VSEPR) theory, molecular orbital theory (MOT) applied to diatomic molecules, delocalized approach to bonding, bonding in electron deficient compounds, hydrogen bonding.
- **Acids and Bases**
  Brief concepts of chemical equilibrium, acids and bases including soft and hard acids and bases (SHAB), concept of relative strength of acids and bases, significance of pH, pKa, pKb and buffer solutions, theory of indicators, solubility, solubility product, common ion effect and their industrial applications.
- **Chemical Equilibrium**
  General equilibrium expressions, reaction quotients, examples of equilibrium reactions in solid, liquid and gas phases, extent of reactions and equilibrium constants, Gibbs energies of formation and calculations of equilibrium constants, effect of temperature and pressure on the equilibrium constant, Van't Hoff equation, Le-Chatelier's principle.

➢ **Practical Chemistry-I**

- Volumetric Titration Calculations.
- Use of pH meter.
- Use of conductivity meter.

Recommended Books:

1. Cotton, F. A.; Wilkinson, G. Basic Inorganic Chemistry, 3rd ed., Wiley, New York, **1995.**
2. Atkins, P. and Paula, J. D., Atkin's Physical Chemistry, 9th ed., Oxford University Press, **2010**.
3. Miessler, G. L.; Tarr, D.A., Inorganic Chemistry, Prentice-Hall International, New Jersey, USA, **1991**.

GEOL-311 Fundamental of Geology Credit Hours: 3(2+1)

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Course Objectives: This course is designed to acquire knowledge about the basic concepts of geology. This will help the students to get knowledge about various types of rocks and minerals and the processes of their formation.

Course Outline:

Introduction and scope of geology; importance and relationship with other sciences; history and philosophy of geology; Earth as a member of the solar system; its origin, age, composition and internal structure; introduction to plate tectonics, Isostasy; mountain building processes; earthquakes and volcanoes; weathering and erosion; introduction, identification and classification of rocks and minerals; sedimentary, igneous and metamorphic structures; introduction to fossils in sedimentary rocks; introduction to folds, faults, joints, cleavage, foliation, lineation and unconformities; Geological Time Scale; Law of Superposition, present is key to the past and Law of Faunal Succession; concept and techniques of geological dating, relative and absolute dating; evolution of life on earth; use of Brunton Compass and GPS, etc.

Recommended Books

1. Physical Geology (16th Edition) by Plummer et al, 2019.
2. Geology in the Field by Compton R R, 2017.
3. Geology of the Himalayan Belt: Deformation, Metamorphism, by Chakrabati B K 2016.
4. Laboratory Manual in Physical Geology (9th Edition), Richard M. Busch, 2011, American Geological Institute, Pearson Education。
5. Fundamentals of Geology by Ashit Baran Roy. Alpha Science International Limited, 2010. ISBN 1842656228, 9781842656228.
6. Lab Manual for Physical Geology by Jones, Norris. W., Johns and Charles E., 2005, McGraw-Hill.
7. Communicating rocks: Writing, speaking, and thinking about Geology by Copeland, 2012.

ENG-311 Functional English Credit Hours: 3(3+0)

Course Objectives: To enable students to understand basics of English grammar. To teach them the use of grammar. To acquaint them with cohesive devices and their functions in the text.

Course Outline:

1. **Foundations of Functional English:**
   - Vocabulary building (contextual usage, synonyms, antonyms and idiomatic expressions)
   - Communicative grammar (subject-verb-agreement, verb tenses, fragments, run-ons, modifiers, articles, word classes, etc.)
   - Word formation (affixation, compounding, clipping, back formation, etc.)
   - Sentence structure (simple, compound, complex and compound-complex)
   - Sound production and pronunciation
2. **Comprehension and Analysis:**
   - Understanding purpose, audience and context
   - Contextual interpretation (tones, biases, stereotypes, assumptions, inferences, etc.)
   - Reading strategies (skimming, scanning, SQ4R, critical reading, etc.)
   - Active listening (overcoming listening barriers, focused listening, etc.)
3. **Effective Communication:**
   - Principles of communication (clarity, coherence, conciseness, courteousness, correctness, etc.)
   - Structuring documents (introduction, body, conclusion and formatting)

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- Inclusivity in communication (gender-neutral language, stereotypes, cross-cultural communication, etc.)
- Public speaking (overcoming stage fright, voice modulation and body language)
- Presentation skills (organization content, visual aids and engaging the audience)
- Informal communication (small talk, networking and conversational skills)
- Professional writing (business e-mails, memos, reports, formal letters, etc.)

Recommended Books:

1. "Understanding and Using English Grammar" by Betty Schrampfer Azar.
2. "English Grammar in Use" by Raymond Murphy.
3. "The Blue Book of Grammar and Punctuation" by Jane Straus.
4. "English for Specific Purposes: A Learning-Centered Approach" by Tom Hutchinson and Alan Waters.
5. "Cambridge English for Job-hunting" by Colm Downes.
6. "Practical English Usage" by Michael Swan.
7. "Reading Literature and Writing Argument" by Missy James and Alan P. Merickel.
8. "Improving Reading: Strategies, Resources, and Common Core Connections" by Jerry Johns and Susan Lenski.
9. "Comprehension: A Paradigm for Cognition" by Walter Kintsch.
10. "Communication Skills for Business Professionals" by J.P. Verma and Meenakshi Raman.

CS-311 Applications of ICT **Credit Hours: 3(2+1)**

Course Content:

1. Introduction to Information and Communication Technologies:
   - Components of Information and Communication Technologies (basics of hardware. software, ICT platforms, networks, local and cloud data storage etc.).
   - Scope of Information and Communication Technologies (use of ICT in education, business, governance, healthcare, digital media and entertainment, etc.).
   - Emerging technologies and future trends.
2. Basic ICT Productivity Tools:
   - Effective use of popular search engines (e.g., Google, Bing, etc.) to explore World Wide Web.
   - Formal communication tools and etiquettes (Gmail, Microsoft Outlook, etc.).
   - Microsoft Office Suites (Word, Excel, PowerPoint).
   - Google Workspace (Google Docs, Sheets, Slides).
   - Dropbox (Cloud storage and file sharing), Google Drive (Cloud storage with Google Docs integration) and Microsoft OneDrive (Cloud storage with Microsoft Office integration).

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- Evernote (Note-taking and organization applications) and OneNote (Microsoft's digital notebook for capturing and organizing ideas).
- Video conferencing (Google Meet, Microsoft Teams, Zoom, etc.).
- Social media applications (Linkedln, Facebook, Instagram, etc.).

3. ICT in Education:
   - Working with learning management systems (Moodle, Canvas, Google Classrooms, etc.).
   - Sources of online education courses (Coursera, edX, Udemy, Khan Academy, etc.).
   - Interactive multimedia and virtual classrooms.
   - ICT in Health and Well-being:
   - Health and fitness tracking devices and applications (Google Fit, Samsung Health, Apple Health, Xiaomi Mi Band, Runkccpcr, etc.).
   - Telemedicine and online health consultations (OLADOC, Sehat Kahani, Marham, etc.).
4. ICT in Personal Financial and Shopping:
   - Online banking and financial management tools (JazzCash, Easypaisa, Zong PayMax, I LINK and MNET, Keenu Wallet, etc.).
   - E-commerce platforms (Daraz.pk, Telcmart, Shophivc, etc.)
   - Digital Citizenship and Online Etiquette:
   - Digital identity and online reputation.
   - Netiquette and respectful online communication.
   - Cyberbullying and online harassment.
5. Ethical Considerations in Use of ICT Platforms and Tools:
   - Intellectual property and copyright issues.
   - Ensuring originality in content creation by avoiding plagiarism and unauthorized use of information sources.
   - Content accuracy and integrity (ensuring that the content shared through ICT platforms is free from misinformation, fake news, and manipulation)

Recommended Books:

1. Discovering Computers" by Vermaat, Shaffer, and Freund.
2. "GO! with Microsoft Office" Series by Gaskin, Vargas, and McLellan.
3. "Exploring Microsoft Office" Series by Grauer and Poatsy.
4. "Computing Essentials" by Morley and Parker. "Technology in Action" by Evans, Martin, and Poatsy.

QUR-300 Understanding of Holy Quran-I **Credit Hours:** 1(1+0)

Course Outline:

Weeks	Lectures (1.5 hrs)	Units	Lessons	Assignments/Home Task	Linguistic Rules

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1.	1.	1	1-6	Writing the meaning of Quranic words Lesson 1-8	Proper Noun Masculine & Feminine
	2.	1	9-14	Writing the meaning of Quranic words 9-14	Two kinds of plural Concept of (و) "And" Common Noun
2.	1.	1	15-17	Writing the meaning of Quranic words, phrases & translation of Sentences 15-17	Demonstrative Noun (This & That for Masculine (هذا- هذه) Demonstrative Noun (This & That for Feminine) (ذلك- تلك)
	2.	1	18-19 & Revisio n (Unit 1)	Writing the meaning of Quranic words , phrases & translation of Sentences 17-19 Quiz	Laam for emphasis (لام التأكيد) Superlative Degree like أكبر Revision of all Quranic Sentences
3.	1.	Unit 2	1-3	Writing the meaning of Quranic words, phrases & translation of Sentences 1-3	Emphatic Particle إن Preposition "For" (اللام) Preposition (في)
	2.	2	4-6	Writing the meaning of Quranic words, phrases & translation of Sentences 4-6	Preposition (على- من- إلى)
4.	1.	2	7- 9	Writing the meaning of Quranic words & translation of Sentences 7-9	Preposition (الباء) Absolute Negation Particle Exceptive Particle (لا النافية (إلا) (ما النافية)(للجنس
	2.	2	10-13 & Revisio n (Unit 2)	Writing the meaning of Quranic words, phrases & translation of Sentences 10-13 Quiz	Subordinating Conjunction(أن), Was (كان), Vocative Particle(حرف النداء)

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5.	1.	Unit 3	1-2	Writing the meaning of Quranic phrases 1-2	Quranic Adjective Compounds (صفة وموصوف)
	2.	3	3-5	Writing the meaning of Quranic phrases & translation of sentences 3-5	Quranic Possessive Construction (مضاف ومضاف إليه)
6.	1.	3	6 -7	Writing the meaning of Quranic phrase translation of sentences 6-7	Quranic Possessive Construction (مضاف ومضاف إليه)
	2.	3	8-10 & Revisio n (Unit 3)	Writing the meaning of Quranic phrase & translation of sentences 8-10 Quiz	Active Participle (اسم الفاعل), Passive Participle (اسم المفعول), Dual (مثنى)
7.	1.	Unit 4	1-2	Writing the meaning of Quranic phrase & translation of sentences 1-2	Personal Pronoun He(هو المنفصل) Possessive Pronoun His ـه المتصل)
	2.	4	3-4	Writing the meaning of Quranic phrase & translation of sentences 3 -4	Possessive Pronoun with prepositions like في بيته Pronoun "His" with prepositions like فيه، منه، له
8.	1.	4	5-8	Writing the meaning of Quranic sentences 5-8	Personal Pronoun You(أنت المنفصل) Possessive Pronoun Your ك المتصل) Possessive Pronoun with prepositions like في بيتك Pronoun "your" with prepositions like فيك، منك، لك
	2.	Mid Term			

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9.	1.	4	9-12	Writing the meaning of Quranic phrases & sentences 9-12	Personal Pronoun She(هي المنفصل) Possessive Pronoun Her ها المتصل) Possessive Pronoun with prepositions في بيتها like Pronoun "Her" with prepositions like لها،
	2.	4	13-16	Writing the meaning of Quranic phrases & sentences 13-16	Personal Pronoun I (أنا المنفصل) Possessive Pronoun Her ي المتصل) Possessive Pronoun with prepositions like في بيتيPronoun "My" with prepositions like لي
10.	1	4	17 & Revisio n Unit 4	Revision of all Quranic sentences of Unit 4 Quiz	Adverb (حال)
	2.	Unit 5	1-2	Writing the meaning of Quranic phrases & sentences 1-2	Masculine Plural جمع المذكر السالم و جمع المذكر السالم المسبوق بحرف الجر
11.	1.	5	3-4	Writing the meaning of Quranic phrases & sentences 3-4	Possessive Construction with Plurals جمع المذكر السالم المسبوق بالإضافة
	2.	5	5-6	Writing the meaning of Quranic phrases, sentences & verses 5-6	Personal Pronoun They (هم المنفصل) Possessive Pronoun Their هم المتصل)
12.	1.	5	7-8	Writing the meaning of Quranic phrases, sentences & verses 7-8	Possessive Pronoun with prepositions like في بيتهمPronoun "Their" with prepositions like لهم

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	2.	5	9-11	Writing the meaning of Quranic phrases, sentences & verses 9-11	Personal Pronoun You (أنتم المنفصل) Possessive Pronoun Your كم المتصل) Possessive Pronoun with prepositions

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					في بيتكم like
13.	1.	5	12-14	Writing the meaning of Quranic phrases & sentences & verses 12-14	Pronoun "Your" with prepositions like لكم Personal Pronoun We (نحن المنفصل) Possessive Pronoun Our نا (المتصل)
	2.	5	15-16	Writing the meaning of Quranic sentences & verses 15-16	Possessive Pronoun with prepositions في بيتنا like Pronoun "Our" with prepositions like لنا
14.	1.	5	17-18	Writing the meaning of Quranic sentences & Verses 17-18	Demonstrative Pronoun These, Those (هؤلاء- أولئك)
	2.	5	19-23	Writing the meaning of Quranic sentences & Verses 19-23	ما / إلا، إن / إلا، إنما، ليس، ما ،) (أ/أم، أن، بل، كأن (ألا، أليس، اليوم، يومئذ، سبحان، مابينهما، قل، إذن، بئس، نعم، كلا، ما أدراك، حسب، أعلم ب، مصير، مرجع، دينا(تمييز)
15.	1.	5	Revision Unit 5	Quiz	
	2.	5	1-3 (till Page 16)	Writing the meaning of Quranic Verbs &Translation of Quranic Sentences & Verses (1-3)	Introduction of Present Tense(فعل مضارع) & Verbal Sentence (جملة فعلية) Present Tense الفعل المضارع صيغة المفرد يعلم
16.	1.	6	3 (From Page 17) & 4 -5	Translation of Quranic Sentences & Verses 3-5	Present Tense الفعل المضارع صيغة المفرد يعلم
	2.	6	6	Translation of Quranic Sentences & Verses	Present Tense الفعل المضارع صيغة الجمع يعلمون

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5. MATH- 314 Pre-Calculus-I Credit Hours: 3(3+0)

6.

7. Course Objectives: To introduce basics of functions with detailed analysis of elementary functions including exponential, logarithmic and trigonometric functions

Course Outlines: Sets, Real Numbers and Their Properties, Polynomials, Linear and Quadratic Equations, Inequalities, Relations and Functions, Review of Linear Functions, Quadratic Functions, Inverse Functions, Exponential and Logarithmic Functions, Trigonometric Functions, Graphs of Trigonometric Functions, Trigonometric Identities, The Law of Sines, The Law of Cosines, Complex Numbers, De Moivre's Theorem.

Recommended Books:

1. M. Lial, J. Hornsby, D. Schneider and C. Daniels, *Precalculus*, 6th Edition, Pearson, 2016.
2. M. Sullivan, *Precalculus*, 11th Edition, Pearson, 2019.
3. J. Stewart, L. Redlin, and S. Watson, *Precalculus: Mathematics for Calculus*, 7th Edition, Cengage Learning, 2015.
4. J. Stewart, L. Redlin, and S. Watson, *Precalculus: Mathematics for Calculus*, 7th Edition, Cengage Learning, 2015.
5. M. Small and C. Kirkpatrick, *Functions 11*, Nelson Canada, 2007.

Semester-II				
1	MATH-321	Calculus-II	3(3+0)	Major
2	MATH-322	Discrete Mathematics	3(3+0)	Major
3	MATH-326	Quantitative Reasoning-II	3(3+0)	General Education
4	ENG-321	Expository Writing	3(3+0)	General Education
5	PS-314	Pakistan Studies	2(2+0)	General Education
6	MATH-327	Introduction to Programming	3(2+1)	Interdisciplinary
7	QUR-301	Understanding of Holy Quran-II	1(1+0)	
8	MATH-323	Pre-Calculus-II	3(3+0)	Non-Credits
Semester Credit Hours			**18**	

MATH-321 Calculus-II Credit Hours: 3(3+0)

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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, PWSPublishers, Boston, Massachusetts, 1983.
7. M. Liebeck, A Concise introduction to pure Mathematics, CRCPress, 2011.
8. A. Kaseberg, Intermediate Algebra, Thomson Brooks/COLE, 2004.
9. J. Stewart, Calculus early transcendental, 7th Edition,Brooks/COLE, 2008.

MATH-322 Discrete Mathematics **Credit Hours: 3(3+0)**

Objectives: Introduces the foundations of discrete mathematics as they apply to Computer Science, focusing on providing a solid theoretical foundation for further work. Further, this course aims to develop understanding and appreciation of the finite nature inherent in most Computer Science problems and structures through study of combinatorial reasoning, abstract algebra, iterative procedures, predicate calculus, tree and graph structures. In this course more emphasis shall be given to statistical and probabilistic formulation with respect to computing aspects.

Course Outline: Introduction to logic and proofs: Direct proofs; proof by contradiction, Sets, Combinatorics, Sequences, Formal logic, Prepositional and predicate calculus, Methods of Proof, Mathematical Induction and Recursion, loop invariants, Relations and functions, Pigeonwhole principle, Trees and Graphs, Elementary number theory, Optimization and matching. Fundamental structures: Functions; relations (more specifically recursions); pigeonhole principle; cardinality and countability, probabilistic methods.

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.

Reference Material:

1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, 6TH edition, 2006, Mcgraw Hill Book Co.
2. Richard Johnsonbaugh, Discrete Mathematics, 7TH edition, 2008, Prentice Hall Publishers.
3. Kolman, Busby & Ross, Discrete Mathematical Structures, 4th edition, 2000, Prentice-Hall Publishers.
4. Ralph P. Grimaldi, Discrete and Combinatorial Mathematics: An Applied Introduction, Addison-Wesley Pub. Co., 1985.

MATH-323 Pre-Calculus-II Credit Hours: 3(3+0)

Course Objectives: To introduce the concept of matrices, conic section, basic probability theory, limits, basics of derivatives and basics of definite integrals

Course Outlines: System of Linear Equations, Matrices and Determinants, Circles, Parabolas, Ellipses, Hyperbolas, Sequences and Series, The Binomial Theorem, Mathematical Induction, Basics of Counting Theory, Basics of Probability, Introduction to Limits and Continuity, Tangent Lines and Derivatives, Area and Definite Integral.

Recommended Books:

1. J. Hornsby, M. Lial and G. Rockswold, *A Graphical Approach to Precalculus with Limits*, 7th Edition, Pearson, 2018.
2. M. Lial, J. Hornsby, D. Schneider and C. Daniels, Precalculus, 6th Edition, Pearson, 2016.
3. R. Larson, Precalculus with Limits, 5th Edition, Cengage Learning, 2021.
4. M. Sullivan, Precalculus, 11th Edition, Pearson, 2019.

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5. J. Stewart, L. Redlin, and S. Watson, Precalculus: Mathematics for Calculus, 7th Edition, Cengage Learning, 2015.

MATH-326 Quantitative Reasoning-II **Credit Hours: 3(3+0)**

Course Objectives: The primary objective of this course is to explore, probability and statistics. The curriculum includes in-depth study of exponential and logarithmic functions, as well as problem-solving related to these mathematical concepts. Solving system of linear equations and matrix algebra is the part of this course which ultimately develops the necessary background for data analysis. Overall, the course aims to equip students with a comprehensive understanding of mathematical concepts relevant to probability and statistics enabling them to apply these skills in real-world scenarios.

Course Outline:

1. **Logic, Logical and critical Reasoning:** Introduction and importance of logic, Inductive, deductive and adductive approaches of reasoning, Proposition Arguments (Valid, invalid) logical connectives, truth tables and propositional equivalences, Logical Fallacies, Venn Diagrams, Predicates and Quantifiers, Quantitate Reasoning exercises using logical reasoning logical reasoning concepts and techniques.

2. Mathematical modeling and Analysis: Introduction to deterministic models, Use of linear function for modeling in real- world situations, Modeling of the system of linear equation and others solutions, Elementary introduction to derivatives in mathematical modeling, Linear and exponential growth and decay models, Quantitative reasoning exercises using mathematical modeling.

3. Statistical Modeling and Analyses: Introduction to Probabilistic models, Bivariate analysis, Scatter plots, Simple linear regression model and correlation analysis, Basics of estimation and confidence interval, Testing of hypothesis (z-test, t-test), Statistical inference in decision making, Quantitative reasoning exercise using statistical modelling.

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1. "Using and Understanding Mathematics: A Quantitative Reasoning Approach" by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
2. "Discrete Mathematics and its Applications" by Kenneth H. Rosen.
3. "Discrete Mathematics with Applications" by Susanna S. Epp.
4. "Applied Mathematics for Business, Economics and Social Sciences" by Frank S Budnick.
5. "Elementary Statistics: A Step by Step Approach" by Allan Bluman.
6. "Introductory Statistics" by Prem S. Mann.
7. "Applied Statistical Modeling" by Salvatore Babones.
8. "Barrons SAT" by Sharvon Weiner Green, M.A and Ira K.Wolf.

ENG-321 Expository Writing **Credit Hours: 3(3+0)**

Course Outline:

1. **Introduction to Expository Writing:**
   - Understanding expository writing (definition, types, purpose and applications)
   - Characteristics of effective expository writing (clarity, coherence and organization)
   - Introduction to paragraph writing
2. **The Writing Process:**
   - Pre-writing techniques (brainstorming, free-writing, mind-mapping, listing, questioning and outlining etc.)
   - Drafting (three stage process of drafting techniques)
   - Revising and editing (ensuring correct grammar, clarity, coherence, conciseness etc.)
   - Proof reading (fine-tuning of the draft)
   - Peer review and feedback (providing and receiving critique)
3. **Essay Organization and Structure:**
   - Introduction and hook (engaging readers and introducing the topic)
   - Thesis statement (crafting a clear and focused central idea)
   - Body Paragraphs (topic sentences, supporting evidence and transitional devices)
   - Conclusion (types of concluding paragraphs and leaving an impact)
   - Ensuring cohesion and coherence (creating seamless connections between paragraphs)
4. **Different Types of Expository Writing:**
   - Description

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- Illustration
- Classification
- Cause and effect (exploring causal relationships and outcomes)
- Process analysis (explaining step-by-step procedures)
- Comparative analysis (analyzing similarities and differences)

5. **Writing for Specific Purposes and Audiences:**
   - Different types of purposes (to inform, to analyze, to persuade, to entertain etc.)
   - Writing for academic audiences (formality, objectivity, and academic conventions)
   - Writing for public audiences (engaging, informative and persuasive language)
   - Different tones and styles for specific purposes and audiences
6. **Ethical Considerations:**
   - Ensuring original writing (finding credible sources, evaluating information etc.)
   - Proper citation and referencing (APA, MLA, or other citation styles)
   - Integrating quotes and evidences (quoting, paraphrasing, and summarizing)
   - Avoiding plagiarism (ethical considerations and best practices)

Recommended Books:

1. "The St. Martin's Guide to Writing" by Rise B. Axelrod and Charles R. Cooper.
2. "They Say / I Say: The Moves That Matter in Academic Writing" by Gerald Graff and Cathy Birkenstein.
3. "Writing Analytically" by David Rosenwasser and Jill Stephen.
4. "Style: Lessons in Clarity and Grace" by Joseph M. Williams and Joseph Bizup.
5. "The Elements of Style" by William Strunk Jr. and E.B. White.
6. "Good Reasons with Contemporary Arguments" by Lester Faigley and Jack Selzer.
7. "Writing to Learn: How to Write - and Think - Clearly About Any Subject at All" by William Zinsser.
8. "The Norton Field Guide to Writing" by Richard Bullock, Maureen Daly Goggin, and Francine Weinberg.
9. "The Art of Styling Sentences" by Ann Longknife and K.D. Sullivan.
10. "Writing Today" by Richard Johnson-Sheehan and Charles Paine.

PS-314 Pakistan Studies Credit Hours: 2(2+0)

DESCRIPTION

This course is designed to provide students with a comprehensive exploration of Pakistan's identity, spanning geographical, historical, and cultural dimensions. It delves into the diverse landscapes, ancient civilizations, and rich cultural heritage that define Pakistan. Moreover, it examines the socio-cultural and political transformations in Pakistan over time including democratic transitions and military interventions. The aim of this course is to inculcate in students a nuanced understanding of Pakistan's past, present, and potential future trajectories, enabling them to critically evaluate the complex dynamics shaping the nation's development.

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COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

- ❖ Have enhanced knowledge of the geographical, historical, and political aspects of Pakistan.
- ❖ Understand the society and culture of Pakistan.
- ❖ Understand and explain the socio-economic developments in Pakistan.
- ❖ Explore contemporary issues and challenges faced by Pakistan and their implications for the future.

SYLLABUS

1. Introduction to Pakistan:

- Geographical location and significance.
- Historical background: Ancient civilizations in the region.
- Factors leading to the creation of Pakistan.

2. Political History of Pakistan:

- Formative phase.
- Military interventions and democratic transitions.

3. Geography of Pakistan:

- Physiography: Mountains, plans, plateaus, deserts, valleys and coastal areas.
- River systems: Indus River and its tributaries.
- Climatic regions of Pakistan.

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4. Society and Culture of Pakistan:

- Socio-cultural diversity
- Languages and literature of Pakistan.

5. Economic Development of Pakistan:

- Agriculture and industrial sectors of Pakistan.
- Economic challenges of Pakistan.

6. Contemporary Issues:

- Foreign relations of Pakistan.
- Security challenges terrorism, extremism, and regional conflicts.
- Environmental problems and sustainable development (SDGs).
- Media and social change.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. "Jinnah of Pakistan" by Stanley Wolpert
2. "The Sole Spokesman: Jinnah, the Muslim League, and the Demand for Pakistan" by Ayesha Jalal
3. "The struggle for Pakistan" by Ishtiaq Husain Qureshi
4. "Pakistan, the Formative Phase, 1857-1948" by Khalid B. Sayeed
5. "Pakistan Studies: A Book of Readings" by Sikandar Hayat
6. "Constitutional and Political History of Pakistan" by Hamid Khan
7. "Trek to Pakistan" by Ahmad Saeed and Kh. Mansur Sarwar
8. "Pakistan: A Modern History" by lan Talbot
9. "Politics in Pakistan: The Nature and Direction of Change" by Khalid B. Sayeed
10. "Physical Geography of Pakistan" by Umar Jahangir
11. "A Geography of Pakistan: Environment, People, and Economy" by Fazle Karim Khan
12. "Pakistan's Foreign Policy: An Historical Analysis" by S. M. Burke
13. "Separatism in East Pakistan" by Rizwan Ullah Kokab
14. "Being Pakistani: Society, Culture and the Arts" by Raza Rumi
15. "Pakistan's Cultural Heritage: Socio-Economic and Technological Aspects" edited by Abdul Jabbar Khan
16. "Language and Politics in Pakistan" by Tariq Rahman
17. "Sociology" by Horton and Hunt
18. "Pakistan in the Twentieth Century: A Political History" by Lawrence Ziring
19. "Economic Development of Pakistan" by Ishrat Husain

"Issues in Pakistan's Economy" by S. Zaidi

QUR-301 Understanding of Holy Quran-II **Credit Hours:** 1(1+0)

Course Outline:

Weeks	Lectures	Units	Lessons	Assignments/Home Task	

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1.	1.	6	6	Understanding & Translation of Verses	Present Tense صيغة جمع مذكر غائب مثل يعبدون
	2.	6	7-8	Understanding & Translation of Verses	Present Tense صيغة جمع مذكر غائب مثل يعبدون
2.	1.	6	9-10	Understanding & Translation of Verses	Present Tense صيغة مفرد مذكر مخاطب (تعبد) وجمع مذكر مخاطب (تعبدون)
	2.	6	11-12	Understanding & Translation of Verses	Present Tense صيغة جمع مذكر مخاطب (تعبدون)

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					صيغة المتكلم (أعبد)
3.	1.	6	13	Understanding & Translation of Verses	Present Tense صيغة جمع المتكلم (نعبد)
	2.	6	14-15	Understanding & Translation of Verses	Negative Imperative صيغة المفرد وصيغة الجمع , لا تعبدْ، لا تعبدوا
4.	1.	6	16-17	Understanding & Translation of Verses	Conditional Sentences & masdar moawal (مصدر موؤل)
	2.	6	18-19	Understanding & Translation of Verses	Laam uttaleel (لام التعليل) & Laam ul jhood(لام الجحود)
5.	1.	6	20-21	Understanding & Translation of Verses	Present with object pronouns & Passive Voice
	2.	6	Revision (Unit 6)	Quiz	
6.	1.	Unit 7	1 (sec 1-3)	Understanding & Translation of Verses	Past Tense صيغة المفرد الغائب
	2.	6	1 (Sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة المفرد للغائب
7.	1.	6	1 (Sec 5-6)	Understanding & Translation of Verses	Past Tense صيغة المفرد للغائب
	2.	6	1 (Sec 7-9)	Understanding & Translation of Verses	Past Tense صيغة المفرد للغائب
8.	1.	7	Revision	Understanding & Translation of Verses QUIZ	Past Tense صيغة المفرد للغائب
	2.	MID TERM			
9.	1.	7	2 (sec 1-2)	Understanding & Translation of Verses	Past Tense صيغة الجمع للغائب عبدوا
	2.	7	2 (sec 3)	Understanding & Translation of Verses	Past Tense صيغة الجمع للغائب عبدوا
10.	1.	7	2 (sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة الجمع للغائب عبدوا
	2.	7	2 (sec 6-7)	Understanding & Translation of Verses	Past Tense صيغة الجمع للغائب عبدوا

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11.	1.	7	3 (sec 1-2)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم عبدنا

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	2.	7	3 (sec 2-3)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم عبدنا
12.	1.	7	3 (sec 3-4)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم عبدنا
	2.	7	3 (sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم عبدنا
13.	1.	7	4 (sec 1-2-3)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمخاطب عبدتم
	2.	7	4 (sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمخاطب عبدتم
14.	1.	7	5-6	Understanding & Translation of Verses Quiz	Past Tense صيغة المتكلم والمخاطب عبد ت ، عبد ْت
	2.	7	7	Understanding & Translation of Verses	Past Tense صيغة المؤنث للغائب عب ْدتْ
15.	1.	7	8	Understanding & Translation of Verses	Passive Voice (Past Tense) فعل مجهول للمفرد
	2.	7	9	Understanding & Translation of Verses	Passive Voice (Past Tense) فعل مجهول الجمع
16.	1.	8	1-4	Understanding & Translation of Verses	Imperative Verb for singular فعل الأمر للمفرد
	2.	7	5-8	Understanding & Translation of Verses	Imperative Verb for plural فعل الأمر للجمع

MATH-327 Introduction to Programming **Credit Hours: 3(3+0)**

Course Learning Outcomes (CLOs):
At the end of the course the students will be able to:
1- Understand basic problem solving steps and logic constructs 2- Apply basic programing concepts 3- Design and implement algorithms to solve real world problems

* BT = Bloom's Taxonomy, C = Cognitive domain, P = Psychomotor domain, A = Affective domain
Course Content:
Introduction to problem solving, Programing techniques, Problem solving techniques, Introduction to flowchart, Introduction to algorithms, Introduction to programming, Programing

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languages, Role of interpreter, compiler, assembler, Basic data types, keywords, Identifiers, Variables and constants, structure of a program, Operator and its types (assignment, increment/ decrement, arithmetic, relational, pointer and logical operators), Input/output statements, Conditional statements and execution flow for conditional statements, Repetitive statements and execution flow for repetitive statements, Functions, Arrays, Pointers/references, String handling and string operations, Structures, Static and dynamic memory allocation, File I/O operations.
Teaching Methodology:
Lecturing, Written Assignments, Project
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Lab, Presentation, Final Exam
Reference Materials:
1. Starting out with Programming Logic & Designs, 4th Edition, Tony Gaddis, 2. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie 3. Object Oriented Programming in C++ by Robert Lafore 4. C How to Program, 7th Edition by Paul Deitel & Harvey Deitel 5. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman

Semester-III				
1	MATH-411	Calculus-III	3(3+0)	Major
2	MATH-412	Linear Algebra-I	3(3+0)	Major
3	MATH-413	Group Theory-I	3(3+0)	Major
4	STAT-316	Probability & Statistics	3(3+0)	Interdisciplinary
5	PS-321	Ideology & Constitution of Pakistan	2(2+0)	General Education
6	IS-312	Islamic Studies/ Ethics for Non-Muslims	2(2+0)	General Education
7		Social Science	2(2+0)	General Education
Semester Credit Hours			**18**	

MATH-411 Calculus-III **Credit Hours: 3(3+0)**

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.

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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. Curland 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 andMultivariable, 3rd Edition. John Wiley & Sons, Inc. 2002.
4. Frank A. Jr, Elliott Mendelson, Calculus, Schaum's outlinesseries, 4th Edition, 1999
5. C.H. Edward and E.D Penney, Calculus and AnalyticsGeometry, 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, 7thEdition, Brooks/COLE, 2008

MATH-412 Linear Algebra-I **Credit Hours: 3(3+0)**

Course objectives: Linear algebra forms the basis for modern mathematics- theoretical, applied and computational. The purpose of this course is to provide students a broad and solid foundation for study of advance mathematics, and it applications in diverse field of science and engineering.

Course Outline: Algebra of matrices, Row and Column operations, rank, inverse of matrices, Transformation, Linear transformation, matrix of a linear transformation. group of matrices and Subgroups, orthogonal transformation, Linear operators. Canonical form of the matrix of a nilpotent operator. Polynomial algebra and canonical form of the matrix of an arbitrary operator. Rings, field, finite and infinite fields (definition and examples), Homomorphism of fields, annihilators, vector spaces, subspaces, Linear combination, Linear dependence and independence, linear span of a subset of a vector space, bases and dimensions of a vector space, Null space, nullity, dimension, Relation of rank, dimension and nullity. Eigen value, eigenvector, eigen value problem with physical Significance, Similar matrices with eigen values, Inner product spaces.

System of differential equations in normal form. Homogeneous linear systems. Solution by diagonalisation. Non-homogeneous linear systems.

RECOMMENDED BOOKS:

1. D.T. Finkbeiner, Introduction to Matrices and Linear Transformations, 3rd. Ed., N.H. Freeman and company San Francisco, 1978.
2. D. C. Lay, Linear Algebra and Its Applications, Addison-Wesley, 3rdEdition, 2005.
3. A. M. Tropper,Linear Algebra, Thomas Nelson & Sons, 1973.
4. S. Lang, Linear Algebra, Addison-Wesley, 1970.
5. K. R. Hoffman and R. Kunze, Linear Algebra , Prentice Hall, 1971.
6. I. N. Herstein, Topics in Algebra, Addison-Wesley, 1980.
7. T. S. Blyth, E. F. Robertson, Essential student Algebra, Vol I-V, Chapman & Hall, 1986.
8. Anton H, *Linear Algebra with Applications* (8th edition), John Wiley, New York
9. Hill RO, *Elementary Linear Algebra with Application* (3rd edition), 1995,Brooks/Cole
10. Leon SJ, *Linear Algebra with Applications* (6th edition), 2002, Prentice Hall, Englewood Cliffs, NJ, USA
11. Nicholson WK, *Elementary Linear Algebra with Applications* (2nd edition), 1994, PWS Publishing Co.

MATH- 413 Group Theory-I Credit Hours: 3(3+0)

Objectives of course: The aim of this course is to introduce students to the basic concept of groups. The course is designed to provide students the basics of groups theory needed in the advance courses.

Course Outline:415

Historical background, Definition pf a group with some examples, Order of an element of a group, Subgroups, Generators and relations, Free groups, Cyclic groups, Finite groups, Cayley's theorem on permutation groups, Cosets and Lagrange's theorem, Normal subgroups, Simplicity, Normalizers, Direct products, Homomorphism, Factor groups, Isomorphism, Automorphism, Isomorphism theorems, Group actions, Stabilizers, Conjugacy classes, Sylow theorems and their applications.

Recommended Books

1. G. Nakose and D. Joyner: Linear Algebra with Applications, (1998).
2. W. Keith Nicholson: *Elementary linear algebra with applications,* (1994)
3. Richard O. Hill: Elementary linear algebra with applications, *3rd edition,* (1995)
3. Steven J. Leon: Linear algebra with applications, *6th edition, (2002).*
4. Shifrin T. and Adams R. M.: Linear Algebra, A Geometric Approach, (2002).
5. J. R. Durbin: Modern Algebra: An Introduction, 3rd Edition, (1992).

STAT-316 Probability and Statistics Credit Hours: 3(3+0)

Course Objectives:

- Students will develop basic understanding of Statistics and related concepts.
- To have introduction of statistics as a field of knowledge and its scope and relevance to other disciplines of natural and social sciences.
- To achieve the capability of critical thinking about data and its sources; have idea about variables and their types and scale measures.

Course Outline::

- **Theory:**
  Definition and importance of Statistics, Data and different types of data, Observation and variables, Discrete and Continuous variables, Primary and Secondary data, Limitation of statistics, Presentation of data: Introduction, Classification, Basic Principles and types of Classification, Frequency distribution, Constructing a Grouped frequency Distribution from raw data, Class boundaries, Class-marks, Relative and Cumulative frequency distribution, Diagrams, Graphs and their Construction, Bar charts, Pie chart, Histogram, Frequency polygon and Frequency curve, Exercises. Measure of Central tendency: Introduction, Types of Averages, (Arithmetic Mean, Geometric Mean, Harmonic Mean, Median and Mode), Quantiles in Grouped and Ungrouped data. Measure of Dispersion: Introduction, Rang, the Mean (or Average) deviation, Standard deviation and Variance, Coefficient of variation. Probability theory, Sample Space, counting sample points, Events, Independent and Dependent Events, Mutually exclusive and Mutually exhaustive Events, Classical Probability, Laws of Probability, Conditional Probability.

Recommended Books:

1. Introduction to Statistical Theory Part-I by Sher Muhammad and Dr. Shahid Kamal (Latest Edition).
2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad.
3. A. Concise Course in A. Level Statistic with world examples by J. Crawshaw and J. Chambers (1994).
4. Basic Statistics; an Inferential Approach 2nd ed., (1986) II Dietrich, Frank H. and Thomes J. Keans.
5. Morgan, George A.; Leech, Nancy L.; Gloeckner, Gene W.; and Barret, Karen C., 2nd ed., 2004 SPSS for Introductory Statistics: Use and Interpretations, New Jersey: Kawrence Erlbaum Associates, Inc.
6. Muhammad, F. (2005). "Statistical Methods and Data Analysis", Kitab Markaz, Bhawana Bazar Faisalabad.

PS-321 Ideology and Constitution of Pakistan Credit Hours: 2(2+0)

Course Outline:

1. **Introduction to the Ideology of Pakistan:**
   - Definition and significance of ideology.
   - Historical context of the creation of Pakistan (with emphasis on socio-political, religious, and cultural dynamics of British India between 1857 till 1947).
   - Contributions of founding fathers of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal, Muhammad Ali Jinnah., etc.
   - Contributions of women and students in the freedom movement for separate homeland for Muslims of British India.
2. **Two-Nation Theory:**
   - Evolution of the Two-Nation Theory (Urdu-Hindi controversy, Partition of Bengal, Simla Deputation 1906, Allama Iqbal's Presidential Address 1930, Congress Ministries 1937 Lahore Resolution 1940).
   - Role of communalism and religious differences.
3. **Introduction to the Constitution of Pakistan:**
   - Definition and importance of a constitution.
   - Ideological factors that shaped the Constitution(s) of Pakistan (Objectives Resolution 1949).
   - Overview of constitutional developments in Pakistan.
4. **Constitution and State Structure:**
   - Structure of Government (executive, legislature, and judiciary).
   - Distribution of powers between federal and provincial governments.
   - 18th Amendment and its impact on federalism.
5. **Fundamental Rights, Principles of Policy and Responsibilities:**
   - Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles 8-28).
   - Overview of Principles of Policy (Articles 29-40).
   - Responsibilities of the Pakistani citizens (Article 5).
6. **Constitutional Amendments:**
   - Procedures for amending the Constitution.
   - Notable constitutional amendments and their implications.

Recommended Books:

1. "The Idea of Pakistan" by Stephen P. Cohen.
2. "Ideology of Pakistan" by Javed Iqbal.
3. "The Struggle for Pakistan" by I.H. Qureshi.
4. "Pakistan the Formative Phase" by Khalid Bin Sayeed.
5. "Pakistan: Political Roots and Development" by Safdar Mahmood.

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6. "Ideology of Pakistan" by Sharif-ul-Mujahid.
7. "The Struggle for Pakistan: A Muslim Homeland and Global Politics" by Ayesha Jalal.
8. "Jinnah, Pakistan and Islamic Identity: The Search for Saladin" by Akbar S. Ahmed.
9. "The Making of Pakistan: A Study in Nationalism" by K.K. Aziz.
10. "Pakistan: A New History" by Ian Talbot.
11. "Pakistan in the Twentieth Century: A Political History" by Lawrence Ziring.
12. "The Constitution of Pakistan 1973". Original.
13. "Constitutional and Political Development of Pakistan" by Hamid Khan.
14. "The Parliament of Pakistan" by Mahboob Hussain.
15. "Constitutional Development in Pakistan " by G.W. Choudhury.
16. "Constitution-Making in Pakistan: The Dynamics of Political Order" by G.W. Choudhury.

IS-312 Islamic Studies Credit Hours: 2(2+0)

Course Outline:

1. **Introduction to Islam:**
   - Definition of Islam and its core beliefs.
   - The Holy Quran (introduction, revelation and compilation).
   - Hadith and Sunnah (compilation, classification, and significance).
   - Key theological concepts and themes (Tawhid, Prophethood, Akhirah etc.).
2. **Sirah of the Holy Prophet (Peace Be Upon Him) as Uswa-i-Hasana:**
   - Life and legacy of the Holy Prophet PBUH.
   - Diverse roles of the Holy Prophet PBUH (as an individual, educator, peace maker, leader etc.).
3. **Islamic History and Civilization:**
   - World before Islam.
   - The Rashidun Caliphate and expansion of Islamic rule.
   - Contribution of Muslim scientists and philosophers in shaping world civilization.
4. **Islamic Jurisprudence (Fiqh):**
   - Fundamental sources of Islamic jurisprudence.
   - Pillars of Islam and their significance.
   - Major schools of Islamic jurisprudence.
   - Significance and principles of Ijtihad.
5. **Family and Society in Islam:**
   - Status and rights of women in Islamic teachings.
   - Marriage, family, and gender roles in Muslim society.
   - Family structure and values in Muslim society.
6. **Islam and the Modern World:**
   - Relevance of Islam in the modern world (globalization, challenges and prospects).

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- Islamophobia, interfaith dialogue, and multiculturalism.
- Islamic viewpoint towards socio-cultural and technological changes.

Recommended Books:

1. "The Five Pillars of Islam: A Journey Through the Divine Acts of Worship" by Muhammac Mustafa Al-Azami.
2. "The Five Pillars of Islam: A Framework for Islamic Values and Character Building" by Musharraf Hussain.
3. "Towards Understanding Islam" by Abul A' la Mawdudi.
4. "Islami Nazria e Hayat" by Khurshid Ahmad.
5. "An Introduction to Islamic Theology" by John Renard.
6. "Islamic Civilization Foundations Belief & Principles" by Abul A' la Mawdudi.
7. "Women and Social Justice: An Islamic Paradigm" by Dr. Anis Ahmad.
8. "Islam: Its Meaning and Message" by Khurshid Ahmad.

EC-414 Introduction to Economics Credit Hours: 2(2+0)

COURSE OBJECTIVES

By the end of the course, students will be able to understand introductory microeconomic and macroeconomic theory, solve basic micro and macro-economic problems, and use these techniques to think about a number of basic policy questions relevant to the operation of the economy. More specifically, this course aims:

• To develop an understanding of introductory microeconomic theory and its relevance to the real word

•To sharpen the problem solving tactics required to solve basic microeconomic/Macroeconomic problems

• To give a broader implications of micro and macro-economic principles and their applications

• To train the students to work with others as a part of team to solve problems

COURSE LEARNING OUTCOMES:

After completing this course, students should have developed a range of skills enabling them to understand economic concepts and use those concepts to analyses specific questions. By the end of this course, students should be able to:

• Understand consumer and firm behavior apply graphical analysis for a variety of economic situations.

• Calculate and Interpret elasticities

• Define and derive short-run and long run production costs

• Explain various market structures

COURSE CONTENT

1.1 The Economic Problem

1.2 Economic Decision Makers

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1.3 The Circular Flow Model
1.4 Distinction between Microeconomics and Macroeconomics
1.5 The Market System

2. Demand & Supply:

2.1 Demand Function, Demand Curve, Engel Curve, Changes in Demand, Law of Demand, shift in Demand, Factors Affecting Demand, Consumer Surplus
2.2 Supply, Supply Function, Supply Curve, Changes in Supply, Factors Affecting Supply, Law of Supply, Producer Surplus
2.3 Equilibrium of Demand and Supply, Market Equilibrium, Price Controls, Taxes and Subsidies

3. Elasticity of Demand & Supply:

3.1 Price Elasticity of Demand & Supply
3.2 Point Elasticity of Demand & Supply
3.3 Arc Elasticity of demand & Supply
3.4 Income Elasticity of Demand & Supply
3.5 Cross Elasticity of demand & Supply

4. Consumer Behavior:

4.1 Utility Analysis (Cardinal Approach), Marginal Utility
4.2 Law of Diminishing Marginal Utility and Law of Equi-Marginal Utility, Consumer Equilibrium

5. Introduction to Macroeconomics

5.1 What is macroeconomics and how economist thinks?
5.2 The economy in aggregate,
5.3 Complexities of the world of business,
5.4 Scope of macroeconomics,
5.5 Brief account of classical and the development of macro-economic after the World War-II
5.6 Concept of business cycles: Boom and Depression,
5.7 Three concerns of macroeconomics, Inflation, GDP growth and unemployment,
5.8 Macroeconomic variables and their mutual relationship,
5.9 Macro-models as abstraction from the real economy.

6. National Income Accounting:

6.1 Definition and concept of national income,
6.2 Measures of national income: Gross Domestic Product (GDP) and Gross National Product (GNP), GDP at factor cost and at market prices, GDP deflator
6.3 Computation of national income: Product, Income and Expenditure approaches,
6.4 Circular flow of income,
6.5 Nominal versus Real income,
6.6 Per capita income and the standard of living.
6.7 Measuring the cost of living: the consumer price index, CPI versus GDP deflator
6.8 Measuring Unemployment rate

7. Components of Aggregate Demand:

7.1 The Concept of Open and closed economy models,

TEXT AND REFERENCE BOOKS:

1.Michael J. Swann, William A. McEachern Microeconomics: A Contemporary Introduction, 3rd

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edition (or latest available)
2. Mankiw N. Gregory, Principles of Microeconomics 7th edition (or latest available).
3.Campbell R. McConnell, Stanley L. Brue, Principles of Economics, 17th edition (or latest available).
4. Paul A. Samuelson, William D. Nordhaus, Economics, Latest Edition
5. N. Gregory Mankiw. Principles of Macroeconomics, (latest edition)
6. Samulson and Nordrons. Economics, 18th Edition, (or latest available)
7. Parkin, Michael. Macroeconomics, Edition Wesley International Inc. (latest edition)

SOC-315 Introduction to Sociology Credit Hours: 2(2+0)

COURSE OBJECTIVES

- To equip student with the basic concepts of sociology and various social phenomenon.
- To familiar the students with social process on the basis of which society is smoothly functioning
- To train students to understand and interpret objectively the role of social process, culture and socialization in their lives.

COURSE OUTLINE::

Introduction

- Introduction, Scope, Nature, and Subject Matter of Sociology
- Historical background
- Sociology as a Science
- Relationship of Sociology with other Social Sciences
- Sociological perspectives in Sociology.
- Role of Sociologists in Society.

Group, Community and Society

- Definition, elements, characteristics of community and society.
- Difference between society and community.
- Various types of societies.
- Difference between rural and urban community.
- Definition and types of social group.

Culture

- Definition, aspects, characteristics, elements, and types of Culture
- Norms, values and social sanctions
- Cultural Universality, Variability, Relativism, Ethnocentrism and Xenocentrism
- Cultural Lag

Socialization & Personality Development

- Meaning, definition and Agencies of Socialization.
- Meaning and definition of self.

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- Meaning, definition and types of Personality
- Responsible Factors in Personality Formation.
- Theories of socialization, self and personality development.

Role and Status

- Definition and types of role.
- Definition and types of status.
- Determinants of status

Social Processes

- Social interaction and forms of social interaction
- Cooperation
- Competition
- Conflict
- Assimilation and acculturation
- Accommodation

Social Stratification and Mobility

- Introduction, Definitions, Determinants and types of social stratification.
- Difference between caste and class.
- Introduction, meaning and definition of social mobility.
- Dynamics and types of social mobility
- Difference between mobility and migration

Collective Behaviors and Social Movements

- Meaning, definitions, types and nature of collective behaviors.
- Meaning, definitions, types of Crowed.
- Meaning, definitions, kinds and life cycle of social movements

COURSE RECOMMENDED BOOKS:

1. Ballantine, Jeanne H. and Roberts, Keith A. (Condensed Version) 2010. *Our Social World.* California: Pine Forge Press/Sage Publication.
2. Brown, Ken 2004. *Sociology*. United Kingdom: Polity Press
3. Brym, Robert J. and Lie, John. *Sociology: Your compass for a new world* (Brief Edition) 2007 Belmont: Thomson Wadsworth.
4. Colander, David C. and Hunt, Elgin F. (Thirteenth Edition) (2010) *Social Sciences: An introduction to the study of Society.* India: Pearson Education/Dorling Dindersley.
5. Gidden, Anthony 2002. *Introduction to Sociology*. UK: Polity Press.
6. Rao, C. N. Shankar (2008) 'Sociology: Principles of Sociology with an Introduction to Social Thoughts' New Delhi: S. Chand & Company.
7. James M. Henslin. (2004). *Sociology: A Down to Earth Approach*. Toronto: Allen and Bacon.
8. Macionis, John J. (2006). 10th Edition *Sociology* New Jersey: Prentice-Hall
9. Montuschi, Eleonora. (2006). *The Objects of Social Sciences* New York: Continuum.

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Hortun, Paul B. and Hunt, Chester L. 1984. *Sociology*. New York: McGraw-Hill

POL-314 Introduction to Political Science Credit Hours: 2(2+0)

COURSE OBJECTIVES

The objective of this course is to introduce the students with the fundamentals of the subject of Political Science and prepare them for advanced studies in the forthcoming semesters. The very basic concepts and terminology commonly used in the further courses of studies are taught to make the students friendly with the subject.

COURSE OUTLINE:

1. Definition of Political Science.
2. Nature of Political Science.
3. Scope of Political Science.
4. Relationship of Political Science with other social sciences.
5. State: its origin and evolution; Western and Islamic concepts of State.
6. Organs of Government: Legislature, Executive, Judiciary.

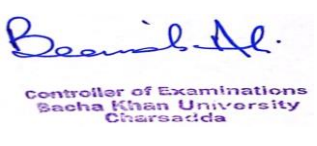
Recommended Books

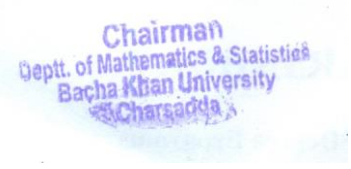
1. Ahmad, Sheikh Bashir. *Riyasat Jo Ilm* (Sindhi meaning Science of State). Jamshoro Institute of Sindhalogy, University of Sindh, 1985.
2. Mazher ul Haq. *Theory and Practice in Political Science*. Lahore: Bookland, 1996.
3. Ian Mackenzi (Ed.). *Political Concepts: A Reader and Guide*. Edinburgh, University Press, 2005.
4. Mohammad Sarwar, *Introduction to Political Science*, Lahore: Ilmi Kutub Khana, 1996.
5. R. C. Agarwal, *Political Theory (Principles of Pol. Science)*. New Delhi: S. Chand & Co., 2006.
6. Robert Jackson and Dorreen Jackson, A Comparative Introduction to Political Science, New Jersey, Prentice – Hall, 1997.
7. Rodee Anderson etc. *Introduction to Political Science*. Islamabad: National Book Foundation, Latest Edition.
8. Roskin, Michael G. *Political Science: An Introduction*. London: Prentice Hall, 1997.
9. Shafi, Choudhry Ahmad. *Usul-e-Siyasiat (Urdu)*. Lahore Standard Book Depot, 1996.
10. V. D. Mahajan. *Political Theory- Principles of Political Science***.** New Delhi: S. Chand & Co., 2006.

PSY-311 Fundamentals of Psychology Credit Hours: 2(2+0)

Course Objectives

- To describe psychology with major areas in the field,



- To identify the parameters of this discipline. Distinguish between the major perspectives on human thought and behaviour. Appreciate the variety of ways psychological data are gathered and evaluated.

- To gain insight into human behaviour and into one's own personality or personal relationships. Explore the ways that psychological theories are used to describe, understand, predict, and control or modify behaviour.

Course Outlines

1. Introduction to Psychology:

a. Nature and Application of Psychology with special reference to Pakistan.
b. Historical Background and Schools of Psychology (A Brief Survey)

2. Methods of Psychology

a. Observation
b. Case History Method Experimental Method
c. Survey Method
d. Interviewing Techniques

3. Biological Basis of Behaviour

a. Neuron: Structure and Functions
b. Central Nervous System and Peripheral Nervous System
c. Endocrine Glands

4. Sensation, Perception and Attention

- Sensation
  - Characteristics and Major Functions of Different Sensations
  - Vision: Structure and function of the Eye
  - Audition: Structure and functions of the Ear
  - Perception
  - Nature of Perception
    - Factors of Perception: Subjective, Objective and Social
    - Kinds of Perception
    - Spatial Perception
    - Temporal Perception; Auditory Perception
- Attention
  - Factors, Subjective and Objective
  - Span of Attention
  - Fluctuation of Attention
  - Distraction of Attention (Causes and Control)

5. Motives

- Definition and Nature
- Classification
- Primary (Biogenic) Motives: Hunger, Thirst, Defection and Urination, Fatigue, Sleep, Pain, Temperature, Regulation, Maternal Behaviour, Sex

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- Secondary (Sociogenic) Motives: Play and Manipulation, Exploration and Curiosity, Affiliation, Achievement and Power, Competition, Cooperation, Social Approval and Self Actualization.

6. Emotions

- Definition and Nature
- Physiological changes during Emotions (Neural, Cardial, Visceral, Glandular),
- Theories of Emotion
- James Lange Theory; Canon-Brad Theory
- Schechter-Singer Theory

7. Learning

- Definition of Learning
- Types of Learning: Classical Operant Conditioning, Methods of Learning: Trial and Error; Learning by Insight; Observational Learning

8. Memory

- Definition and Nature
- Memory Processes: Retention, Recall and Recognition
- Forgetting: Nature and Causes

9. Thinking

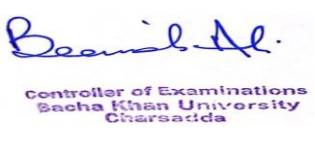
- Definition and Nature
- Tools of Thinking: Imagery, Language, Concepts
- Kinds of Thinking
- Problem Solving, Decision Making, Reasoning

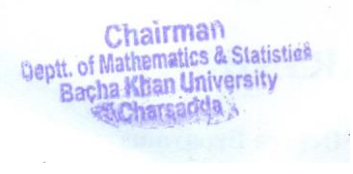
Recommended Books

1. Atkinson R. C., & Smith E. E. (2000). Introduction to psychology (13th ed.). Harcourt Brace College Publishers.
2. Fernald, L. D., & Fernald, P. S. (2005). Introduction to psychology. USA: WMC Brown Publishers.
3. Leahey, T. H. (1992). A history of psychology: Main currents in psychological thought. New Jersey: Prentice-Hall International, Inc.
4. Myers, D. G. (1992). Psychology. (3rd ed.). New York: Wadsworth Publishers.

Semester-IV				
1	MATH-421	Number Theory	3(3+0)	Major
2	MATH-422	Numerical Methods	3(3+0)	Major
3	MATH-423	Data Structure & Algorithms	3(3+0)	Major
4	MATH-424	Ordinary Differential Equations	3(3+0)	Major
5	SOC-313	Civics and Community Engagement	2(2+0)	General Education
6	MGT-411	Entrepreneurship	2(2+0)	General Education
Semester Credit Hours			**16**	

MATH-421 Number Theory **Credit Hours: 3(3+0)**



Objectives of course: The aim of this course is to introduce students to some of the basic ideas of number theory. Number theory is the study of the basic structure and properties of integers. Learning Number Theory helps improving one's ability of mathematical thinking. 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:

Divisibility and Factorization: Divisibility, Prime numbers, Greatest common divisors, Euclidean algorithm, Fundamental theorem of arithmetic.

Congruences: Congruences, linear congruences in one variable, Chinese remainder theorem, Wilson's Theorem, Fermat's theorem, Euler's theorem.

Arithmetic Functions: Arithmetic functions, multiplicative functions, Euler's Phi-function, Perfect numbers, Moebius function, Moebius inversion formula.

Quadratic Residues: Quadratic residues and non-residues, Legendre symbol, Law of quadratic reciprocity.

Primitive Roots: Order of an integer, Primitive roots for primes, Primitive root theorem. Diophantine Equations: Linear Diophantine equations, Pythagorean triples, Representation of integers as sum of squares.

Main text:

1. K.H. Rosen, **Elementary Number Theory and its Applications**, 5th edition, *AddisonWesley*, 2005.

Reference books:

1. J. K. Strayer, **Elementary Number Theory**, *Waveland Press, Inc*. 2001
2. D.M. Burton**, Elementary Number Theory**, *McGraw-Hill*, 2007.

MATH-422 Numerical Methods **Credit Hours: 3(3+0)**

Objectives of course: This course is designed to explore the numerical techniques, algorithm and discuss their theoretical background and efficiency. In this course we shall consider the several numerical approaches including root finding methods, interpolation, numerical integration etc.

Course Outline:

Numerical Solution of Non-linear Equations: The bisection method, the method of false position, the Newton-Raphson method, Rate of convergence of iterative methods.

Eigen value problems: Rutishauser method, the power and inverse power method, Jacobi's method, Given's method and House-holder's method. Numerical solutions of simultaneous linear algebraic equations: Solution by matrix inversion methods and Iterative methods (Jacobi, Gauss-Seidel, Successive over relaxation), convergence of iterative methods.

The error of interpolating polynomials. Finite difference operators (forward, backward, central, average and shift) and tables. Newton's forward and backward difference formulas.

Numerical integration: The Rectangular, Trapezoidal and Simpson rules. Romberg integration. Method of undetermined coefficients.

RECOMMENDED BOOKS:

1. W. A. Smith, Elementary Numerical Analysis, Harper & Row Pub. Int., 1979.
2.C. E. Froberg, Introduction to Numerical Analysis, Addsion-Wesley Co., 1974.
3.M. K. Jain, Numerical Methods for Scientific and Engineering Comp., Wiley E. Ltd, 1985.
4.R. L. Burden, J. D. Faires, Introduction to Numerical Analysis. 8th Ed, 2004.

MATH-423 Data Structure and Algorithms **Credit Hours: 3(3+0)**

Course Objectives: To introduce data structures like arrays, stacks, queues, trees and apply algorithmic techniques to solve sorting, searching and optimization problems with time and space complexity.

Course Outlines: Algorithm analysis, asymptotic analysis, big-oh notation, recursion, binary search, analyzing recursive algorithms, linear, binary and multiple recursion, array-based sequences, low-level arrays, dynamic arrays, stacks, queues, deques, linked lists, singly, circularly and doubly linked lists, trees, general trees, binary trees, implementing trees, tree traversal algorithms, priority queues, implementing priority queues, heaps, maps, hash tables, sorted maps, skip lists, sets, multisets and multimaps, binary search trees, balanced search trees, sorting and selection, merge-sort, quick sort.

Recommended Books:

1. J. Canning, A. Broder and R. Lafore, *Data Structures & Algorithms in Python,* Addison-Wesley Professional, 2022.
2. J. Wengrow, *A Common-Sense Guide to Data Structures and Algorithms in Python, Volume 1: Level Up Your Core Programming Skills*, Pragmatic Bookshelf, 2024.
3. M. T. Goodrich, R. Tamassia and M. H. Goldwasser, *Data Structures and Algorithms in Python,* Wiley, 2013.
4. B. Baka, *Python Data Structures and Algorithms: Improve application performance with graphs, stacks, and queues*, Packt Publishing, 2017.

MATH-424 Ordinary Differential Equations **Credit Hours: 3(3+0)**

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

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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 Richati 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, Modelling.

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.

SOC-313 Civics and Community Engagement Credit Hours: 2(2+0)

Course Outline:

1. **Civics and Citizenship:**
   - Concepts of civics, citizenship, and civic engagement.
   - Foundations of modern society and citizenship.
   - Types of citizenship: active, participatory, digital, etc.
2. **State, Government and Civil Society:**
   - Structure and functions of government in Pakistan.
   - The relationship between democracy and civil society.
   - Right to vote and importance of political participation and representation.
3. **Rights and Responsibilities:**
   - Overview of fundamental rights and liberties of citizens under Constitution of Pakistan 1973.
   - Civic responsibilities and duties.
   - Ethical considerations in civic engagement (accountability, non-violence, peaceful dialogue, civility, etc.)
4. **Community Engagement:**
   - Concept, nature and characteristics of community.
   - Community development and social cohesion.
   - Approaches to effective community engagement.
   - Case studies of successful community driven initiatives.
5. **Advocacy and Activism:**
   - Public discourse and public opinion.
   - Role of advocacy in addressing social issues.
   - Social action movements.
6. **Digital Citizenship and Technology:**
   - The use of digital platforms for civic engagement.
   - Cyber ethics and responsible use of social media.
   - Digital divides and disparities (access, usage, socioeconomic, geographic, etc.) and their impacts on citizenship.
7. **Diversity, Inclusion and Social Justice:**
   - Understanding diversity in society (ethnic, cultural, economic, political etc.).
   - Youth, women and minorities' engagement in social development.
   - Addressing social inequalities and injustices in Pakistan.
   - Promoting inclusive citizenship and equal rights for societal harmony and peaceful co-existence.

Recommended Books:

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1. "Civics Today: Citizenship, Economics, & You" by McGraw-Hill Education.
2. "Citizenship in Diverse Societies" by Will Kymlicka and Wayne Norman.
3. "Engaging Youth in Civic Life" by James Youniss and Peter Levine.
4. "Digital Citizenship in Action: Empowering Students to Engage in Online Communities" by Kristen Mattson.
5. "Globalization and Citizenship: In the Pursuit of a Cosmopolitan Education" by Graham Pike and David Selby.
6. "Community Engagement: Principles, Strategies, and Practices" by Becky J. Feldpausch and Susan M. Omilian.
7. "Creating Social Change: A Blueprint for a Better World" by Matthew Clarke and Marie-Monique Steckel.

MGT-411 Entrepreneurship **Credit Hours: 2(2+0)**

Course Outline:

1. **Introduction to Entrepreneurship:**
   - Definition and concept of entrepreneurship.
   - Why to become an entrepreneur?
   - Entrepreneurial process.
   - Role of entrepreneurship in economic development.
2. **Entrepreneurial Skills:**
   - Characteristics and qualities of successful entrepreneurs (including stories of successes and failures).
   - Areas of essential entrepreneurial skill and ability such as creative and critical thinking, innovation and risk taking abilities etc.
3. **Opportunity Recognition and Idea Generation:**
   - Opportunity identification, evaluation and exploitation;
   - Innovative idea generation techniques for entrepreneurial ventures.
4. **Marketing and Sales**
   - Target market identification and segmentation;
   - Four P's of Marketing.
   - Developing a marketing strategy.
   - Branding.

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5. **Financial Literacy:**
   - Basic concepts of income, savings and investments.
   - Basic concepts of assets, liabilities and equity.
   - Basic concepts of revenue and expenses.
   - Overview of cash-flows.
   - Overview of banking products including Islamic modes of financing.
   - Sources of funding for startups (angel financing, debt financing, equity financing etc.).
6. **Team Building for Startups:**
   - Characteristics and features of effective teams.
   - Team building and effective leadership for startups.
7. **Regulatory Requirements to Establish Enterprises in Pakistan:**
   - Types of enterprises (e.g., sole proprietorship; partnership; private limited companies etc.).
   - Intellectual property rights and protection.
   - Regulatory requirements to register an enterprise in Pakistan, with special emphasis on export firms.
   - Taxation and financial reporting obligation.

Recommended Books:

1. "Entrepreneurship: Successfully Launching New Ventures" by Bruce R. Barringer and R. Duane Ireland.
2. "Entrepreneurship: Theory, Process, and Practice" by Donald F. Kuratko.
3. "New Venture Creation: Entrepreneurship for the 21st Century" by Jeffry A. Timmons, Stephen Spinelli Jr., and Rob Adams.
4. "Entrepreneurship: A Real-World Approach" by Rhonda Abrams.
5. "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries.
6. "Effectual Entrepreneurship" by Stuart Read, Saras Sarasvathy, Nick Dew, Robert Wiltbank, and Anne-Valérie Ohlsson.

Semester-V				
1	MATH-511	Real Analysis-I	3(3+0)	Major
2	MATH-512	Set Topology	3(3+0)	Major
3	MATH-513	Partial Differential Equations	3(3+0)	Major
4	CS-514	Advanced Programming	3(3+0)	Interdisciplinary
5	MATH-514	Introduction to Mechanics	3(3+0)	Interdisciplinary
Semester Credit Hours			**15**	

MATH-511 Real Analysis-I **Credit Hours: 3(3+0)**

Objectives of course: At the end of this course the students will be able to understand the basic set theoretic statements and emphasize the proofs' development of various statements by

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induction. Define the limit of, a function at a value, a sequence and the Cauchy criterion. Prove various theorems about limits of sequences and functions and emphasize the proofs' development. Define continuity of a function and uniform continuity of a function, prove various theorems about continuous functions and emphasize the proofs' development. Define the derivative of a function of one variable, prove various theorems about the derivatives of functions and emphasize the proofs' development. Define a cluster point and an accumulation point, prove, Rolles's Theorem, extreme value theorem, boundedness theorem and the Mean Value theorem and emphasize the proofs' development.

Course Outline:

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

Sequences and Series of Real Numbers: Limits of sequences, The extended real number system. Euclidean space, Numerical sequences, Limits superior and inferior, Sub 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 maximizes, uniform continuity. Continuity and connectedness, Intermediate mean Value Theorem. Monotone functions and discontinuities.

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

Recommended Books:

1. S. Lang, Analysis I, Addison-Wesley Publ. Co.,Reading, Massachusetts, 1968.
2. W. Rudin, Principles of Mathematical Analysis, 3rd ed., Mc.Graw15Hill, 1976.
3. B. S. Thomson, J. B. Bruckner and A. M. Bruckner, ElementaryReal Analysis, 2nd Ed. 2008.
4. G. Boros, V. Moll, Irresistible Integrals: Symbolics, Analysisan Experiments in the Evaluation of Integrals, CambridgeUniversity Press, 2004.
5. J. Borwein, D. Bailey, R. Girgenson, Experimentation inMathematics: 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.

MATH-512 Set Topology Credit Hours: 3(3+0)

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 able to determine whether a function defined on a metric or topological space is continuous or not and what homeomorphisms are.

Contents: Motivation and introduction, sets and their operations, countable and uncountable sets, cardinal and transfinite numbers. Topological spaces, open and closed sets, interior, closure and boundary of a set, neighbourhoods and neighbourhood systems, isolated points, some topological theorems, topology in terms of closed sets, limit points, the derived and perfect sets, dense sets

and separable spaces, topological bases, criteria for topological bases, local bases, first and second countable spaces, relationship between separability and second countability, relative or induced topologies, necessary and sufficient condition for a subset of a subspace to be open in the original space, induced bases. Metric spaces, topology induced by a metric, equivalent topologies, formulation with closed sets, Cauchy sequence, complete metric spaces, characterization of completeness, Cantor's intersection theorem, the completion of metric space, metrizable spaces.

Recommended Books:

1. J. R. Munkres: Topology A First Course, (1975).
2. G. F. Simon: Introduction to Topology and Modern Analysis, (1963).
3. W. J. Pervin: Foundation of General Topology, (1965).

MATH-513 Partial Differential Equations Credit Hours: 3(3+0)

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, 3rdedition, 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.

MATH-514 Introduction to Mechanics Credit Hours: 3(3+0)

Course Outline:

Composition of Forces: Component of a force, Composition of Concurrent Forces, **The** λ, μ Theorem, Equilibrium of a Particle, Moment of a Force about a Point, Moment of a Force about a Point, Couples, Equivalent Couples, Composition of Couples, Resolution of a Force into a Force and a Couple, Reduction of a System of Coplanar, Forces to one Force and One Couple, Reduction of a System of Parallel Forces, Conditions of Equilibrium of a Coplanar Force System.

Friction: Friction, Laws of Fric1ion, Angle of Friction. Cone of Friction, equilibrium of a Particle on a Rough Inclined Plane and Horizontal Plane.

Virtual Work: Preliminary Definitions and Results, Applied Forces and Forces of Constraint, Virtual Displacement and Virtual Work, Workless Constraints, Principle of Virtual Work

Kinematics: Introduction, Velocity and acceleration, Cartesian components of velocity and acceleration, Tangential and normal components of velocity and acceleration, Radial and transverse components of velocity and acceleration.

Rectilinear Motion: Introduction, Motion with constant acceleration, Motion with variable acceleration, Graphical method, Motion of a free particle along the vertical line, Simple harmonic motion

Motion of a Projectile: Trajectory of a projectile, Speed of the projectile, Parabola of safety, Range on an inclined plane.

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 PublishingCo., 1980.
4. C. F. Chorlton, Text Book of Dynamics, Ellis Horwood, 1983.
5. M. R. Spiegel, Theoretical Mechanics, 3rd Edition, Addison-WesleyPublishing Company, 2004.
6. G. R. Fowles and G. L. Cassiday, Analytical Mechanics, 7th edition, Thomson Brooks/COLE, USA, 2005.

CS-514 Advanced Programming Credit Hours: 3(3+0)

CS-514 Advance Programming			
Credit Hours:	3(2-1)	**Prerequisites:**	OOP

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
1- Design, implement and test readable, efficient programs that take advantage of Python built-in capabilities and follow Python best practices.	C	6
2- Understand implementation differences and performance tradeoffs associated with various Python data structures.	C	2
3- Develop Python applications using the modules and packages available in the Python standard library.	C	6
4- Develop Python applications using third party libraries.	C	6
5- Design, implement and test Python programs that include a graphical user interface, data analysis and visualization, web data extraction and web applications.	C	6

* BT = Bloom's Taxonomy, C = Cognitive domain, P = Psychomotor domain, A = Affective domain

Course Content:

Introduction to Python Programming, environment setup, brief comparison of Python with other languages, basic python command line operations, Mathematical operators, Syntax and Variables. Numbers, strings, casting, strings. Arrays, Lists, Sets, Tuples and Dictionaries. Control statements, if, if-else, while loop, for loop. Functions, Lambda and Recursion. Classes and objects. Inheritance, Python Iterators, Python Scope, Python Modules. File Handling: Reading and Writing Files in Python. Python NumPy, Python SciPy, Pandas, Python MySQL.

Teaching Methodology:

Lectures, Written Assignments, Semester Project, Presentations

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Lab, Presentation, Final Exam

Reference Materials:

1. Bishop, C. (2011). Pattern recognition and machine learning (Latest ed.). Springer.

2. Harrington, P. (2012). Machine learning in action (5th Ed.). Greenwich, CT: Manning

3. Mohri, M., Rostamizadeh, A., & Talwalkar, A. (2012). Foundations of machine learning (Latest ed.). MIT press.

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4. Richert, W. (2013). Building machine learning systems with python (Latest ed.). Packt Publishing Ltd.

5. Python Crash Course, 2nd Edition: A Hands-On, Project-Based Introduction to Programming.

6. Python Data Science Handbook Essential Tools for Working with Data Science 1st Edition by Jake VanderPlas

Semester-VI				
1	MATH-521	Real Analysis-II	3(3+0)	Major
2	MATH-522	Complex Analysis	3(3+0)	Major
3	MATH-	Elective-I	3(3+0)	Major
4	AI-612	Machine Learning	3(2+1)	Interdisciplinary
5	PHY-214	Introduction to Classical Mechanics	3(3+0)	Interdisciplinary
6	MATH-523	Internship	3(3+0)	
Semester Credit Hours			**18**	

MATH-521 Real Analysis-II Credit Hours: 3(3+0)

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.

Fourier series; Orthogonal functions, Legendre, Hermite and Laguerre polynomials, Convergence in the mean. Fourier-Legendre and Fourier-Bessel series, Bessel inequality, Parseval equality. Convergence of the trigonometric Fourier series.

Recommended Books:

1. S. Lang, Analysis I, II, Addison-Wesley Publ. Co., Reading,Massachusetts,1968,1969.

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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.

MATH- 522 Complex Analysis Credit Hours: 3(3+0)

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.

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AI- 612 Machine Learning Credit Hours: 3(2+1)

Crouse Outline: Introduction to machine learning; concept learning: General-to specific ordering of hypotheses, Version spaces Algorithm, Candidate elimination algorithm; Supervised Learning: decision trees, Naive Bayes, Artificial Neural Networks, Support Vector Machines, Overfitting, noisy data, and pruning, Measuring Classifier Accuracy; Linear and Logistic regression; Unsupervised Learning: Hierarchical Aglomerative Clustering. k-means partitional clustering; Self-Organizing Maps (SOM) k-Nearest neighbor algorithm; Semi- supervised learning with EM using labeled and unlabled data; Reinforcement Learning: Hidden Markov models, Monte Carlo inference Exploration vs. Exploitation Trade-off, Markov Decision Processes; Ensemble Learning: Using committees of multiple hypotheses. Bagging, boosting.

Recommended Books:

1. Machine Learning, Tom, M., McGraw Hill, 1997.
2. Machine Learning: A Probabilistic Perspective, Kevin P. Murphy, MIT Press,2012.

PHY- 422 Classical Mechanics Credit Hours: 3(3+0)

Objectives: To give a basic understanding of the classical mechanics concepts

Course Contents:

Review of Newtonian Mechanics: Frame of reference, orthogonal transformations, angular velocity and angular acceleration, Newton's laws of motion, Galilean transformation, conservation laws, systems of particles, motion under a constant force, motions under variable force, time-varying mass system.

The Lagrange Formulation of Mechanics and Hamilton Dynamics: Generalized coordinates and constraints, D-Alembert's principle and Lagrange's Equations, Hamilton's principle, integrals of motion, non-conservative system and generalized potential, Lagrange's multiplier method, the Hamiltonian of a dynamical system, canonical equations, canonical transformations, Poisson brackets, phase space and Liouville's theorem.

Central Force Motion: The two-body problem, effective potential and classification of orbits, Kepler's laws, stability of circular orbits, hyperbolic orbits and Rutherford scattering, center of mass co-ordinate system, scattering cross-sections.

Motion in Non-Inertial Systems: Accelerated translational co -ordinate system, dynamics in rotating co-ordinate system, motion of a particle near the surface of the earth.

The Motion of Rigid Bodies: The Euler angles, rotational kinetic energy and angular momentum, the inertia tensor, Euler equations of motion, motion of a torque-free symmetrical top, stability of rotational motion.

Recommended Books:

1. T. L. Chow, "Classical Mechanics", John Wiley, 1995.
2. Kibble and F. Berkshire, "Classical Mechanics", World Scientific, 5th ed. 2004.

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3. S.T. Thornton, J.B. Marion, "Classical Dynamics of Particles and Systems", Brooks Cole; 5th ed. (2003).

Semester-VII				
1	MATH-611	Differential Geometry	3(3+0)	Major
2	MATH-612	Mathematical Methods	3(3+0)	Major
3	MATH-	Elective-II	3(3+0)	Major
4	MATH-	Elective-III	3(3+0)	Major
5	MATH-	Elective-IV	3(3+0)	Major
6	MATH-613	Scientific Writing & Research Methods	3(3+0)	Interdisciplinary
Semester Credit Hours			**18**	

MATH-611 Differential Geometry **Credit Hours: 3(3+0)**

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

Course Outline:

Historical background; Motivation and applications, Index notation and summation convention, Space curves, The tangent vector field, Parameterization, Arc length, Curvature, Principal normal, Binormal, Torsion, Osculating, Normal and Rectifying planes, Frenet-Serret Theorem, Spherical images, Sphere curves, Spherical contacts, Fundamental theorem of space curves, Line integrals and Green's theorem, Local surface theory, Coordinate transformations, Tangent and the Normal planes, Parametric curves, First fundamental form and the metric tensor, Normal and geodesic curvatures, Gauss's formulae, Christoffel symbols of first and second kinds, Parallel vector fields along a curve and parallelism, Second fundamental form and the Weingarten map, Principal, Gaussian, Mean and Normal curvatures, Dupin indicatrices, Conjugate and asymptotic directions, Isometries and the fundamental theorem of surfaces.

Recommended Books:

1. R. S. Millman and G. D. Parker, Elements of DifferentialGeometry, 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 PublishingHouse, New Delhi. 2005.
6. M. R. Spiegel, Vector Analysis, McGraw Hill BookCompany, Singapore, 1981.

7. A. W. Joshi, Matrices and Tensors in Physics, Wiley EasternLimited, 1991.
8 F. Chorlton, Vector and Tensor Methods, Ellis HorwoodPublisher, U.K., 1977.

MATH-612 Mathematical Methods Credit Hours: 3(3+0)

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..

MATH-613 Scientific Writing & Research Methods Credit Hours: 3(3+0)

Introduction to Scientific Research in Mathematics: Nature, scope, and objectives of research Pure vs applied research in mathematics, Components of a research study: problem, hypothesis, variables.

Research Process and Methodology: Steps in the research process, Selection and formulation of research problems, Inductive and deductive reasoning in mathematics, Types of reasoning and proof strategies (direct, contradiction, induction)

Literature Review and Research Gap: Purpose and structure of a literature review, identifying

credible sources: MathSciNet, arXiv, JSTOR, Google Scholar, Annotated bibliography, Finding research gaps.
Scientific and Mathematical Writing: Features of good scientific writing, Structure of a mathematical research paper, Writing clear theorems, lemmas, definitions, Avoiding common writing errors in mathematics.
Tools for Scientific Writing: Introduction to LaTeX and Overleaf, Writing, equations, tables, references in LaTeX, Reference management software, (Zotero, JabRef, Mendeley).
Citation and Referencing: Importance of referencing and avoiding plagiarism, Common referencing styles (APA, AMS), Using BibTeX with LaTeX.
Research Ethics: Academic integrity and plagiarism, Authorship and credit, Research misconduct and its consequences, Copyright and intellectual property.
Proposal and Report Writing: Components of a research proposal, Writing a mini-thesis or semester project report, Abstract and summary writing.
Scientific Communication and Presentation: Presentation of mathematical ideas, Making effective PowerPoint and Beamer (LaTeX) presentations, Poster presentations and seminar participation.
Practical / Lab Work (1 Credit Hour): Practice sessions in LaTeX, formatting a mathematical report, Searching and citing references from digital libraries, Preparing a short research proposal on a mathematical topic, Creating and presenting slides using Beamer, Ethical writing practices: paraphrasing, citation checking tools, Seminars, Group activities and peer review, Seminar presentations.

Recommended Textbooks & Resources:

1. Creswell, J. W. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches
2. Higham, N. J. Handbook of Writing for the Mathematical Sciences
3. Lamport, L. LaTeX: A Document Preparation System
4. HEC Digital Library (MathSciNet, JSTOR, SpringerLink, Elsevier)
American Mathematical Society (AMS) Author Guidelines

Elective Courses for BS Mathematics

Sr. No.	Course Code	Course Title	Credit Hours
1	MATH-631	Measure Theory	3(3+0)
2	MATH-632	Rings and Modules	3(3+0)
3	MATH-633	Group Action	3(3+0)
4	MATH-634	Group Theory-II	3(3+0)
5	MATH-635	Graph Theory	3(3+0)
6	MATH-636	Galois Theory	3(3+0)

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7	MATH-637	Fluid Mechanics	3(3+0)
8	MATH-638	Mathematical Modelling	3(3+0)
9	MATH-639	Integral Equations	3(3+0)
10	MATH-640	Ring Theory	3(3+0)
11	MATH-641	Introduction to Algebraic geometry	3(3+0)
12	MATH-642	Continuous Groups	3(3+0)
13	MATH-643	Introduction to Combinotorics	3(3+0)
14	MATH-644	Introductions to Algebraic Systems	3(3+0)
15	MATH-645	Dynamics	3(3+0)
16	MATH-646	Special Functions	3(3+0)
17	MATH-647	Quantum Mechanics	3(3+0)
18	MATH-648	Mathematical Biology	3(3+0)
19	MATH-649	Ring and Fields	3(3+0)
20	MATH-650	Operation Research	3(3+0)
21	MATH-651	Functional Analysis-I	3(3+0)
23	MATH-652	Functional Analysis-II	3(3+0)
24	MATH-653	Linear Algebra-II	3(3+0)
25	MATH-654	Numerical Analysis	3(3+0)
26	MATH-655	Optimization Theory	3(3+0)
27	MATH-656	History of Mathematics	3(3+0)
28	MATH-657	Introduction to Fractional Differential Equations	3(3+0)
29	MATH-658	Vector and Tensor Analysis	3(3+0)
30	MATH-659	Dynamical Systems	3(3+0)

Course Outline: for BS Mathematics (Elective Courses)

MATH-631 Measure Theory **Credit Hours: 3(3+0)**

Objectives of course: Measure theory is that branch of mathematics which evolves from the idea of "weighing" a set by attaching a non-negative number to it which signifies its worth. This generalises the usual physical ideas of length, area and mass as well as probability. It turns out that these ideas are vital for developing the modern theory of integration. The aim of this course is to give a more rigorous introduction to the theory of measure and develop the ideas of Lebesgue integration and its properties.

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Course Outline:

Measurable Sets: Outer measure, Lebesgue measure, Lebesgue measurable sets, Borel sets, Non measurable sets.

Measurable Functions : Lebesgue measurable functions, Simple functions, characteristic functions, Borel measurable function Littlewood three principle.

The Lebsegue Integration: Review of the Riemann integral, Lebsegue integral, Integral of a nonnegative function, Integral of measurable functions, Convergence in measure.

Reference Books:

1. D. Smith, M. Eggen and R. St. Andre, A Transition to Advanced Mathematics, (Brooks, 2001)
2. Seymour Lipshcutz, Set Theory and Related Topics, (Mc-Graw Hill Book Company, 1999)
3. H. L. Royden, Real Analysis, (Macmillam, 1968)
4. D. L. Cohan, Measure Theory, (Bir Khauser, 1980)
5. P.R. Halmos, Measure Theory, (Von Nostrand, New York, 1950)

MATH-632 Rings and Modules **Credit Hours: 3(3+0)**

Course Outline: Rings and modules, decomposition of modules, decomposition theorem, the primary decomposition theorem, The primary decomposition, Abelian groups as Z-modules, Abelian groups, Sylow's theorem, linear transformation and matries, invariants and the Jordan canonical form, the rational canonical form theorem - (linear transformation version), The Jordan canonical form theorem, conjugacy classes in general linear groups.

Recommended Books:

1. Blyth, T., Module theory, O.U.P., Oxford, 1977.
2. Hartley, B. and Hawkes, T., Rings, modules and linear algebra, Chapman, G., Lecture Nortes on Modules, Michigan University Press.

MATH-633 Group Action **Credit Hours: 3(3+0)**

Course Outline: Actions of Groups, Permutation representation, Equivalence of actions, Regular representation, Cosets spaces, Linear groups and vector spaces. Affine group and affine spaces, Transitivity and orbits, Partition of G-spaces into orbits, Orbits as conjugacy class Computation of orbits, The classification of transitive G-spaces Catalogue of all transitive G-spaces up to G-isomorphism, One-one correspondence between the right coset of Ga and the G-orbit, G-isomorphism between coset spaces and conjugation in G. Simplicity of A5, Frobenius-Burnside lemma, Examples of morphisms, G-invariance, Relationship between morphisms and congruences, Order preserving one-one correspondences between congruences on Ω and subrroups H of G that contain the stabilizer Gα. The alternating groups, Linear groups, Projective

groups, Mobius groups, Orthogonal groups, unitary groups, Cauchy's theorem, P-groups, Sylow P-subgroups, Sylow theorems, Simplicity of An when n $\geq$ 5.

Recommended Books:

1. J.S. Rose, A Course on Group Theory, Cambridge University Press, 1978.
2. H. Wielandt, Finite Permutation Groups. Academic Press, 1964.
3. J.B. Fraleigh, A Course in Algebra, Addison-Wesley 1982.

MATH-634 Group Theory-II **Credit Hours: 3(3+0)**

Course Outline: Group action, solvable and nilpotent groups, P-groups, upper and lower central series, finitely generated abelian groups,T-groups, Dedekind groups, subnormal subgroups, characteristic groups, Wielandt subgroups, Wielandt theorem, Frattini subgroups, fitting subgroups, Socle subgroups, Endomorphism and Automorphism, power automorphism of groups, universal power automorphism, simple groups.(Definition and examples). Direct product of groups, Sylow groups and Sylow theorems, normal series of a group, refinement theorem, composition series and Jordan Holder theorem

RECOMMENDED BOOKS:

1. J. B. Fraleigh, A First Course in Algebra, Addison Wesley Co., 1976.
2. I. N. Herstein, Topics in Algebra, Ginn & Co.
3. P. M. Cohn, Algebra Vol. I & II, John Wiley & Sons.
4. A. Majeed, Theory of Groups, University Grant Commission.
5. T. S. Blyth, E. F. Robertson, Essential student Algebra, Vol I-V, Chapman & Hall, 1986.
6. T. S. Blyth, E. F. Robertson, Algebra Through Practice, Book I-VI, CUP, 1984.

MATH-635 Graph Theory **Credit Hours: 3(3+0)**

Course Outline: Undirected graphs, Geometric graphs, Abstract graphs, Isomorphism, Edge progressions chains and circuits rank and nullity, Degrees, Trees. Bipartite graphs, Unicursal graphs, Hamiltonian Graphs. Directed graphs, Arc Progressions, paths progression and cycle progression. Partition and distances in graphs, edge partitions, Arc partitions, Hamiltonian chains and circuits, vertex partitions, radius and diameter, minimal length problem. Foundation of electrical network theory. Matrix representation, the incidence matrix, the circuit matrix, the cut-set matrix, the vertex or adjacency matrix, the path matrix. Network Flows, network flow problems.

RECOMMENDED BOOKS:

1. R. G. Busacker, T. L. Seaty, Finite graphs and Networks', An introduction with applications', McGraw Hill Book Company.
2. R. J. Wilson, Introduction to Graph Theory, Longman Scientific and Technical, 1985.

Wai-Kaichen,Applied graph Theory "graphs and electrical networks, North-Holland Pub., 1976. Bela Bollobas,Advances in Graph Theory.

MATH-636 Galois Theory **Credit Hours: 3(3+0)**

Course Outline: Integral domains and Fields, Homomorphisms and ideals, Quotient Rings, Polynomial rings in one indeterminate over Fields, Prime ideals and Maximal ideals, irreducible Polynomials. Algebraic and Transcendental field extensions, Simple Extensions, Composite Extensions, Splitting Fields, The Degree of an Extension, Ruler and Compass Constructions. Normality and Separability. Circle Division, The Galois Group, Toots of Unity, Solvability by Radicals, Galois extensions, The Fundamental Theorem of Galois Theory, Galois's Great Theorem, Algebraically Closed Fields.

Recommended Books:

1. Joseph Rotman, "Galois Theory", Springer-Veriog, New York, Inc. (2005)
2. Lan Steward, "Galois Theory", Chapman & Hall, New York (2004)
3. David S. Dummit and Richard M. Foote, "Abstract Algebra", John Wiley & Sons, Inc, New York (2002).

MATH-637 Fluid Mechanics **Credit Hours: 3(3+0)**

Course Outline: Viscous Fluids: Review of the basics of fluids, Two-dimensional motion, stream function, complex potential and some potential flows; sources, sinks and doublets; Circle theorem; Method of images; Blasius theorem; Aerofoil and the theorem of Kutta and Joukowski; Vortex motion; Karman's vortex street. Viscous Fluids, constitutive equations; Navier-Stokes equations; Exact solutions of Navier-stokes equations, Steady unidirectional flow; Poiseuille flow, Couette flow, Unsteady Unidirectional flow; sudden motion of a plane boundary in a fluid at rest, flow due to an oscillatory boundary, Equations of motion relative to a rotating system, Ekman flow, Dynamical similarity and the Reynolds number, Boundary layer concept and its governing equations; Flow over a flat plate (Blasius solution); Reynolds equations of turbulent motion.

RECOMMENDED BOOKS:

- I. G. Currie, Fundamental Mechanics of Fluids, McGraw-Hill Co., 1974.
- Schlichting, Boundary Layer Theory, McGraw-Hill Co., 1979.
- F. Chorltan, Fluids Dynamics, CBS Pub. & Dist., 1985.
- F. M. White, Introduction to fluid mechanics.
- Fox, McDonald, Introduction to fluid mechanics.

MATH-638 Mathematical Modelling **Credit Hours: 3(3+0)**

Objectives of Course: Mathematics is used in many areas such as engineering, ecological systems, biological systems, financial systems, economics, etc. In all such applications one approximates the actual situation by an idealized model. This is an introductory course of modeling, consisting of three parts: modeling with ordinary differential equations and their systems; partial differential equations; and integral equations. The course will not be concerned with the techniques for solving the equations but with setting up the equations in specific applications. Whereas the first two types of equations have already been dealt with, the third type has not. Consequently, solutions of the former will be discussed but of the latter will barely be touched upon.

Course Outline: Concepts of model and modeling, functions, linear equations, linear-differential equations, nonlinear-differential equations and integral equations as models.

Ordinary-Differential Equations: Modeling with first order differential equations: Newton's law of cooling; radioactive decay; motion in a gravitational field; population growth; mixing problem; Newtonian mechanics. Modeling with second order differential equations: vibrations; application to biological systems; modeling with periodic or impulse forcing functions, Modeling with systems of first order differential equations; competitive hunter model; predator-prey model.

Partial-Differential Equations: Methodology of mathematical modeling; objective, background, approximation and idealization, model validation, compounding. Modeling wave phenomena (wave equation); shallow water waves, uniform transmission line, traffic flow, RC circuits, Modeling the heat equation and some application to heat conduction problems in rods, lamina, cylinders etc. Modeling the potential equation (Laplace equation), applications in fluid mechanics, gravitational problems, Equation of continuity.

Recommended Books:

1. Giordano FR, Weir MD, Differential Equations: A Modeling Approach, 1994, Addison-Wesley, Reading, Ma, USA (suggested text)
2. Jerri AJ, Introduction to Integral Equations with Applications, 1985, Marcel Dekker, New York
3. Myint UT, Debnath L, Partial Differential Equations for Scientists and Engineers (3rd edition), 1987, North Holland, Amsterdam

MATH-639 Integral Equations Credit Hours: 3(3+0)

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 behaviour 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.

MATH-640 Ring Theory Credit Hours: 3(3+0)

Course Outline: Rings and Fields, Integral domains ,ideals, Operations on ideals, quotient rings and homomorphism of rings. Isomorphism, Isomorphism theorems, Embedability of an integral domain in a field, Field of quotients, Maximal and Prime ideals and their properties, Divisibility theory in integral domains, Polynomial rings, Division Algorithm, Remainder theorem, Field extensions.

RECOMMENDED BOOKS:

1. J. B. Fraleigh, A First Course in Algebra, Addison Wesley Co., 1976.
2. I. N. Herstein, Topic in Algebra, Ginn & Co.
3. P. M. Cohn, Algebra Vol. I & II, John Wiley & Sons.
4. Burton, A First Course in Rings & Ideals, Addison Wesley Co.
5. J. Lambek, Lectures on Rings & Modules, Blaisdel.
6. T. S. Blyth, E.F. Robertson, Essential student Algebra, Vol I-V, Chapman & Hall, 1986.
7. T. W. Hungerford, Abstract Algebra: An Introduction

MATH-641 Introduction to Algebraic geometry Credit Hours: 3(3+0)

Course Outline: Algebraic varieties: Affine algebraic varieties, Hibert basis Theorem, Decomposition of variety into irreducible components, Hibert's Nulttstellensatz, The Sectrum of a Ring, Projective variety and the homogeneous Spectrum. Functions and Morphisms: Some properties of Zariski topology, Rings and modules of functions and their properties, Coordinate ring and polynomial functions, Polynomial maps, Regular and rational functions, Morphisms, Rational maps. Dimension: The Krull dimension of Topological Spaces and Rings, Prime Ideal

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Chain and Integral Extensions, The Dimension of Affine Algebras and Affine Algebraic Varieties, The Dimension of Projective Varieties.

Applications: The product of varieties, On dimension, Tangent space and smoothness, Completeness.

Recommended Books:

- O. Zariski and P. Samual, Commutative Algebra, Vol. 1, Van Nostrand, Princeton, N. J., 1958.
- M.F. Atiyah and I. G. Macdonald, Introduction to Commutative Algebra, Addison Wesley Pub. Co., 1969.
- I.R. Shafarevich, Basic Algebraic Geometry, Springer Verlag, 1974.
- R. Hartshorne, Algebraic Geometry, Springer Verlag, 1977.
- E, Kunz, Introduction to Commutative Algebra and Algebraic Geometry, Boston; Basel; Stuttgrat: Birkhauser, 1985.

MATH-642 Continuous Groups Credit Hours: 3(3+0)

Course Outline: Continuous Groups; Gl(n,R), Gl(n,C), So(p,q), Sp(2n); generalities on continuous groups; groups of isometries, classification of two and three dimensional Euclidean space according to their isometries; introduction to Lie groups with special emphasis on matrix Lie groups; relationship of isometries and Lie group; theorem of Cartan; correspondence of continuous groups with Lie algebras; classification of groups of low dimensions; homogeneous spaces and orbit types; curvature of invariant metrics on Lie groups and homogeneous spaces.

Recommended Books:

1. Bredon, G.E., Introduction to compact transformation groups, Academic Press, 1972.
2. Eisenhart, L.P., Continuous groups of transformations, Priceton U.P., 1933.
3.Pontrjagin, L.S., Topological groups, Princeton University Press, 1939.
4.Husain Taqdir., Introduction to Topological Groups, W.B. Saunder's Company,1966.
5.Miller Willard, Jr., Symmetry groups and their application, Academic Press New York and London 1972.

MATH-643 Introduction to Combinatorics Credit Hours: 3(3+0)

Course Outline: To basic counting principles, Permutations, Combinations. The injective and bijective principles, Arrangements and selections with repetitions. Graphs in Combinatorics.The Binomial theorem, combinatorial identities. Properties of binomial coefficients, Multinomial coefficients, The multinomial theorem. The Pigeonhole principle, Examples, Ramsay numbers, The principle of inclusion and exclusion, Generalization. Integer solutions. Surjective mapping, Stirling numbers of the second kind, The Sieve of Eratostheries, Euler φ-function, The Probleme des Manages. Ordinary Generating Functions, Modelling problems. Partition of integers,

Exponential generating functions. Linear homogeneous recurrence relations, Algebraic solutions of linear recurrence relations and constant functions, The method of generating functions, A non-linear recurrence relation and Catalpa numbers

Recommended Books:

1. A Tucker, Applied Combinatorics, John Wiley & Sons, New York, 2nd Edition, 1985.
2. C.C. Chen and K.M.Koh, Principles and Techniques in Combinatorics, World Scientific Pub. Co. Pte. Ltd, Singapore. 1992.
3. V.K.Balakrishnan, Theory and Problems of Combunatorics, Schaum's Outline Series, MeGraw-Hill International Edition, Singapore, 1995.
4. C.L.Liu, Introduction to Combinatorial Mathematics, McGraw-Hill, New York, 1968.
5. J.H.van Ling & R.M. Wilson, A course on Combinatorics, 2nd Edition, Cambridge University Press, Cambridge, 2001.

MATH- 644 Introductions to Algebraic Systems Credit Hours: 3(3+0)

Course Outline: An introduction to the use of abstract methods in mathematics, using algebraic systems that play an important role in many applications of mathematics. Abelian groups, Commutative rings with identity, fields, Ideals, Polynonial rings, Principal Ideal domains, arithmetic of integers mod n and finite fields. Vector spaces over arbitrary fields, Examples of Algebra of Polynomial rings over an arbitrary field, subspaces, bass, linear transformations. Eigenvalues, eigenvectors, eigenspaces, Characteristies, Polynomial, Minimal Polynomial, Linear Transformation as a matrix operator, geometric and algebraic multiplicity and diagonalisation. Groups: subgroups, cosets, Lagrange's theorem, homomorphisms. Applications to coding theory will be chosen from: linear codes, encoding and decoding, the dual code, the parity check matrix, syndrome decoding, Hamming codes, perfect codes, cyclic codes, BCH codes.

Recommended Books:

1. Any book labeled "Abstract Algebra" or "An Introduction to Abstract Algebra". Call numbers are AQ 162 and QA266.
2. In addition. John B Fraleigh A First Course in Abstract Algebra, 5th edition, Addison-Wesley, 1994, AQ266.F7.

MATH-645 Dynamics Credit Hours: 3(3+0)

Course Outline: Particle Dynamics: Projectile motion under gravity, constrained particle motion, angular momentum of a particle. Orbital Motion: Motion of a particle under a central force, use of reciprocal polar co-ordinates, use of pedal co-ordinates and equations, Kepler's laws of planetary motion. Motion of a system of Particles: Linear momentum of a system of particles, angular momentum and rate of change of angular momentum of a system, use of centroid, moving origins, impulsive forces, elastic impact. Introduction to Rigid Body Dynamics: Moments and

products of inertia, the theorems of parallel and perpendicular axes, angular momentum of a rigid body about a fixed point and about fixed axes, principal axes. Kinetic energy of a rigid body rotating about a fixed point, general motion of a rigid body, momental ellipsoid, equimomental system, coplanar distribution.

RECOMMENDED BOOKS:

- F. Chorlton, Text book of Dynamics, Ellis Horwood Ltd., 1983.
- L. A. Pars, Introduction to Dynamics, Cambridge Uni. Press, 1953.
3. A. S. Remsey, Dynamics Part-I, Cambridge Uni. Press, 1962.
4. J. L. Synge and B. A. Griffith, Principle of Mechanics, McGraw Hill Book Co., 1970.

MATH-646 Special Functions Credit Hours: 3(3+0)

Course Outline: Definition and properties of Gamma function, Beta function, Incomplete Gamma function. Digama and Polygamma function. Definition and generating function of Legendre polynomials. Recurrence relation and Legendre polynomials. Recurrence relation and Legendre differential equation. Rodrigue's formula. An Integral representation of Legendre polynomials and orthogonality. Hermite polynomials. Differential equation solvable with Bessel functions. An Integral form of Bessel function and orthogonality. The Laplace transformation and application of differential equations.

RECOMMENDED BOOKS:

1. L. C. Andrews, Special functions for Engineers and applied mathematics, McMillan Publishing Company.
2. N.W. Lebedev, Special functions and their applications, Dover Publishing Inc., 1972.
3. B. Spain, M. G. Smith, Functions of Mathematical Physics, Van Nostrand Reinhold Comp., 1970.
4. W. E.Boyee, R. C.Dipri, Elementary differential equations and boundary value problems,John Wiley and Sons, 1986.
1. E.D. Rainvill, Special Functions, McGraw Hill, 1992

MATH-647 Quantum Mechanics Credit Hours: 3(3+0)

Course Outline: Inadequacy of Classical Mechanics, Wave particle duality. Schrodinger's equation, Harmonic oscillator, One dimensional motion in a potential well. Reflection by and transmission across a potential barrier, Uncertainty principle, Dirac delta function, Operator formulism in Quantum Mechanics, Angular momentum. Pauli Exclusion Principle. Hydrogen atom.

RECOMMENDED BOOKS:

1. R.L.White, Basic Quantum Mechanics, McGraw Hill Book Co. NY, 1966.
2. L.I.Schiff, Quantum Mechanics, McGraw Hill Kogakusha Ltd., 1955.

3. P.T.Mathews, Introduction to Quantum Mechanics, McGraw Hill Book Co., 1974.
4. Dicke & Wittke, Introduction to Quantum Mechanics, Addison Wesley Pub. Co. Inc., 1966.

MATH-648 Mathematical Biology **Credit Hours: 3(3+0)**

Objectives of Course: Interactions between the mathematical and biological sciences have been increasing rapidly in recent years. This course will help the students to understand how to form mathematical models from bio data or infectious disease.

Course Outlines: History of mathematical models. Formation of biological model. Equilibria and global and local stability of biological models. Investigations of some basic biological model including SI, SIS, SIR epidemic and endemic disease model, Logistic equation and evolution models, the Lotka Voltera models. Introduction to optimal control and some important applications.

Recommended Books:

1. Jeffrey R. Chasnov , Mathematical Biology, Hong Kong University Press , 2009
2. Elizabeth S. Allman and John A. Rhodes, An Introduction to Mathematical Models in Biology, Cambridge University Press, 2004.
3.Miklos Farkas , Dynamical Models in Biology, Academic Press, New York, 2001.

MATH-649 Rings and Fields **Credit Hours: 3(3+0)**

Course Outline: Rings, Subrings, Ideals, Factor ring, Definitions and basic concepts, Homomorphisms, Homomorphism theorems, Polynomial rings, Unique factorization domain, Factorization theory, Euclidean domains, Arithmetic in Euclidean domains, Extension fields, Algebraic and transcendental elements, Simple extension, Introduction to Galois theory, Examples of finite fields, application of vector spaces to binary linear codes and Markov (chain) Process, Application in Economics. Findings finite agebras through GAP.

Recommended Books:

1. S. J. Axler: Linear Algebra Done Right (1996).
2. B. Kolman and D. R. Hill: Introductory Linear Algebra with Applications, (2001).
3. D. S. Dummit and R.M. Foote: Abstract Algebra, (2002).
4. K. Nomizu: Fundamentals of Linear Algebra, (1966)

MATH- 650 Operation Research **Credit Hours: 3(3+0)**

Course Outline: Introduction to Operations Research and real life Phases, introduction to linear programming (LP) with examples, Graphical solutions to Mathematical Model with Special Cases, Simplex Algorithm and its different cases, Big M Method and Two phase Method, Scheduling and Blending Problems, The Transportation Problems, The Transshipment Problems, The Assignment

Problems, integer Programming, network Models, Inventory Models, Dynamic Programming and Queuing Theory.

Recommended Books:

- Hamdy A. Taha, Operations Research-An Introduction, 10th Ed. Pearson Education, 2016.
- B. E Gillett, Introduction to Operations Research, Tata McGraw Hill Publishing Company Ltd., New Delhi,1979.
- F.S Hillier and G. J. Liebraman, Operations Research, CBS Publishers and Distributors, New Delhi, 1974.

MATH- 651 Functional Analysis-I Credit Hours: 3(3+0)

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.

MATH- 652 Functional Analysis-II Credit Hours: 3(3+0)

Course Outline: The Hahn-Banach theorem, principle of uniform boundedness, open mapping theorem, closed graph theorem, Weak topologies and the Banach-Alouglu theorem, extreme points and the Klein-Milman theorem.The dual and bi-dual spaces, reflexive spaces, compact operators, Spectrum and eigenvalues of an operator, elementary spectral theory.

Recommended Books:

1. Kreyszing, E., Introductory Functional Analysis and Applications, John Wiley, 1973.
2. Taylor, A.E., and Lay, D.C., Introduction of Functional Analysis, John Wiley, 1979.

3. Heuser, H.G., Functional Analysis, John Wiley, 1982.
4. Groetsch, C.W., Elements of Applicable Functional Analysis, Marcel Dekker, 1980.

MATH- 653 Linear Algebra-II **Credit Hours: 3(3+0)**
MATH- 654 Numerical Analysis **Credit Hours: 3(3+0)**

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.

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.

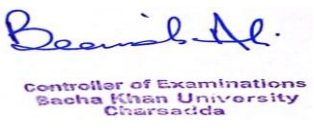
Numerical integration: Rectangular rule, trapezoidal rule, Simpson's 1/3 and 3/8 rules, Boole's and Weddle's rules, Newton-Cotes formulae, Gaussian quadrature.

Difference Equations:

Numerical solutions of Differential equations: Numerical Solution of ODEs (Taylors' series methods, Euler and Modified Euler Methods, RK methods, Predictor Corrector Methods), Numerical Solutions of PDEs (Finite difference method)

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.

MATH-655 Optimization Theory **Credit Hours: 3(3+0)**

Course Outline: Linear programming: simplex method, duality theory, dualand primal-dual simplex methods. Unconstrained optimization: optimality conditions, one-dimensional problems, multi-dimensional problems and the method of steepest descent. Constrained optimization with equality constraints: optimality conditions, Lagrange multipliers, Hessians and bordered Hessians. Inequality constraints and the Kuhn-Tucker Theorem. The calculus of variations, the Euler-Lagrange equations, functionals depending on several variables, variational problems in parametric form, transportation models and networks.

Recommended Books:

- Elsgolts L, *Differential Equations and the Calculus of Variations*, 1970, Mir Publishers, Moscow
- Gotfried BS, Weisman J, *Introduction to Optimization Theory*, 1973, Prentice Hall, Englewood Cliffs, NJ, USA
- Luenberger DG, *Introduction to Linear and Non-Linear Programming*, 1973, Addision-Wesley, Reading, Ma, USA

MATH- 656 History of Mathematics **Credit Hours: 3(3+0)**

Course Objectives

By the end of this course, students will be able to:

- Understand the chronological development of mathematical concepts.
- Appreciate the contributions of various civilizations to mathematics.
- Recognize the historical context and practical motivations for mathematical discoveries.
- Analyze original historical texts and their impact on modern mathematics.

Course Content Outline

Mathematics in Ancient Civilizations

- **Babylonians** used a base-60 system and developed algebraic tablets.
- **Egyptians** applied geometry for land surveying; arithmetic appears in the *Rhind Papyrus*.

Greek Mathematics

- **Early Greek thinkers** (like Thales and Pythagoras) pioneered deductive reasoning and number theory.
- **Later Greeks** like Euclid developed axiomatic systems, while Archimedes and Apollonius explored applied mathematics and conic sections.

Indian Mathematics

- Introduced the **decimal system and zero**.
- Mathematicians like **Aryabhata, Brahmagupta, and Bhaskara** contributed to algebra and trigonometry.

Chinese Mathematics

- Key work: *The Nine Chapters on the Mathematical Art*.
- Notable for **magic squares**, **solving equations**, and **geometric insights by Liu Hui**.

Islamic Golden Age

- **Al-Khwarizmi** advanced algebra.
- Developed **trigonometry and astronomical methods**, while preserving Greek and Indian knowledge.

Medieval European Mathematics

- **Fibonacci's Liber Abaci** introduced Arabic numerals.
- Despite stagnation, universities and Islamic scholarship influenced European thought.

Renaissance and Early Modern Era

- Revival of Greek works sparked progress.
- **Vieta** advanced symbolic algebra; **geometry** influenced Renaissance art.

MATH- 657 Introductory Fractional Differential Equations Credit Hours: 3(3+0)

Course Objectives: This course provides an introduction to the concept of fractional differential equations and their applications. Students will learn the basics of fractional calculus, how to

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formulate and solve simple fractional differential equations, and gain insight into real-world applications of these equations.

Course Outlines: Introduction to Fractional Calculus: Definitions and motivation for fractional calculus. Basics of fractional derivatives and integrals, Gamma and Mittag-Leffler functions, Caputo fractional derivative, Hadamard fractional derivative, Hilfer fractional derivative, Atangana-Baleanu fractional derivative, Caputo-Fabrizio fractional derivative, Conformable fractional derivative, fractional derivatives with variable order, the fractional Laplace transform, initial and boundary value problems of fractional derivatives. Applications of fractional differential equations in modeling physical systems.

Recommended Books:

1. I. Podlubny, Fractional Differential Equations, Academic Press, 1998.
2. B. Jin, Fractional Differential Equations: An Approach via Fractional Derivatives, Springer, 2021.
3. A. A. Kilbas, H. M. Srivastava and J. J. Trujillo, Theory and Applications of Fractional Differential Equations, Elsevier, 2006.
4. K. S. Miller and B. Ross, An Introduction to the Fractional Calculus and Fractional Differential Equations, Wiley, 1993.
5. M. Benchohra, E. Karapinar, J. E. Lazreg, A. Salim, Fractional Differential Equations: New Advancements for Generalized Fractional Derivatives, Springer, 2023.

MATH- 658 Vector and Tensor Analysis Credit Hours: 3(3+0)

Objectives of course: This course shall assume background in calculus. It covers basic principles of Vector and Tensor Analysis which are frequently used in applied mathematics.

Course Outlines:

3-D vectors, scalar-and vector-triple products, scalar- and vector-point functions, differentiation and integration of vectors, line integrals, path independence, surface integrals, volume integrals, gradient, divergence and curl with physical significance and applications, vector identities, Greens theorem in a plane, divergence theorem, Stokes theorem, coordinate systems and their bases, the polar, spherical and the cylindrical coordinates, tensors of first, second and higher orders, algebra of tensors, contraction of tensors, quotient theorem, quotient theorem, symmetric and skewsymmetric tensors, summation convention, kronecker delta, Levi-Civita symbol, vectors as quantities transforming under rotations with notation, alternating symbol, relation between alternating symbol and kronecker delta, invariance property, isotropic tensors, differentiation of tensors, application of tensors in modeling anisotropic systems, study physical tensors (moment of inertia, index of refraction, etc.), diagnolization of inertia tensor as aligning coordinate frame with natural symmetries of the system**.**

Main text:

1. Bourne D. E, Kendall PC, Vector Analysis and Cartesian Tensors, 2nd edition, 2018.

Reference Books:

1. N. A. Shah, **Vector and Tensor Analysis**, *A-One Publishers*, *Lahore,* 2005.

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2. G. D. Smith, **Vector Analysis**, *Oxford University Press, Oxford.*
3. M. R. Spiegel**, Vector Analysis, 1974,** *McGraw Hill, New York.*
4. A. Qadir, **An Introduction to Vector Analysis,** *A.H. Publishers, Al-Fazal Market, Urdu Bazar, Lahore,* 1996

MATH- 659 Dynamical Systems **Credit Hours: 3(3+0)**

Course Outline:

Introduction to Dynamical system, Linear and nonlinear Dynamical systems, Autonomous and nonautonomous systems. First-Order Equations: The Simplest Examples, The Logistic Population Model, Constant Harvesting and Bifurcations, Periodic Harvesting and Periodic Solutions, Computing the Poincare Map. Planar Linear Systems: Second-Order Differential Equations, Planar Systems, Preliminaries from Algebra, Eigen values and Eigenvectors, Solving Linear Systems, The Linearity Principle. Phase Portraits for Planar Systems: Real Distinct Eigen values, Complex Eigenvalues, Repeated Eigenvalue, Changing Coordinates. Classification of Planar Systems: The Trace-Determinant Plane, Dynamical Classification. Higher Dimensional Linear Systems: Distinct Eigen values, Harmonic Oscillators, Repeated Eigenvalues, The Exponential of a Matrix. Nonautonomous Linear Systems.

Recommended Books:

1. Differential Equations, Dynamical Systems and Introduction to Chaos byMorris W.Hirsch, Stephen Smale and Robert L.Devaney.
2. Nonlinear Dynamics and Chaos by Steven H.Strogatz.

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M.Phil. Mathematics

Scheme of Study for M. Phil Mathematics

ELIGIBILITY CRITERIA FOR M. PHIL

To be eligible for admission in M. Phil/MS Programme, a candidate is required to have:

1. Sixteen years of schooling or 4 year education after HSSC/F.A/F.Sc/Grade 12 or equivalent will be required for admission in the M.Phil/MS Program.
2. Qualifying the GAT-General/NTS conducted by the National Testing Service or other testing agencies or the Bacha Khan University, Charsadda admission test with a minimum

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60% cumulative score at the time of admission to M.Phil / MS. (The GAT-General test is valid for a period of two years).

3. The candidates should have obtained 2nd division in annual system of examination and 2.50 CGPA in BS (Hons) 4-years/M.Sc (2 years) in semester system examination.

1. Selection shall be made on the basis of cumulative merit to be determined from previous academic record, written test and interview.

Semester-wise break up

S. No	Course Code	Course Title	Credit Hours	Category
Semester-I				
1	MATH-701	Advanced Partial Differential Equations	3(3+0)	Core Course
2	MATH-702	Advanced Topology	3(3+0)	Core Course
3	MATH-	Elective-I	3(3+0)	Elective
4	MATH-	Elective-II	3(3+0)	Elective
Semester Credit Hours			**12**	
Semester-II				
1	MATH-703	Advanced Numerical Methods	3(3+0)	Core Course
2	MATH-704	Advanced Ring Theory	3(3+0)	Core Course
3	MATH-	Elective-III	3(3+0)	Elective
4	MATH-	Elective-IV	3(3+0)	Elective
Semester Credit Hours			12	
Semester-III				
1	QUR-700	Understanding of Holy Quran-I	1(1+0)	
2	QUR-701	Understanding of Holy Quran-II	1(1+0)	
3	MATH- 799	Research Thesis	6(6+0)	
Semester Credit Hours			**8**	
Semester-IV				
1	MATH- 799	Research Thesis	6(6+0)	
Semester Credit Hours			**6**	

Optional Courses for M. Phil

S. No	Course Code	Course Title	Credit Hours
1	MATH-705	Advanced Algebra	3(3+0)
2	MATH-706	Advanced Graph Theory	3(3+0)
3	MATH-707	Advanced Group Theory	3(3+0)

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4	MATH-708	Advanced Operation Research-I	3(3+0)
5	MATH-709	Advanced Operation Research-II	3(3+0)
6	MATH-710	Algebraic Topology	3(3+0)
7	MATH-711	Advanced Analytical Dynamics-I	3(3+0)
8	MATH-712	Advanced Analytical Dynamics-II	3(3+0)
9	MATH-713	Advanced Functional Analysis	3(3+0)
10	MATH-714	Banach Algebra	3(3+0)
11	MATH-715	Advanced Mathematical Biology	3(3+0)
12	MATH-716	Computational Fluid dynamics	3(3+0)
13	MATH-717	Computational Methods	3(3+0)
14	MATH-718	Convolution in Geometric Function Theory	3(3+0)
15	MATH-719	Differential Subordination Theory	3(3+0)
16	MATH-720	Advanced Geometric Function Theory	3(3+0)
17	MATH-721	Advanced Integral Equations	3(3+0)
18	MATH-722	Large Scale Scientific Computation	3(3+0)
19	MATH-723	Mathematical Logic	3(3+0)
20	MATH-724	Advanced Mathematical Methods	3(3+0)
21	MATH-725	Mathematical Techniques for Boundary Value Problems	3(3+0)
22	MATH-726	Multivariate Analysis-I	3(3+0)
23	MATH-727	Multivariate Analysis-II	3(3+0)
24	MATH-728	Numerical Analysis of Spectral Methods	3(3+0)
25	MATH-729	Numerical Linear Algebra	3(3+0)
26	MATH-730	Numerical Solutions of Integral Equations-I	3(3+0)
27	MATH-731	Numerical Solutions of Integral Equations-II	3(3+0)
28	MATH-732	Numerical Solution of ODE's	3(3+0)
29	MATH-733	Heat Transfer	3(3+0)
30	MATH-734	Advanced Optimization Theory-I	3(3+0)
31	MATH-735	Advanced Optimization Theory-II	3(3+0)
32	MATH-736	Perturbation Methods-I	3(3+0)
33	MATH-737	Perturbation Methods-II	3(3+0)
34	MATH-738	Probability and Probability Distributions-I	3(3+0)
35	MATH-739	Probability and Probability Distributions-II	3(3+0)
36	MATH-740	Semi Group Theory	3(3+0)
37	MATH-741	Viscous Fluid-I	3(3+0)
38	MATH-742	Viscous Fluid-II	3(3+0)
39	MATH-743	Fuzzy Logic and Algebra	3(3+0)
40	MATH-744	Rough Set Theory and its Applications	3(3+0)
41	MATH-745	LA-Semigroups	3(3+0)
42	MATH-746	Theory of Group Actions	3(3+0)
43	MATH-747	Theory of Group Graphs	3(3+0)
44	MATH-748	Topics in Pure Mathematics*	3(3+0)

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45	MATH-749	Topics in Computational Mathematics*	3(3+0)
46	MATH-750	Topics in Applied Mathematics*	3(3+0)
47	MATH-751	Numerical Solution of PDEs-I	3(3+0)
48	MATH-752	Numerical Solution of PDEs-II	3(3+0)
49	MATH-753	Special Relativity	3(3+0)
50	MATH-754	General Relativity	3(3+0)
51	MATH-755	Symmetry Methods in Differential Equations	3(3+0)
52	MATH-756	Advanced History of Mathematics	3(3+0)

***Course Outline: will be presented and designed by the instructor.**

MATH-701 ADVANCED PARTIAL DIFFERENTIAL EQUATIONS

Credit Hours: 3(3+0)

Objective of Course: This course is an advance to the theory of partial differential equations (PDEs). Upon successful completion the student will learn linear operators and linearity, partial differential equation and associated boundary and initial value problems, and well posed problems, the concept of maximum principle, existence and uniqueness, the concept of Green's functions and be able to derive them and use them in some simple cases, the notions of Poisson's equation and the Poisson integral formula, three-dimensional wave equation.

Course Outline: Cauchy's Problems for Linear Second Order Equations in n-independent Variables; Cauchy Kowalewski Theorem; Characteristic Surfaces; Adjoint Operators; Bicharacteristics; Spherical and Cylindrical Waves; Heat Equation; Wave Equation; Laplace Equation; Maximum-Minimum Principle; Integral Transforms.

RECOMMENDED BOOKS

1. R. Dennemyer, Introduction to P.D.E's & Boundary Value Problems, McGraw Hill Com., 1968
2. C. R. Chester, Techniques in P.D.E's, McGraw Hill Com., 1971.

MATH-702 ADVANCED TOPOLOGY

Credit Hours: 3(3+0)

Objective of Course:

Topology is one of the most active and advanced fields of mathematics, and it is indispensible for many other fields, such as Analysis, Geometry or Algebra. This course is an advance course of Topology.

Course Outline:

Directed sets and nets, subnets and cluster points, sequences and subsequences, quotient spaces, the Tychonoff theorem, completely regular spaces, the Stone-Eeih compactification, meterization theorems and paracompactness, function spaces.

RECOMMENDED BOOKS:

1. J. L. Kelley, General Topology, Springer-Verlag, 1975.
2. S. Willard, General Topology, Addison Wesley Pub. Co., 1970.
3. J. R. Munkers, Topology (a first course), Prentice Hill Inc., 1975.

MATH-703 ADVANCED NUMERICAL METHODS Credit Hours: 3(3+0)

MATH-704 ADVANCED RING THEORY Credit Hours: 3(3+0)

Objective of Course:

The aim of the course is to familiar the student with the concepts of ring theory. Ring theory is very important in the field of abstract algebra like the concept of vector spaces in linear algebra and functional analysis. Ring theory is the study of rings-algebraic structure in which addition and multiplication are defined and have similar properties to those familiar from the integers. Ring theory studies the structure of rings, their representation, or, in different language, modules, special classes of rings (group rings, division rings) as well as an array of properties that proved to be of interest both within the theory itself and for its applications, such as homological properties and polynomial identities. Commutative rings are much better understood than non-commutative ones. Algebraic geometry and algebraic number theory, which provide many natural examples of commutative rings, have driven much of the development of commutative ring theory, which is now, under the name of commutative algebra, a major area of modern mathematics

Course Outline:

Radical classes; Semisimple Classes; the Upper radical; Semis images; the lower radical; Heretariness of the lower radical class and the simple Upper radical class; Partitions of simple rings; Minimal left ideals; wedderbusn-Artin Structure theorem; the Brown –McCoy radical; the Jacobson Radical; Connections among radical Classes: Homomorphically closed semisimple classes.

RECOMMENDED BOOKS

- P. Hiegant, Radical and Semi-simple Classes of Ring, Queen paper in pure and applied Mathematics, Queens University Kingston, Ontario, 1974.

MATH-705 ADVANCED ALGEBRA Credit Hours: 3(3+0)

Objective of Course:

The goal of the course is to introduce the student with the theory of Advance topics in abstract algebra. The course is designed for the understanding of Field extensions, Galois Theory and Valuation theory which is very important for the new research domain in abstract algebra for example in Algebraic topology. Galois Theory provides a means of proving the impossibility of

duplicating the cube, squaring the circle and trisecting a general angle. It also gives beautiful and almost complete algebraic proofs of fundamental Theorems of algebra.

Course Outline:

Quadratic forms and modular functions, Interpretation of rings and Ideals, Finite invariants of a field, Hilbert sequence of fields and groups, Artin theorem and symbols, The field extension, Splitting field, Sylow theory, Jordan- Hölder theory, Galois theory, Valuation theory.

RECOMMENDED BOOKS:

1. P. M. Cohn, Algebra Vol. I & II, John Wiley & Sons.
2. Burton, A First Course in Rings & Ideals, Addison Wesley Co.
3. J. Lambek, Lectures on Rings & Modules, Blaisdel.
4. M. S. Atiyab, I. G. Macdonald, Introduction to Commutative Algebra, Addison Wesley Pub. Com., London, 1969.
5. D. E. A. Burton, First Course in Rings and Ideals, Addison Wesley Pub. Company, 1968.
6. O. Mariski, P. Samuel, Commutative Algebra, London, 1963.
7. I. Kaplansky, Commutative Rings University of Chicago Press.
8. F. W. Anderson, K. R. Puller, Rings and Category of Modules, Springer-Verlag.

MATH-706 ADVANCED GRAPH THEORY Credit Hours: 3(3+0)

Objective of Course: The aim of the course is to introduce the student to the theory of graphs, particularly algorithmic graph theory. The student will learn a number of standard and powerful algorithms, as well as demonstrating methodologies in graph techniques. In addition the student will be introduced to the use of graphs in the solution of complex problems. Graph theory has become one of the major tools for the design and analysis of algorithms, as well as the focus of much interest in theoretical computer science.

Course Outline:

Review of basic concepts (Vertices, edges, loop, degree, complete graphs, graph isomorphism, adjacency matrices, subgraphs, walks, paths, circuits, The Konigsberg bridge problem, connected graphs, disconnected graphs, and components).

Euler graphs, Euler line, operations on graphs, Hamiltonian paths and circuits, The Travelling salesman problem, Trees, properties of trees, pendant vertices in a tree, distance and centers in a tree, rooted and binary trees, spanning trees, fundamental circuits, finding all spanning trees of a graph, spanning trees in a weighted graph, Kruskal's algorithm, Prim's algorithm, Boruska's algorithm, Cut-Sets, properties of a cut-set, fundamental cut-sets, connectivity and seperability. Network Flows, network flow problems, 1-Isomorphism, 2-Isomorphism, Planar and Dual graphs, Kuratowski's two graphs, different representations of a planar graph, coloring, partitioning and covering, chromatic partitioning, algorithm for maximum independent set, Matching, Dijkstra

algorithm for shortest path, Maximal flow problem, Residual network, Ford-Fulkerson algorithm, Bread-first search algorithm, Depth-first search algorithm.

RECOMMENDED BOOKS

1. R. G. Busacker, T. L. Seaty, Finite graphs and Networks', An introduction with applications', McGraw Hill Book Company.
2. R. J. Wilson, Introduction to Graph Theory, Longman Scientific and technical, 1985.
3. Wai-Kaichen, Applied graph Theory "graphs and Electrical networks, North-Holland Pub. 1976.
4. N. Deo, Graph Theory with Applications to Engineering and Computer Science,Prentice-Hall, INC. Englewood Cliffs, N.J.

MATH-707 ADVANCED GROUP THEORY Credit Hours: 3(3+0)

Objective of Course: The aim of the course is to introduce the student with the basic concepts of group theory. The concept of group is fundamental in abstract algebra. Almost all structures in abstract algebra are special cases of groups e.g. Galois Theory uses groups to describe the symmetries of the roots of a polynomial, Algebraic Knot Theories takes in a crucial way on classifying spaces of groups. Similarly Algebraic topology is another domain which prominently associates groups to the objects the theory is interested in.

Course Outline: Normal and Subnormal Series, Abelian and Central Series, Direct Products, Finitely Generated Abelian Groups, Splitting Theorems, Solvable and Nilpotent Groups, Commutators Subgroup, Derived Series, The Lower and Upper Central Series, Characterization of Finite Nilpotent Groups, Fitting Subgroup, Frattini Subgroup, Dedekind Groups, Super solvable Groups, Solvable Groups with Minimal Condition. Subnormal Subgroups, Minimal Condition on Subnormal Subgroups, The Subnormal Socle, the Wielandt Subgroup and Wielandt Series, T-Groups, Power Automorphisms, Structure and Construction of Finite Soluble T-Groups.

RECOMMENDED BOOKS

1. D.J.S. Robinson, A Course in the Theory of Groups, Graduate Texts in Mathematics 80, Springer, N Y, 1982.
2. K. Doerk, T. Hawkes, Finite Soluble Groups, De Gruyter Expositions in Mathematics 4, Walter De Gruyter, Berlin, 1992.

MATH-708 ADVANCED OPERATION RESEARCH-I Credit Hours: 3(3+0)

Objective of Course:

This course is intended to provide students with an advance knowledge that can make them appreciate the use of various research operations tools in decision making in organizations. At the end of the Course participants are expected to demonstrate a working knowledge of the

various OR /OM tools in making decisions as well as being able to formulate organizational problems into OR models for seeking optimal solutions.

Course Outline:

Introduction; Definition and Historical background; or models; Principal Components of decision problems; Type of or models; phases of or study.

Linear programming; Graphical solution; Examples of LP applications; The standard form; Basic Solutions and bases; The Simplex method; Special cases in simplex method application; Sensitivity analysis; The Dual problem; Definition of the Dual problem; Primal –Dual relationships; Dual simplex method. Transportation model; Definition and application; solution of the transportation model; The assignment model; The transhipment model.

RECOMMENDED BOOKS

1. H. A. Taha, Operations Research An Introduction, Collier MacMillan, 1982.
2. H. Lieberman, Introduction to operation research, 8th edition, The McGraw Hill Co.

MATH-709 ADVANCED OPERATIONS RESEARCH-II Credit Hours: 3(3+0)

Objective of Course:

This course will focus on mathematical modelling. A strong emphasis will be given to model formulation. On the methodology side, Linear and Integer Programming techniques will be introduced. At the end of the course, students will have the skills to build their own formulations, to expand existing formulations, to critically evaluate the impact of model assumptions and to choose an appropriate solution technique for a given formulation.

Course Outline:

Dynamic programming; Elements of the DP model; Definition of the state and stages; examples of the DP model and computations; problem of dimensionality; solution of linear programming by DP. Game Theory; two-persons Zero-sameGames; mixed strategies; Graphical solution of (2xn) and (mx2) games; Solution of (mxn) Games by Linear programming. Project scheduling by PERT-CPM; Arrow diagram representation; Construction of the time chart; cost consideration in project scheduling; project control. Inventory Model; The general inventory problem and definition; Deterministic (static and dynamic) Inventory models.

RECOMMENDED BOOKS

1. H. A. Taha, Operations Research An Introduction, Collier MacMillan, 1982.
2. H. Lieberman, Introduction to operation research, 8th edition,The McGraw Hillco.

MATH-710 ALGEBRAIC TOPOLOGY Credit Hours: 3(3+0)

Objective of Course:

This course is an introduction to algebraic topology. Algebraic topology studies topological spaces by associating to them algebraic invariants. The principal algebraic invariants considered in this

course are the fundamental group (also known as the first homotopy group) and the homology groups. It is fundamental for students interested in research in Algebraic Geometry, Differential Geometry, Mathematical Physics, and Topology; it is also important for students in Algebra and in Number Theory.

Course Outline:

Homology theory: Homology groups, simplical homology, exact sequences. Singular homology.Cohomology, Duality and Topological manifolds.The Alexander Poincar's duality theorem.General homotopy theory: some geometric construction. Homotopy classes of maps, Exact sequences, Fibre and cofibre maps.

RECOMMENDED BOOKS:

1. E. H. Spanier, Algebraic Topology, Tata McGraw Hill.
2. C. Kosniowski, A First Course in Algebraic Topology, Cambridge Uni. Press, 1988.
3. C. R. E. Maunder, Algebraic Topology, Cambridge Uni. Press,1980.
4. J. Mayer, Algebraic Topology, Prentice Hall NJ.

MATH-711 ADVANCE ANALYTICAL DYNAMICS-I Credit Hours: 3(3+0)

Objective of Course:

This course is designed to teach the students how mathematics could be used in solving problems in the contemporary Science/Technology and Engineering world. Therefore, the course is structured to expose the students to the skills required to attain a level of proficiency in Analytical Dynamics.

Course Outline:

Equations of dynamics and its various forms; Equations of Lagrange and Euler, Jacobi's elliptic functions and the qualitative and quantitative Solutions of the problems of Euler and Poisson.The Problems of Lagrange and Poisson.Dynamical system; Equations of Hamilton and Appell; Hamilton–Jacobi theorem; Separable systems' Holder's variational principles and its consequences.

RECOMMENDED BOOKS

1. L. A. Pars, A Treatise on Analytical Dynamics, Heinman London, 1965.
2. E. T. Whittaker, A treatise on Dynamics of Rigid Bodies and Particles, Cambridge Uni. Press, 1965.

MATH-712 ADVANCED ANALYTICAL DYNAMICS-II Credit Hours: 3(3+0)

Objective of Course:

The aim of this course is to give students advance topics analytical dynamics.

Course Outline:

Groups of continuous Transformations and Poincare's Equations; Systems with one degree of freedom; Singular Points; Cycle characteristics of systems with a Degree of freedom; Ergodic theorem; Metric indecompossability; stability of motion periodic Orbits.

RECOMMENDED BOOKS

1. L. A. Pars, A Treatise on Analytical Dynamics, Heinman London, 1965.
2. E. T. Whittaker, A treatise on Dynamics of Rigid Bodies and Particles,Camb. Uni.Press, 1965

MATH-713 ADVANCED FUNCTIONAL ANALYSIS Credit Hours: 3(3+0)

Objective of Course:

The course combines ideas and methods from different areas of mathematics. It is designed especially for students who want to choose operator algebras as their speciality, but the content of the course will also be useful to students interested in other branches of analysis. This point of view turned out to be particularly useful for the study of differentialand integral equations.

Course Outline:

Normed Spaces. Banach spaces; Bounded Linear operators; Compactness and Continuity; Finite Dimensional Normed Linear spaces; The Stone Weirstrass Theorem and Aseoli Aezela Theorem; Bounded linear Functionals; Dual spaces; The Hahn Banach Theorem. The Riesz Representation Theorem. Contraction, Fixed Point Theorem and its applications, Reflexive spaces. Strong and Weak Convergence. Convergence of Sequences of Operators and Functionals; Bair's Theorem; The Principle of Uniform Boundedness; The Open Mapping Theorem and Closed Graph Theorem; Compact Linear Operators, Applications in Approximation Theory.

RECOMMENDED BOOKS.

1. A. L. Brown, A. Page, Elements of Functional Analysis, Van Nostl found and Reinholt Company London, 1997.
2. E. Kreyszig, Introductory Functional Analysis With Applications, John Wiley & Sons, N. Y.1989.
3. A. E. Taylor, D. C. Lay, Introduction to Functional Analysis, 2nd Edition. Robert E. Krieger Pub. Company Florida, 1986.
4. J. D. Conway, A Course in Functional Analysis, Spring-Verlag, 1994.

MATH-714 BANACH ALGEBRA Credit Hours: 3(3+0)

Objective of Course:

Banach algebras have a lot of structure, combining the topological features of a Banach space, with the algebraic features of a ring. The main focus will be on examining Banach algebras consisting of continuous linear operators on Hilbert and Banach spaces.

Course Outline:

Banach Algebras; Ideals; Homomorphisms; Quotients Algebras; Winner's lemma; Gelfand's Theory of Commulative Banach Algebras; The Notions of Gelfand's topology; Radicals; Gelfand's Transforms; Basic properties of Spectra; Gelfand–Mazer Theorem; Symbolic Calculus; Differentiation; Analytic Functions; Integration of A–valued Functions; Normed Rings; Gelfand–Naimark Theorem.

RECOMMENDED BOOKS

1. W. Rudin, Functional Analysis, McGraw Hill Pub., N.Y.
2. M. A. Naimark, Normed Algebras, Wolters Noordhoff Pub., Netherland, 1972.
3. W. Zelazko, Banach Algebras, American Elsevier Pub., N.Y., 1973.
4. C. E. Rickart, Banach Algebras, D. Van Nostrand Pub., New York, 1960.

MATH-715 ADVANCED MATHEMATICAL BIOLOGY Credit Hours: 3(3+0)

Objective of Course:

This course is intended to equip students with skills and techniques of model formulating, analysing and interpreting mathematical models in Biology, Ecology, Epidemics, etc.

Course Outline:

The history of a system in the course of irreversibility transformation.The statistical meaning of irreversibility. Evolution conceived as a redistribution. The programme of physical biology.The fundamental equations of the kinetics of the evolving systems.(General case; equations with one dependent variable; equations with two or three dependent variables).Analysis of the growth function.

RECOMMENDED BOOKS

1. A. J. Lotka, Elements of Mathematical Biology, Dover Publications, N.Y., 1956.
2.

MATH-716 COMPUTATIONAL FLUID DYNAMICS Credit Hours: 3(3+0)

Objective of Course:

Computational Fluid Dynamics (CFD), an extremely versatile technology requiring high performance computing environment is poised to take over as a universal software for simulating multi-physics problems in industrial R&D. The course is designed to reflect the broad range of CFD applications by providing a range of optional modules to address specific application areas.

Course Outline:

Prerequisites: Numerical Methods/Fluid Dynamics at M.Sc Level Philosophy of Computational Fluid Dynamics, Basic of Computational Fluid Dynamics: Incompressible plane flows, Stream function and vorticity equations, Conservative form and normalizing systems, Method for solving vorticity transport equation, Basic finite difference forms, Conservative property, Convergence

and stability analysis, Explicit and implicit methods, Stream function equation and boundary conditions, Schemes for adjective diffusion equation, Upwind differencing and artificial vorticity, Solution for primitive variables.

RECOMMENDED BOOKS

1. C. A. J. Fletcher, Computational Techniques for Fluid Dynamics, Volume 1 & 2, Springer Verlag, 1992.
2. C. Y. Chow, Introduction to Computational Fluid Dynamics, John Wiley, 1979.
3. M. Holt, Numerical Methods in Fluid Mechanics, Springer Verlag, 1977.
4. H. J. Wirz and J. J. Smolderen, Numerical Methods in Fluid Dynamics, Hemisphere, 1978.
5. D. A. Anderson, J. C. Tannehill and R. H. Pletcher, Computational Fluid Dynamics and Heat Transfer, McGraw Hill, 1984.
6. J. D. Anderson, Computational Fluid Dynamics: The Basics with Applications, McGraw- Hill, 1995.
7. K. Hoffmann and S. T. Chiang, Computational Fluid Dynamics for Engineers, Vols. 1 and 2, Engineering Education System, 1993.

MATH-717 COMPUTATIONAL METHODS Credit Hours: 3(3+0)

Objective of Course:

A study and analysis of important numerical and computational methods for solving engineering and scientific problems. The course will include methods for solving linear and nonlinear equations, evaluating integrals, solving ordinary and partial differential equations, and determining eigenvalues and eigenvectors or matrices. The student will be required to write and run computer programs.

Course Outline:

Review of Numerical Methods (Bisection, Newton, Fixed point iteration), Review of Direct Methods for Linear Equations (Gauss, LUD, Tridiagonal), Cholesky
Decomposition. Review of Matrix Algebra, Vector and Matrix Norms. Iterative Methods for solving linear equations (Jacobi, Gauss-Siedel, SOR methods), Eigen-value problems, Power method, Inverse power method and other techniques, Newton's method for system of non-linear equations, Numerical solution of Boundary Value Problems, Numerical solution of Partial differential equations.

RECOMMENDED BOOKS

1. R. L. Burden, J. D. Fairs;An Introduction to Numerical Analysis, 1993.
2. G. D. Smith, Numerical Solutions of P.D.Es, 1999.
3. J. H. Wilkinson, The Algebraic Eigenvlaue Problems, 1965.
4. U. Asher et al., Numerical solution of Boundary Value Problems in ODE's, 1986.

MATH-718 CONVOLUTION IN GEOMETRIC FUNCTION THEORY
Credit Hours: 3(3+0)

The duality principle, test sets, convolution invariance Application to Geometric Function Theory, univalence criteria via convolution and applications prestarlike functions, applications to close-to-convex and related functions.

RECOMMENDED BOOKS

1. Convolutions and Geometric Function Theory by Ruscheweyh (1982)
2. Univalent Functions" by Ch. Pommerenke (1975)

MATH-719 DIFFERENTIAL SUBORDINATION THEORY Credit Hours: 3(3+0)

Subordination, Hypergeometic Functions, classes of functions, Integral operators, Differential operator. Second order differential subordination some fundamental results. The open Door Lemma and Integral Existence theorem.Classical subordination.

RECOMMENDED BOOKS

1. "Differential Subordinations" (2000) by S. S. Miller and P. T. Mocanu.
2. "Univalent Functions" Vol I & II, by A. W. Goodman

MATH-720 GEOMETRIC FUNCTION THEORY Credit Hours: 3(3+0)

Riemann mapping theorem, conformal mappings and their properties, univalent functions and their subclasses, Functions with positive real part, Herglotz Formula, Some basic properties of univalent and multivalent functions. Radius Problems, Alexander Theorem, Integral Representation of Star like Function, Convex Function

RECOMMENDED BOOKS

1. Geometric function theory and non-linear analysis by Tadeusz Iwaniec, Gaven Martin.
2. Topics in geometric function theory By Carl Hanson FitzGerald.
3. A. W. Goodman, Univalent Functions, Vol I & II.

MATH-721 ADVANCED INTEGRAL EQUATIONS Credit Hours: 3(3+0)

Objective of Course:

This course unit consists of methods of solving various mathematical problems which arise in science. The method of Green's functions is a powerful tool in solving linear ordinary and partial differential equations, and the course starts with an introduction to this topic. There are situations where physical laws are better expressed as integral equations. On successful completion of this course students will be able to solve ordinary and partial differential equations.

Course Outline:

Controller of Examinations
Bacha Khan University
Charsadda

Chairman
Deptt. of Mathematics & Statistics
Bacha Khan University
Charsadda

Bacha Khan University Charsadda
Assistant Registrar
Academics

Existence Theorem; Integral Equations with L Kernels; Applications to Partial Differential Equations; Integral Transforms; Wiener-Hopf Techniques

RECOMMENDED BOOKS

1. H. H. Stad, Integral Equations, John Wiley, 1973.
2. I. Stakgold, Boundary Value Problems of Mathematical Physics, McMillan NY, 1968.

MATH-722 LARGE SCALE SCIENTIFIC COMPUTATION Credit Hours: 3(3+0)

Objective of Course:

The overall goal of the course is to provide a basic understanding of how to develop algorithms and how to implement them in distributed memory computers using the message-passing paradigm and some advance methods in numerical computations. The students will be prepared either for research in an area where computational techniques play a significant role, or for a career in business or industry.

Course Outline:

Prerequisites: Scientific Computing, Numerical Analysis, Numerical Linear Algebra

Large sparse linear systems, Storage schemes, Review of stationary iterative process, Krylov subspace methods, Conjugate gradients(CG), BiCG, MINRES and GMRES, The Lanczos iteration, From Lanczos to Gauss quadrature, Preconditioning, Error bounds for CG and GMRES, Effects of finite precision arithmetic, Multigrid methods, Multigrid as a preconditioner for Krylov subspace methods. Nonlinear systems, Newton's method and some of its variants, Newton GMRES, Continuation methods, Conjugate direction method, Davidon-Fletcher-Powell Algorithms.

Software Support: HOMPACK, LAPACK

RECOMMENDED BOOKS:

1. J. M. Ortega and W. C. Rheinboldt, Iterative Solution of Nonlinear Equations in Several Variables, Academic Press, 1970.
2. C. T. Kelly, Iterative Methods for Linear and Nonlinear Equations, SIAM, Philadelphia, 1995.
3. A. Greenbaum, Iterative Methods for Solving Linear Systems, SIAM, Philadelphia, 1997
4. O. Axelsson, Iterative Solution Methods, Cambridge University Press, 1994.
5. P. Wesseling, An Introduction to Multigrid Methods, John Wiley & Sons, 1992.
6. C. W. Ueberrhuber, Numerical Computation: Methods, Software and Analysis, Springer Verlag, 1997.

MATH-723 MATHEMATICAL LOGIC Credit Hours: 3(3+0)

Course Outline:

Introduction, propositional calculus, methods of proof, analysis of arguments, predicate

calculus and quantifiers, boolean algebra to logic, boolean functions, boolean algebra and propositional logic. logic gates, combinational circuits.

RECOMMENDED BOOKS:

1. Irving m.copi, symbolic logic, collier macmillan publishers, 1973
2. Patric j. hurley, a concise introduction to logic, ward worth publishing company,
3. elliott mendelson, boolean algebra and switching circuits, mcgraw hill book company, 1970.

MATH-724 AVANCED MATHEMATICAL METHODS Credit Hours: 3(3+0)

Objective of Course:

The course will cover some mathematical techniques commonly used in theoretical physics. This is not a course in pure mathematics, but rather on the application of mathematics to problems of interest in the physical sciences.

The students will learn the following topics:

• Hilbert spaces: complete orthonormal sets of functions
• Special functions (Legendre polynomials, Fourier series and integrals, spherical harmonics)
• Sturm-Liouville systems: orthogonal polynomials
• Green's functions

Course Outline:

General solution of Bessel equation, Recurrence relations, Orthogonality of Bessel functions, Modified Bessel functions, Applications. General solution of Legendre equation, Legendre polynomials, Associated Legendre polynomials, Rodrigues formula, Orthogonality of Legendre polynomials, Application. Concept and calculation of Green's function, Approximate Green's function, Green's function method for differential equations, Fourier Series, Generalized Fourier series, Fourier Cosine series, Fourier Sine series, Fourier integrals. Fourier transform, Laplace transform, Z-transform, Hankel transform, Mellin transform. Solution of differential equation by Laplace and Fourier transform methods.

RECOMMENDED BOOKS

1. G. N. Watson, A Treatise on the Theory of Bessel Functions, Cambridge University Press, 1944.
2. G. F. Roach, Green's Functions, Cambridge University Press, 1995.
3. A. D. Poularikas, The Transforms and Applications – Handbook, CRC Press, 1996.
4. J. W. Brown and R. Churchill, Fourier Series and Boundary Value Problems, McGraw Hill, 1993.

MATH-725 MATHEMATICAL TECHNIQUES FOR BOUNDARY VALUE PROBLEMS **Credit Hours: 3(3+0)**

Objective of Course:

This course has a major focus on training analytical and logical thinking and learning fundamental methods for solving ordinary and partial differential equations. Both the knowledge about differential equations as well as the training of analytical faculties will be useful for the students in the course of their further studies. The course also explores the capacity and motivation for intellectual development through the solution of both simple and more complex mathematical problems from the important field of differential equations.

Course Outline:

Green's function method with applications to wave-propagation. Perturbation method: regular and singular perturbation techniques with applications. Variational methods.A survey of transform techniques; Wiener-Hopf technique with applications to diffraction problems.

RECOMMENDED BOOKS

1. A. Nayfeh, Perturbation methods.
2. I. Stakgold, Boundary Value Problems of Mathematical Physics.
3. B. Noble, Methods based on the Wiener-Hopf technique for the solution of Partial Differential Equations.
4. R. Mitra, S. W. Lee, Analytical Techniques in the Theory of Guided Waves.

MATH-726 MULTIVARIATE ANALYSIS-I **Credit Hours: 3(3+0)**

Objective of Course:

The course is designed to understand the statistical analysis of the data collected on more than one (response) variable. These variables may be correlated with each other, and their statistical dependence is often taken into account when analyzing such data. This consideration of statistical dependence makes multivariate analysis somewhat different in approach and considerably more complex than the corresponding univariate analysis, when there is only one response variable under consideration.

Course Outline:

Introduction: Some multivariate problems and techniques. The data matrix Summary statistics. Normal distribution theory: characterization and properties linear forms. The Wish art distribution. The hostelling T^2 distribution. Distribution related to the multinomial.

Estimation and Hypothesis testing. Maximum likelihood estimation and other techniques. The Behrens Fisher problem. Simultaneous confidence intervals. Multivariate hypothesis testing design matrices of degenerate rank. Multiple correlation. Least squares estimation discarding of variables.

RECOMMENDED BOOKS

1. K. V. Mardia, J. T. Kent, J. M. Bibby, Multivariate Analysis, Academic Press London, 1982.
2. A. M. Kshirsagar, Multivariate Analysis, Marcell Dekker, New York, 1972.

MATH-727 MULTIVARIATE ANALYSIS-II Credit Hours: 3(3+0)

Objective of Course:

This is a course in multivariate statistical analysis, for students interested in quantitative methods of marketing research and more generally, for students of sciences. The aim of the course is to explore multivariate techniques used in modern marketing practice and in wider social research. Emphasis will be placed on case studies of marketing practice and on the practical application of the methods discussed. Topics to be drawn from: analysis of variance; regression analysis; principal components analysis; discriminant analysis; canonical correlation analysis; factor analysis; cluster analysis; multi-dimensional scaling.

Course Outline:

Principal component analysis: Definition and properties of principal comp . Hypotheses about principal components. Correspondence analysis. Discarding of variables. Principal component analysis in regression. Factor analysis. The factor model. Relationships between factor analysis and principal component analysis. Canonical correlation analysis, dummy variables and qualitative data. Qualitative and quantitative data. Discriminant analysis: discrimination when the populations are known. Fisher's linear discriminant function. Discrimination under estimation. Multivariate analysis of variance: formulation of multivariate one-way classification. Testing fixed contras is. Canonical variables and lest of dimensionality. Two-way classification.

RECOMMENDED BOOKS

1. K. V. Mardia, J. T. Kent, J. M. Bibby, Multivariate Analysis, Academic Press London, 1982.
2. A. M. Kshirsagar, Multivariate Analysis, Marcell Dekker, New York, 1972.

MATH-728 NUMERICAL ANALYSIS OF SPECTRAL METHODS Credit Hours: 3(3+0)

Objective of Course:

This course is a mathematical introduction to appoximation theory, with a focus on spectral methods. The emphasis will be on both the analysis and the implementation of these methods. At the heart of both these methods is the same idea- the approximation of the solution by a (truncated) series expansion. The student will learn some basic theoretical results on spectral approximations for the issues of stability and convergence, on practical algorithms for implementing spectral methods, and on designing efficient and accurate spectral algorithms for solving PDEs of current interest.

Course Outline:

Introduction: Spectral Method: Survey of Approximation; Theory; Review of Convergence Theory; Algebraic Stability; Spectral Methods Using Fourier Series; Applications of Algebraic – Stability Analysis; Constant Coefficient HyperbolicEquations; Time Differencing Efficient Implementations of Spectral Methods; Numerical Results of Hyperbolic Problems.

RECOMMENDED BOOKS

1. D. Gottlies, S. A. Orszag, Numerical Analysis of Spectral Method (Theory an Applications) J. W. Arrowsmith Ltd., England.
2. C. Canunto, M. Y. Hussani, A Quarteroni, T. Zang, Spectral Method in Fluid Dynamics, Springer-Verlag, N.Y.

MATH-729 NUMERICAL LINEAR ALGEBRA Credit Hours: 3(3+0)

Objective of Course:

Students will learn the basic and advance direct methods for solving system of linear equations and linear least square equations, matrix factorization methods, basic computer arithmetic and the concepts of conditioning and stability of a numerical method, numerical methods for computing eigenvalues and their derivation, basic iterative methods, singular value decomposition. They will also improve their problem solving skills in computational linear algebra.

Course Outline:

Matrix-Vector operations, Orthogonal vectors and matrices, Matrix and vector norms, Singular value decomposition (SVD), Projectors and QR factorization, Gram-Schmidt orthogonalization process, Householder triangularization, Least-squares problems, Condition numbers, Gaussian elimination and LU factorization, Pivoting and LUP factorization, Stability of Gaussian elimination, Cholesky Factorization, Overview of eigenvalue problems, Reduction to upper-Heisenberg Tridiagonal form, Power and

inverse power iteration, QR algorithm without shifts, QR algorithm with shifts, Arnold iteration, GMRES method, Lanczos iteration Orthogonal polynomials and Gauss quadrature, Conjugate gradient (CG) method, Bi-Orthogonalization method.

RECOMMENDED BOOKS

1. L. N. Trefethen, D. Bau,Numerical linear algebra, SIAM, Philadelphia, 1997.
2. G. Allaire, S. M. Kaber, K. Trabelsi,Numerical Linear Algebra, Springer Science+Business Media, LLC.2008 ,
3. W. Brandal, Numerical Linear Algebra.
4. L. Fox, An introduction to numerical linear algebra.

MATH-730 NUMERICAL SOLUTIONS OF INTEGRAL EQUATIONS-I Credit Hours: 3(3+0)

Objective of Course:

Controller of Examinations Bacha Khan University Charsadda

Chairman Deptt. of Mathematics & Statistics Bacha Khan University Charsadda

Bacha Khan University Charsadda Assistant Registrar Academics

The course deals with integral equations, their origin, properties and solutions, both approximate and numerical.

Course Outline:

INTRODUCTION TO THE THEORY OF INTEGRAL EQUATIONS:

Definition; Existence Theorems; Integral Equations with L Kernels; Quadrature and Fourier Series; Function Spaces and Linear Operators; Basic Approximation Theory.

QUADRATURE METHODS FOR FREDHOLM EQUATIONS OF THE SECOND KIND

Introduction; Formulation of Discrete Equation; Choice of Quadrature Formula; Use of Finite Differences; Deferred Approach to the Limit; Nonlinear Equations; Singular Integral Equations; Removal of the Diagonal Term; Use of Peduct Integration Methods; Singularity in the Solution; Error Analysis of Quadrature Methods

EXPANSION METHODS

Nature of Approximating Function; Criteria for Determining the Approximation; Choice of (x), & (x)…..; Theory of Projection Methods; Other methods:

RAYLEIGH-RITZ-GALERKIN METHODS

Introduction; The Eigenvalue Problem; Inhomogeneous Equations; Error Estimates; Numerical Performance; Extension to Nonlinear Equations; Comparison with Other Methods

RECOMMENDED BOOKS

1. C. T. H. Baker, Integral Equations, Cleradon Press, 1977.
2. F. Smithies, Integral Equations, Cambridge University Press, 1958.
3. Squire, Numerical Integration for Engineer, American Elsevier Publishing Co., 1970.

MATH-731 NUMERICALSOLUTIONS OF INTEGRAL EQUATIONS-II
Credit Hours: 3(3+0)

Objective of Course:

This course is an introduction to fast solvers for integral equations, the course will concentrate mainly on integral equations arising from elliptic problems but, if time permits, the parabolic and hyperbolic cases will be briefly outlined. At the end of the
course the student will be able to comfortably apply various numerical techniques for the solution of different kinds of integral equations.

Course Outline:

NUMERICAL SOLUTIONS OF THE EIGENVALUE PROBLEM

Methods based on Quadrature Rules; Treatment of Discontinuities Using Methods Based on Approximate Integration; Expansion Methods for Eigenproblem

VOLTTERRA EQUATIONS OF THE SECOND KIND

Introduction; Multistep Methods; Runge-Kutta Methods; Bock methods; Spline Approximations; Convergence and Stability;

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Deptt. of Mathematics & Statistics
Bacha Khan University
Charsadda

Bacha Khan University Charsadda
Assistant Registrar
Academics

METHODS FOR VELTERRA EQUATIONS OF THE FIRST KIND

Introduction; Conversion to Equations of the Second Kind; Numerical Methods of Solution; Use of Quadrature Rules in the Equation of the First Kind; higher Order Accuracy; Product Integration

FREDHOLM EQUATIONS OF THE FIRST KIND

Introduction; nature of the Problem, Singular Function Analysis; Fundamental Theorems; Applications; noise; need for Filtering; Methods of Expansion in Singular Functions; Use of Other Expansions; Methods of Regularization; Interactive Methods

RECOMMENDED BOOKS:

1. C. T. H. Baker, Integral Equations, Cleradon Press, 1977.
2. F. Smithies, Integral Equations, Cambridge University Press, 1958.
3. Squire, Numerical Integration for Engineer, American Elsevier Publishing Co., 1970.

MATH-732 NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS Credit Hours: 3(3+0)

Objective of Course:

This course will provide an overview of classical solution methods for ordinary equations. The focus will be on one step, multistep, finite–difference and shooting techniques and their stability and convergence. At the end of the course, the students will be able to implement several numerical techniques for finding approximate solutions to ordinary differential equations.

Course Outline:

PRELIMINARIES:

Some Theorems from the Theory of Differential Equations; Initial Value Problems for First Order Ordinary Differential Equations and for Systems of First Order Ordinary Differential Equations; Deduction of Higher Order Differential Equations to First-Order Linear System's with Constant Co-efficient; Linear Difference; Equations with Constant Co-efficient

LINEAR MULTISTEP METHODS:

The General Linear Multistep Methods; Derivation Through Taylor Expansions; Derivation Through Numerical Integration; Derivation Though Interpolation; Convergence; Order and Error Constant; Local and Global Truncation Error; Consistency and Numerical Stability; Attainable order of Stable Methods.

Problems in Applying Linear Multistep Methods; Starting Values; A Bound for the Local Truncation Error; Weak Stability; General Methods for Finding Intervals of Absolute and Relative Stability; Predictor-Corrector Methods; The Local Truncation Error of Predictor-Corrector Methods; Weak Stability of Predictor-Corrector Methods. Introduction; Order and Convergence of the General Explicit One-Step Method; Derivation of Classical Runge-Kutta Methods; Runge-

Kutta Methods of order Greater Than Four; Error Estimates and Error Bounds for Runge Kutta Methods; Comparison with P Predictor-Corrector Methods; Implicit Runge-Kutta Methods.

RECOMMENDED BOOKS

1. Greenspan, Numerical solutions of ODE's for classical Relativistic and Nanosystems, 2006.
2. C. E. Froberg, Numerical mathematics, The Benjamin Cummings Pub. Com. Inc., 1985.
3. G. M. Phillips, P. J. Taylor, Theory and Applications of Numerical Analysis, Academic Press, 1973.
4. W. E. Pre et al., Numerical Recipes, Cambridge University Press, 1986.
5. M. K. Jain, Numerical Solution of Differential Equations, Wiley Eastern Ltd.
6. W. E. Milne, Numerical Solution of Differential Equations, Dover Pub. Inc., N.Y.

MATH-734 ADVANCED OPTIMIZATION THEORY-I Credit Hours: 3(3+0)

Objective of Course:

This course deals with the mathematical theory of optimization. Theory and algorithms for nonlinear optimization, focusing on optimization. Quasi-Newton methods; conjugate-gradient and methods for large-scale problems; algorithms for least-squares problems linear and nonlinear equations; constrained optimization. Upon successful completion of this course, the student will be able to understand:

(1) basic theoretical principles in optimization;
(2) formulation of optimization models;
(3) solution methods in optimization.

Course Outline:

Statement of the problem, condition for optimality, concept of direction of search, alternating direction and steepest descent methods, conjugate direction method, conjugate gradient method, Newton's method, Quasi-Newton equation, derivation of updating formulae for Quasi-Newton equation, The Gauss-Newton method, The Levenberg-Marquart method, The corrected Gauss-Newton method, Methods for large scale problems.

RECOMMENDED BOOKS:

1. P. E. Gill, E. Murray, H. H. Wright, Practical Optimization, Academic Press, 1981.
2. R. Fletcher, Practical Methods of Optimization Vol.I & II, John Wiley and Sons, 1980.
3. S. S. Rao, Optimization Theory and Application, Wiley Eastern Ltd., 1984.
4. D. G. Luenberger, Optimization by Vector Space Methods, John Wiley & Sons, 1968.
5. D. G. Luenberger, Introduction to Linear & Nonlinear Programming. Addison Wesley Publishing Co. Sydney, 1965.

5. M. S. Bazara, C. M. Shetty, Nonlinear Programming: Theory and Algorithms, John Wiley, 1979.

MATH-735 ADVANCED OPTIMIZATION THEORY-II Credit Hours: 3(3+0)

Objective of Course:

This course deals with theory and algorithms for nonlinear optimization, focusing on unconstrained optimization. Algorithms for problems and nonlinear equations; gradient projection algorithms for bound-constrained problems; Lagrange's multiplier methods for nonlinearly constrained optimization.

Course Outline:

Theory of constrained optimization, condition of optimality, methods for minimizing a general function subject to linear equality constraints, active set strategies for linear inequality constraints, special forms of the objectives functions, Lagrange multiplier estimates, Changes in working set, Barries function methods, Penalty functions methods, Methods based on Lagrangian functions reduced gradient and gradient projection methods.

RECOMMENDED BOOKS:

1. P. E. Gill, E. Murray, H. H. Wright, Practical Optimization, Academic Press, 1981.
2. R. Fletcher, Practical Methods of Optimization Vol.I & II, John Wiley and Sons, 1980.
3. S. S. Rao, Optimization Theory and Application, Wiley Eastern Ltd., 1984.
4. D. G. Luenberger, Optimization by Vector Space Methods, John Wiley & Sons, 1968.
5. D. G. Luenberger, Introduction to Linear & Nonlinear Programming. Addison Wesley Publishing Co. Sydney, 1965.
6. M. S. Bazara, C. M. Shetty, Nonlinear Programming: Theory and Algorithms, John Wiley, 1979.

MATH-736 PERTURBATION METHODS-I Credit Hours: 3(3+0)

Objective of Course:

The aim of the course is to lay an introduction to the perturbation theory to solve ordinary differential equations, partial differential equations as well as integral equations. The emphasis in this course is on the adaptation of several mathematical methods and techniques to their swift and effective application in solving advanced problems in applied mathematics and theoretical physics.

Course Outline:

Difference equations, Dimensional analysis, Expansions, Approximate solutions of linear differential equations, order symbols, Asymptotic series, Quadratic and cubic algebraic equations and its solutions by perturbation method, Straightforward expansion, Lindsted-Poincar

Technique, Method of Renormalization, Method of multiple scales, dominant balance method, WKB method, Method of strained parameters.

RECOMMENDED BOOKS

1. Alan W. Bush, Perturbation methods for engineers and scientists,CRC Press.
2. C. Bender, S. Orszag, Advanced mathematical methods for scientists and engineers,MGH, 1978.
3. E. Zauderer, Partial Differential Equations of Applied Mathematics, T 2nd edition ,1998.
4. Ali Hasan Nayfeh, Introduction to perturbation techniques, A wiley-Interscience Publication, John Wiley & SONS, INC.

MATH-737 PERTURBATION METHODS-II Credit Hours: 3(3+0)

Objective of Course:

The goal of the course is to study some advance method to the perturbation theory to solve ordinary differential equations, partial differential equations as well as integral equations.

Course Outline:

Regular perturbation, Singular perturbation, Boundary layer, The method of matched asymptotic expansion, equations with large parameter, , Solution of partial differential equations by perturbation methods, Asymptotic expansion of integrals Laplace's method, Watson's Lemma, Riemann-Lebesgue lemma.

RECOMMENDED BOOKS

1. Alan W. Bush, Perturbation methods for engineers and scientists, CRC Press.
2. C. Bender, S. Orszag, Advanced mathematical methods for scientists and engineers, MGH, 1978.
3. E. Zauderer, Partial Differential Equations of Applied Mathematics, T 2nd edition, 1998.
4. Ali Hasan Nayfeh, Introduction to perturbation techniques, A wiley-Interscience Publication, John Wiley & SONS, INC.

MATH-738 PROBABILITY AND PROBABILITY DISTRIBUTIONS-I

Credit Hours: 3(3+0)

Objective of Course:

The objective of the course is to study some important topics of probability theory. It focuses on probability distributions and estimation methods.

Course Outline:

Historical origin of term Probability, Conditional Probability, Baye'stheorem, Chebyshev inequality. Random variables, Distribution function, Probability density function, Probability distribution of two variables, Binomial, Poisson, Hyper geometric, Negative Binomial, Geometric, Uniform, Exponential, Beta, Gamma and Normal distributions, Bivariate Normal distribution, Multivariate normal distribution, Central, limit Theorem, Probability as based of estimation, Properties of good estimator, Unbaised, Consistent, Sufficient, Efficient estimators, Minimum variance unbiased estimators,

RECOMMENDED BOOKS

1. A. Stuarts, Ord, J. K. Kendalls, Advanced theory of mathematics (Vol I), CharlesCoriffi & Co, London.
2. A. M. Mood, Graybill, D.C.Boes, Introduction to the theory of statistics, McGraw Hill, NY.
3. R. M. Hogg, A. T. Craig, Introduction to mathematical statistics, McMillan Co., New York.
4. A. S. Hirai, Estimation of statistical parameters, Ilmi Kitab Khana, Lahore, Pakistan.
5. R. E. Walpole, Introduction to mathematical statistics.

MATH-739 PROBABILITY AND PROBABILITY DISTRIBUTIONS-II

Credit Hours: 3(3+0)

Objective of Course:

This course introduces the basic notions of probability theory and develops them to the stage where one can apply the probabilistic ideas in statistical inference and modeling, and the study of stochastic processes.

Course Outline:

Moments generating function and characteristic functions, Cauchy distribution, Laplace distribution, Weiball distribution, Maxwell distribution, Pareto distribution, Raleigh distribution, Lag normal distribution, Inversion and uniqueness theorems, Convolution of function, Sampling distribution, Distribution of mean, median, rang and quartiles, Central and Non Central t, F and F and Chi-Square distribution, Neyman Pearson theorem, Uniform most powerful tests, like hood ratio tests, The sequential probability ratio test, Interval estimation for different parameters.

RECOMMENDED BOOKS

1. A. Stuarts, Ord, J. K. Kendalls, Advanced theory of mathematics (Vol I), Charles Coriffi & Co, London.
2. A. M. Mood, Graybill, D.C.Boes, Introduction to the theory of statistics, McGraw Hill, NY.
3. R. M. Hogg, A.T.Craig, Introduction to mathematical statistics, McMillan Co., New York.

4. A. S. Hirai, Estimation of statistical parameters, Ilmi Kitab Khana, Lahore, Pakistan.
5. R. E. Walpole, Introduction to mathematical statistics.

MATH-740 SEMIGROUP THEORY Credit Hours: 3(3+0)

Objective of Course:

The aim of the course is to familiar the student with the concepts of semi group theory. The formal study of semi groups began in the early 20th century. Semi groups are important in many areas of mathematics because they are the abstract algebraic underpinning of "memoryless" systems: time-dependent systems that start from scratch at each iteration. In applied mathematics, semi groups are fundamental models for linear time-invariant systems. In partial differential equations, a semi group is associated to any equation whose spatial evolution is independent of time. The theory of finite semi groups has been of particular importance in theoretical computer science since the 1950s because of the natural link between finite semi groups and finite automata. In probability theory, semi groups are associated with Markov Process.

Course Outline:

Introductory Ideas; Basic Definitions; Cyclic Semi groups; Order Sets; Semi Lattices and lattices; Binary Relations; Equivalences; Congruence; Free Semi groups; Green's Equivalences; L,R,H,J and D, Regular Semi groups; O–Simple Semi groups; Simple and O–Simple Semi groups; Rees's Theorem; Primitive Idempotent; Completely O–Simple Semi groups; Finite Congruence–Free Semi groups; Union of Groups; Bands; Free Bands; Varieties of Bands; Inverse Semi groups; Congruence on Inverse Semi groups; Fundamental Inverse Semi groups; Bisimple and Simple Inverse Semi groups; Orthodox Semi groups.

RECOMMENDED BOOKS

1. A. H. Clifford, G. B. Preston, The Algebraic Theory of Semigroups Vol. I & II, AMS Math, Survey, 1961 & 1967
2. J. M. Houie, An Introduction to Semigroups Theory, Academic Press, 1967.

MATH-741 VISCOUS FLUID-I Credit Hours: 3(3+0)

Objective of Course:

This course explores viscous fluid and its applications. The course material can be used as a reference source for future real world situations. After successful completion of this course, students will be able to understand the concept and solve viscous fluid problems.

Course Outline:

Eulerian approach, Lagrangian description, Properties of fluids, Transport properties, Kinematic properties, thermodynamics properties, Boundary conditions for viscous flows and heat conducting flows problems, Conservation of mass (equation of continuity), conservation of momentum (equations of Navier-Stokes), conservation of energy (energy equations), Dimensionalization and dimensionless parameters in viscous flow, Vorticity transport equation,

Stream function, Steady flow, unsteady flow, creeping flow and boundary layer flow, Couette flows, Poiseuille flow, Couette Poiseuille flow between parallel plates, Stokes first problem, Stokes second problem,

Unsteady flow between two infinite plates, Asymptotic suction flows: uniform suction on a plane, flow between parallel plates with top suction and bottom injection.

RECOMMENDED BOOKS

1. Frank M. White ,Viscous Fluid Flow, Second Edition, McGRAW-HILL, Inc.
2. Hermann Schlichting,Boundary-layer Theory ,Seventh Edition, McGraw-Hill Series in Mechanical Engineering.
3. G.K. Batchelor, An introduction to fluid dynamics, Cambridge University Press.

MATH-742 VISCOUS FLUID-II Credit Hours: 3(3+0)

Objective of Course:

This course deals with the advance methods for the solution of viscous fluid problems. After successful completion of this course, students will be able to solve viscous fluid problems in higher dimensions.

Course Outline:

Similarity solution, Berman problem, Plane stagnation flow, axisymmetric stagnation flow, flow near an infinite rotating disk, Jeffery Hammel flow in a wedge shaped region and it solution for small wedge angle, Stokes solution for an immersed sphere, Derivation of boundary-layer equations for two-dimensional flow, The laminar boundary layer equations, The approximate method due to the von Karman and K. Pohlhausen for two dimensional flows, Blasius problem of flat plate flow, Falker-Skan wedge flows, Heat transfer for Falker-Skan flows, two dimensional steady free convection, viscous flows over a stretching sheet, thin film flows

RECOMMENDED BOOKS

1. Frank M. White ,Viscous Fluid Flow, Second Edition, McGRAW-HILL, Inc.
2. Hermann Schlichting, Boundary-layer Theory ,Seventh Edition, McGraw-Hill Series in Mechanical Engineering.
3. G. K. Batchelor, An introduction to fluid dynamics, Cambridge University Press.

MATH-743 FUZZY LOGIC AND ALGEBRA Credit Hours: 3(3+0)

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 fuzzy sets

Course Outline:

Logics, sets, subsets, Functions and relations, Partially ordered sets ,The lattice of subsets of a set, characteristic functions, fuzzy Sets, definitions and examples ,Lattice theoretical operations on

fuzzy sets,Fuzzy sets, functions and fuzzy relations, Types of fuzzy sets, intuitionistic fuzzy sets, picture fuzzy sets Algebraic operators, fuzzy measure, fuzzy relations, fuzzy analysis and Applications of fuzzy algebra.

Recommended Books

(1) Fuzzy Set Theory by R. LOWEN.
(2) Fuzzy set theory and its applications by H. J. Zimmermann.
(3) Fuzzy Semi groups by J. N. Mordeson, D. S. Malik, N. Kuroki.

MATH-751 NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS-I Credit Hours: 3(3+0)

Objective of Course:

This course explores an introduction to various numerical methods for partial differential equations with emphasis on finite difference type methods. The course also illustrates, via numerics, the distinguishing mathematical properties of various commonly occurring partial differential equations.

Course Outline:

Numerical Methods for Parabolic PDEs; review of finite difference methods, explicit methods, Crank-Nicolson implicit method, Local Truncation Error, Stability, Consistency and convergence, Fourier stability methods, alternating directions implicit method, higher level schemes, nonlinear equations, predictor corrector methods, computer problems,Two dimensional parabolic equations and finite difference schemes,computer problems. Numerical methods for hyperbolic PDEs; method of characteristics, finite-difference methods-Lax-Wendroff method, Courant-Friedrichs-Lewy method, two-space Hyperbolic equations, computer implementations. Numerical Methods for Elliptic PDEs; finite-difference methods, Poisson Equation, Laplace Equations, Curved boundary, finite-differences in Polar co-ordinates.

RECOMMENDED BOOKS

1. C. Jhonson, Numerical Solutions of Partial Differential Equations by the finite methods, Cambridge University Press
2. W. F. Ames, Numerical methods for P.D.Es, Academic Press.
3. G. D. Smith, Numerical Solutions of P.D.Es finite difference methods, Clarendon Press, Oxford.
4. G. W. Thomas, Numerical Solutions of P.D.E's.

MATH-753 SPECIAL RELATIVITY Credit Hours: 3(3+0)

Course Outline: Historical background and fundamental concepts of Special theory of Relativity. Lorentz transformations (for motion along one axis). Length contraction, Time dilation and simultaneity. Velocity addition formulae. 3-dimensional Lorentz transformations. Introduction to 4-vector formalism. Lorentz transformations in the 4-vector formalism. The Lorentz and Poincare groups. Introduction to classical Mechanics. Minkowski spacetime and null cone. 4-velocity, 4-momentum and 4-force. Application of Special Relativity to Doppler shift and Compton effect. Particle scattering. Binding energy, particle production and decay. Electromagnetism in Relativity. Electric current. Maxwell's equations and electromagnetic waves. The 4-vector formulation of Maxwell's equations. Special Relativity with small acceleration.

Recommended Books:

1. Qadir, A. Relativity, An Introduction to the Special Theory, World Scientific, 1989.
2. D' Inverno. R., Introducing Einstein's Relativity, Oxford University Press, 1992.
3. Goldstein, H., Classical Mechanics, Addison Wesley, New York, 1962.
4. Jackson, J.D., Classical Electrodynamics, John Wiley, New York, 1962.
5. Rindler, W., Essential Relativity, Springer-Verlag, 1977.

MATH-754 GENERAL RELATIVITY Credit Hours: 3(3+0)

Course Outline: The Einstein field equations. The principles of general relativity. The stress-energy momentum tensor. The vacuum Einstein equations and the Schwarzschild solution. The three classical tests of general relativity. The homogeneous sphere and the interior Schwarzschild solution. Birkhoff's theorem. The Reissner-Nordstrom solution and the generalised Birkhoff's theorem. The Kerr and Kerr-Newman solution. Essential and coordinate singularities. Event horizon and black holes. Eddington-Finkelstein. Kruskal-Szekres coordinates. Penrose diagrams for Schwarzschild, Reissner-Nordstrom solutions.

Recommended Books:

1.Wald, R.M., Introduction to General Relativity, University of Chicago Press, Chicago,1984.
2.Adler, R., Bazine, M., and Schiffer, M., Introduction to General Relativity, McGraw- Hill Inc.,1965.
3.Rindler, W., Essential Relativity, Springer Verlag 1977.

PhD Mathematics

ELIGIBILITY CRITERIA FOR Ph.D

- As per HEC Criteria

Semester-wise break up

S. No	Course Code	Course Title	Credit Hours	Category
Semester-I				
1	MATH-	Elective-I	3(3+0)	Elective
2	MATH-	Elective-II	3(3+0)	Elective
3	MATH-	Elective-III	3(3+0)	Elective
4		Understanding of Holy Quran-I	1(1+0)	
Semester Credit Hours			**10**	
Semester-II				
1	MATH-	Elective-I	3(3+0)	Elective
2	MATH-	Elective-II	3(3+0)	Elective
3	MATH-	Elective-III	3(3+0)	Elective
4		Understanding of Holy Quran-II	1(1+0)	
Semester Credit Hours			**10**	

Third to Sixth Semester — Credit Hours

MATH- 899 Research Thesis — **18**

Optional Courses for PhD			
S. No	**Course Code**	**Course Title**	**Credit Hours**
1	MATH-801	Advanced Partial Differential Equations	3(3+0)
2	MATH-802	Advanced Topology	3(3+0)
3	MATH-803	Advanced Numerical Methods	3(3+0)

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4	MATH-804	Advanced Ring Theory	3(3+0)
5	MATH-805	Advanced Algebra	3(3+0)
6	MATH-806	Advanced Graph Theory	3(3+0)
7	MATH-807	Advanced Group Theory	3(3+0)
8	MATH-808	Advanced Operation Research-I	3(3+0)
9	MATH-809	Advanced Operation Research-II	3(3+0)
10	MATH-810	Algebraic Topology	3(3+0)
11	MATH-811	Advanced Analytical Dynamics-I	3(3+0)
12	MATH-812	Advanced Analytical Dynamics-II	3(3+0)
13	MATH-813	Advanced Functional Analysis	3(3+0)
14	MATH-814	Banach Algebra	3(3+0)
15	MATH-815	Advanced Mathematical Biology	3(3+0)
16	MATH-816	Computational Fluid dynamics	3(3+0)
17	MATH-817	Computational Methods	3(3+0)
18	MATH-818	Convolution in Geometric Function Theory	3(3+0)
19	MATH-819	Differential Subordination Theory	3(3+0)
20	MATH-820	Advanced Geometric Function Theory	3(3+0)
21	MATH-821	Advanced Integral Equations	3(3+0)
22	MATH-822	Large Scale Scientific Computation	3(3+0)
23	MATH-823	Mathematical Logic	3(3+0)
24	MATH-824	Advanced Mathematical Methods	3(3+0)
25	MATH-825	Mathematical Techniques for Boundary Value Problems	3(3+0)
26	MATH-826	Multivariate Analysis-I	3(3+0)
27	MATH-827	Multivariate Analysis-II	3(3+0)
28	MATH-828	Numerical Analysis of Spectral Methods	3(3+0)
29	MATH-829	Numerical Linear Algebra	3(3+0)
30	MATH-830	Numerical Solutions of Integral Equations-I	3(3+0)
31	MATH-831	Numerical Solutions of Integral Equations-II	3(3+0)
32	MATH-832	Numerical Solution of ODE's	3(3+0)
33	MATH-833	Heat Transfer	3(3+0)
34	MATH-834	Advanced Optimization Theory-I	3(3+0)
35	MATH-835	Advanced Optimization Theory-II	3(3+0)
36	MATH-836	Perturbation Methods-I	3(3+0)
37	MATH-837	Perturbation Methods-II	3(3+0)
38	MATH-838	Probability and Probability Distributions-I	3(3+0)
39	MATH-839	Probability and Probability Distributions-II	3(3+0)
40	MATH-840	Semi Group Theory	3(3+0)
41	MATH-841	Viscous Fluid-I	3(3+0)
42	MATH-842	Viscous Fluid-II	3(3+0)
43	MATH-843	Fuzzy Logic and Algebra	3(3+0)
44	MATH-844	Rough Set Theory and its Applications	3(3+0)

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45	MATH-845	LA-Semigroups	3(3+0)
46	MATH-846	Theory of Group Actions	3(3+0)
47	MATH-847	Theory of Group Graphs	3(3+0)
48	MATH-848	Topics in Pure Mathematics*	3(3+0)
49	MATH-849	Topics in Computational Mathematics*	3(3+0)
50	MATH-850	Topics in Applied Mathematics*	3(3+0)
51	MATH-851	Numerical Solution of PDEs-I	3(3+0)
52	MATH-852	Numerical Solution of PDEs-II	3(3+0)
53	MATH-853	Special Relativity	3(3+0)
54	MATH-854	General Relativity	3(3+0)
55	MATH-855	Symmetry Methods in Differential Equations	3(3+0)
56	MATH-856	Advanced History of Mathematics	3(3+0)

***Course Outline: will be presented and designed by the instructor.**

MATH-801 ADVANCED PARTIAL DIFFERENTIAL EQUATIONS

Credit Hours: 3(3+0)

Objective of Course: This course is an advance to the theory of partial differential equations (PDEs). Upon successful completion the student will learn linear operators and linearity, partial differential equation and associated boundary and initial value problems, and well posed problems, the concept of maximum principle, existence and uniqueness, the concept of Green's functions and be able to derive them and use them in some simple cases, the notions of Poisson's equation and the Poisson integral formula, three-dimensional wave equation.

Course Outline: Cauchy's Problems for Linear Second Order Equations in n-independent Variables; Cauchy Kowalewski Theorem; Characteristic Surfaces; Adjoint Operators; Bicharacteristics; Spherical and Cylindrical Waves; Heat Equation; Wave Equation; Laplace Equation; Maximum-Minimum Principle; Integral Transforms.

RECOMMENDED BOOKS

6. R. Dennemyer, Introduction to P.D.E's & Boundary Value Problems, McGraw Hill Com., 1968
7. C. R. Chester, Techniques in P.D.E's, McGraw Hill Com., 1971.

MATH-802 ADVANCED TOPOLOGY

Credit Hours: 3(3+0)

Objective of Course:

Topology is one of the most active and advanced fields of mathematics, and it is indispensible for many other fields, such as Analysis, Geometry or Algebra. This course is an advance course of Topology.

Course Outline:

Directed sets and nets, subnets and cluster points, sequences and subsequences, quotient spaces, the Tychonoff theorem, completely regular spaces, the Stone-Eeih compactification, meterization theorems and paracompactness, function spaces.

RECOMMENDED BOOKS:

1. J. L. Kelley, General Topology, Springer-Verlag, 1975.
2. S. Willard, General Topology, Addison Wesley Pub. Co., 1970.
3. J. R. Munkers, Topology (a first course), Prentice Hill Inc., 1975.

MATH-803 ADVANCED NUMERICAL METHODS Credit Hours: 3(3+0)

MATH-804 ADVANCED RING THEORY Credit Hours: 3(3+0)

Objective of Course:

The aim of the course is to familiar the student with the concepts of ring theory. Ring theory is very important in the field of abstract algebra like the concept of vector spaces in linear algebra and functional analysis. Ring theory is the study of rings-algebraic structure in which addition and multiplication are defined and have similar properties to those familiar from the integers. Ring theory studies the structure of rings, their representation, or, in different language, modules, special classes of rings (group rings, division rings) as well as an array of properties that proved to be of interest both within the theory itself and for its applications, such as homological properties and polynomial identities. Commutative rings are much better understood than non-commutative ones. Algebraic geometry and algebraic number theory, which provide many natural examples of commutative rings, have driven much of the development of commutative ring theory, which is now, under the name of commutative algebra, a major area of modern mathematics

Course Outline:

Radical classes; Semisimple Classes; the Upper radical; Semis images; the lower radical; Heretariness of the lower radical class and the simple Upper radical class; Partitions of simple rings; Minimal left ideals; wedderbusn-Artin Structure theorem; the Brown –McCoy radical; the Jacobson Radical; Connections among radical Classes: Homomorphically closed semisimple classes.

RECOMMENDED BOOKS

- P. Hiegant, Radical and Semi-simple Classes of Ring, Queen paper in pure and applied Mathematics, Queens University Kingston, Ontario, 1974.

MATH-805 ADVANCED ALGEBRA Credit Hours: 3(3+0)

Objective of Course:

The goal of the course is to introduce the student with the theory of Advance topics in abstract algebra. The course is designed for the understanding of Field extensions, Galois Theory and Valuation theory which is very important for the new research domain in abstract algebra for example in Algebraic topology. Galois Theory provides a means of proving the impossibility of duplicating the cube, squaring the circle and trisecting a general angle. It also gives beautiful and almost complete algebraic proofs of fundamental Theorems of algebra.

Course Outline:

Quadratic forms and modular functions, Interpretation of rings and Ideals, Finite invariants of a field, Hilbert sequence of fields and groups, Artin theorem and symbols, The field extension, Splitting field, Sylow theory, Jordan- Hölder theory, Galois theory, Valuation theory.

RECOMMENDED BOOKS:

1. P. M. Cohn, Algebra Vol. I & II, John Wiley & Sons.
2. Burton, A First Course in Rings & Ideals, Addison Wesley Co.
3. J. Lambek, Lectures on Rings & Modules, Blaisdel.
4. M. S. Atiyab, I. G. Macdonald, Introduction to Commutative Algebra, Addison Wesley Pub. Com., London, 1969.
5. D. E. A. Burton, First Course in Rings and Ideals, Addison Wesley Pub. Company, 1968.
9. O. Mariski, P. Samuel, Commutative Algebra, London, 1963.
10. I. Kaplansky, Commutative Rings University of Chicago Press.
11. F. W. Anderson, K. R. Puller, Rings and Category of Modules, Springer-Verlag.

MATH-806 ADVANCED GRAPH THEORY Credit Hours: 3(3+0)

Objective of Course: The aim of the course is to introduce the student to the theory of graphs, particularly algorithmic graph theory. The student will learn a number of standard and powerful algorithms, as well as demonstrating methodologies in graph techniques. In addition the student will be introduced to the use of graphs in the solution of complex problems. Graph theory has become one of the major tools for the design and analysis of algorithms, as well as the focus of much interest in theoretical computer science.

Course Outline:

Review of basic concepts (Vertices, edges, loop, degree, complete graphs, graph isomorphism, adjacency matrices, subgraphs, walks, paths, circuits, The Konigsberg bridge problem, connected graphs, disconnected graphs, and components).

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Euler graphs, Euler line, operations on graphs, Hamiltonian paths and circuits, The Travelling salesman problem, Trees, properties of trees, pendant vertices in a tree, distance and centers in a tree, rooted and binary trees, spanning trees, fundamental circuits, finding all spanning trees of a graph, spanning trees in a weighted graph, Kruskal's algorithm, Prim's algorithm, Boruska's algorithm, Cut-Sets, properties of a cut-set, fundamental cut-sets, connectivity and seperability. Network Flows, network flow problems, 1-Isomorphism, 2-Isomorphism, Planar and Dual graphs, Kuratowski's two graphs, different representations of a planar graph, coloring, partitioning and covering, chromatic partitioning, algorithm for maximum independent set, Matching, Dijkstra algorithm for shortest path, Maximal flow problem, Residual network, Ford-Fulkerson algorithm, Bread-first search algorithm, Depth-first search algorithm.

RECOMMENDED BOOKS

5. R. G. Busacker, T. L. Seaty, Finite graphs and Networks', An introduction with applications', McGraw Hill Book Company.
6. R. J. Wilson, Introduction to Graph Theory, Longman Scientific and technical, 1985.
7. Wai-Kaichen, Applied graph Theory "graphs and Electrical networks, North-Holland Pub. 1976.
8. N. Deo, Graph Theory with Applications to Engineering and Computer Science,Prentice-Hall, INC. Englewood Cliffs, N.J.

MATH-807 ADVANCED GROUP THEORY Credit Hours: 3(3+0)

Objective of Course: The aim of the course is to introduce the student with the basic concepts of group theory. The concept of group is fundamental in abstract algebra. Almost all structures in abstract algebra are special cases of groups e.g. Galois Theory uses groups to describe the symmetries of the roots of a polynomial, Algebraic Knot Theories takes in a crucial way on classifying spaces of groups. Similarly Algebraic topology is another domain which prominently associates groups to the objects the theory is interested in.

Course Outline: Normal and Subnormal Series, Abelian and Central Series, Direct Products, Finitely Generated Abelian Groups, Splitting Theorems, Solvable and Nilpotent Groups, Commutators Subgroup, Derived Series, The Lower and Upper Central Series, Characterization of Finite Nilpotent Groups, Fitting Subgroup, Frattini Subgroup, Dedekind Groups, Super solvable Groups, Solvable Groups with Minimal Condition. Subnormal Subgroups, Minimal Condition on Subnormal Subgroups, The Subnormal Socle, the Wielandt Subgroup and Wielandt Series, T-Groups, Power Automorphisms, Structure and Construction of Finite Soluble T-Groups.

RECOMMENDED BOOKS

3. D.J.S. Robinson, A Course in the Theory of Groups, Graduate Texts in Mathematics 80, Springer, N Y, 1982.

4. K. Doerk, T. Hawkes, Finite Soluble Groups, De Gruyter Expositions in Mathematics 4, Walter De Gruyter, Berlin, 1992.

MATH-808 ADVANCED OPERATION RESEARCH-I Credit Hours: 3(3+0)

Objective of Course:

This course is intended to provide students with an advance knowledge that can make them appreciate the use of various research operations tools in decision making in organizations. At the end of the Course participants are expected to demonstrate a working knowledge of the various OR /OM tools in making decisions as well as being able to formulate organizational problems into OR models for seeking optimal solutions.

Course Outline:

Introduction; Definition and Historical background; or models; Principal Components of decision problems; Type of or models; phases of or study.

Linear programming; Graphical solution; Examples of LP applications; The standard form; Basic Solutions and bases; The Simplex method; Special cases in simplex method application; Sensitivity analysis; The Dual problem; Definition of the Dual problem; Primal –Dual relationships; Dual simplex method. Transportation model; Definition and application; solution of the transportation model; The assignment model; The transhipment model.

RECOMMENDED BOOKS

1. H. A. Taha, Operations Research An Introduction, Collier MacMillan, 1982.
2. H. Lieberman, Introduction to operation research, 8th edition, The McGraw Hill Co.

MATH-809 ADVANCED OPERATIONS RESEARCH-II Credit Hours: 3(3+0)

Objective of Course:

This course will focus on mathematical modelling. A strong emphasis will be given to model formulation. On the methodology side, Linear and Integer Programming techniques will be introduced. At the end of the course, students will have the skills to build their own formulations, to expand existing formulations, to critically evaluate the impact of model assumptions and to choose an appropriate solution technique for a given formulation.

Course Outline:

Dynamic programming; Elements of the DP model; Definition of the state and stages; examples of the DP model and computations; problem of dimensionality; solution of linear programming by DP. Game Theory; two-persons Zero-sameGames; mixed strategies; Graphical solution of (2xn) and (mx2) games; Solution of (mxn) Games by Linear programming. Project scheduling by PERT-CPM; Arrow diagram representation; Construction of the time chart; cost consideration in project scheduling; project control. Inventory Model; The general inventory problem and definition; Deterministic (static and dynamic) Inventory models.

RECOMMENDED BOOKS

1. H. A. Taha, Operations Research An Introduction, Collier MacMillan, 1982.
2. H. Lieberman, Introduction to operation research, 8th edition,The McGraw Hillco.

MATH-810 ALGEBRAIC TOPOLOGY Credit Hours: 3(3+0)

Objective of Course:

This course is an introduction to algebraic topology. Algebraic topology studies topological spaces by associating to them algebraic invariants. The principal algebraic invariants considered in this course are the fundamental group (also known as the first homotopy group) and the homology groups. It is fundamental for students interested in research in Algebraic Geometry, Differential Geometry, Mathematical Physics, and Topology; it is also important for students in Algebra and in Number Theory.

Course Outline:

Homology theory: Homology groups, simplical homology, exact sequences. Singular homology.Cohomology, Duality and Topological manifolds.The Alexander Poincar's duality theorem.General homotopy theory: some geometric construction. Homotopy classes of maps, Exact sequences, Fibre and cofibre maps.

RECOMMENDED BOOKS:

1. E. H. Spanier, Algebraic Topology, Tata McGraw Hill.
2. C. Kosniowski, A First Course in Algebraic Topology, Cambridge Uni. Press, 1988.
3. C. R. E. Maunder, Algebraic Topology, Cambridge Uni. Press,1980.
4. J. Mayer, Algebraic Topology, Prentice Hall NJ.

MATH-811 ADVANCE ANALYTICAL DYNAMICS-I Credit Hours: 3(3+0)

Objective of Course:

This course is designed to teach the students how mathematics could be used in solving problems in the contemporary Science/Technology and Engineering world. Therefore, the course is structured to expose the students to the skills required to attain a level of proficiency in Analytical Dynamics.

Course Outline:

Equations of dynamics and its various forms; Equations of Lagrange and Euler, Jacobi's elliptic functions and the qualitative and quantitative Solutions of the problems of Euler and Poisson.The Problems of Lagrange and Poisson.Dynamical system; Equations of Hamilton and Appell; Hamilton–Jacobi theorem; Separable systems' Holder's variational principles and its consequences.

RECOMMENDED BOOKS

1. L. A. Pars, A Treatise on Analytical Dynamics, Heinman London, 1965.
2. E. T. Whittaker, A treatise on Dynamics of Rigid Bodies and Particles, Cambridge Uni. Press, 1965.

MATH-812 ADVANCED ANALYTICAL DYNAMICS-II Credit Hours: 3(3+0)

Objective of Course:

The aim of this course is to give students advance topics analytical dynamics.

Course Outline:

Groups of continuous Transformations and Poincare's Equations; Systems with one degree of freedom; Singular Points; Cycle characteristics of systems with a Degree of freedom; Ergodic theorem; Metric indecompossability; stability of motion periodic Orbits.

RECOMMENDED BOOKS

1. L. A. Pars, A Treatise on Analytical Dynamics, Heinman London, 1965.
2. E. T. Whittaker, A treatise on Dynamics of Rigid Bodies and Particles,Camb. Uni.Press, 1965

MATH-813 ADVANCED FUNCTIONAL ANALYSIS Credit Hours: 3(3+0)

Objective of Course:

The course combines ideas and methods from different areas of mathematics. It is designed especially for students who want to choose operator algebras as their speciality, but the content of the course will also be useful to students interested in other branches of analysis. This point of view turned out to be particularly useful for the study of differentialand integral equations.

Course Outline:

Normed Spaces. Banach spaces; Bounded Linear operators; Compactness and Continuity; Finite Dimensional Normed Linear spaces; The Stone Weirstrass Theorem and Aseoli Aezela Theorem; Bounded linear Functionals; Dual spaces; The Hahn Banach Theorem. The Riesz Representation Theorem. Contraction, Fixed Point Theorem and its applications, Reflexive spaces. Strong and Weak Convergence. Convergence of Sequences of Operators and Functionals; Bair's Theorem; The Principle of Uniform Boundedness; The Open Mapping Theorem and Closed Graph Theorem; Compact Linear Operators, Applications in Approximation Theory.

RECOMMENDED BOOKS.

2. A. L. Brown, A. Page, Elements of Functional Analysis, Van Nostl found and Reinholt Company London, 1997.
2. E. Kreyszig, Introductory Functional Analysis With Applications, John Wiley & Sons, N. Y.1989.
3. A. E. Taylor, D. C. Lay, Introduction to Functional Analysis, 2nd Edition. Robert E. Krieger Pub. Company Florida, 1986.

4. J. D. Conway, A Course in Functional Analysis, Spring-Verlag, 1994.

MATH-814 BANACH ALGEBRA Credit Hours: 3(3+0)

Objective of Course:

Banach algebras have a lot of structure, combining the topological features of a Banach space, with the algebraic features of a ring. The main focus will be on examining Banach algebras consisting of continuous linear operators on Hilbert and Banach spaces.

Course Outline:

Banach Algebras; Ideals; Homomorphisms; Quotients Algebras; Winner's lemma; Gelfand's Theory of Commulative Banach Algebras; The Notions of Gelfand's topology; Radicals; Gelfand's Transforms; Basic properties of Spectra; Gelfand–Mazer Theorem; Symbolic Calculus; Differentiation; Analytic Functions; Integration of A–valued Functions; Normed Rings; Gelfand–Naimark Theorem.

RECOMMENDED BOOKS

1. W. Rudin, Functional Analysis, McGraw Hill Pub., N.Y.
2. M. A. Naimark, Normed Algebras, Wolters Noordhoff Pub., Netherland, 1972.
3. W. Zelazko, Banach Algebras, American Elsevier Pub., N.Y., 1973.
4. C. E. Rickart, Banach Algebras, D. Van Nostrand Pub., New York, 1960.

MATH-815 ADVANCED MATHEMATICAL BIOLOGY Credit Hours: 3(3+0)

Objective of Course:

This course is intended to equip students with skills and techniques of model formulating, analysing and interpreting mathematical models in Biology, Ecology, Epidemics, etc.

Course Outline:

The history of a system in the course of irreversibility transformation.The statistical meaning of irreversibility. Evolution conceived as a redistribution. The programme of physical biology.The fundamental equations of the kinetics of the evolving systems.(General case; equations with one dependent variable; equations with two or three dependent variables).Analysis of the growth function.

RECOMMENDED BOOKS

3. A. J. Lotka, Elements of Mathematical Biology, Dover Publications, N.Y., 1956.
4.

MATH-816 COMPUTATIONAL FLUID DYNAMICS Credit Hours: 3(3+0)

Objective of Course:

Computational Fluid Dynamics (CFD), an extremely versatile technology requiring high performance computing environment is poised to take over as a universal software for simulating multi-physics problems in industrial R&D. The course is designed to reflect the broad range of CFD applications by providing a range of optional modules to address specific application areas.

Course Outline:

Prerequisites: Numerical Methods/Fluid Dynamics at M.Sc Level Philosophy of Computational Fluid Dynamics, Basic of Computational Fluid Dynamics: Incompressible plane flows, Stream function and vorticity equations, Conservative form and normalizing systems, Method for solving vorticity transport equation, Basic finite difference forms, Conservative property, Convergence and stability analysis, Explicit and implicit methods, Stream function equation and boundary conditions, Schemes for adjective diffusion equation, Upwind differencing and artificial vorticity, Solution for primitive variables.

RECOMMENDED BOOKS

8. C. A. J. Fletcher, Computational Techniques for Fluid Dynamics, Volume 1 & 2, Springer Verlag, 1992.
9. C. Y. Chow, Introduction to Computational Fluid Dynamics, John Wiley, 1979.
10. M. Holt, Numerical Methods in Fluid Mechanics, Springer Verlag, 1977.
11. H. J. Wirz and J. J. Smolderen, Numerical Methods in Fluid Dynamics, Hemisphere, 1978.
12. D. A. Anderson, J. C. Tannehill and R. H. Pletcher, Computational Fluid Dynamics and Heat Transfer, McGraw Hill, 1984.
13. J. D. Anderson, Computational Fluid Dynamics: The Basics with Applications, McGraw- Hill, 1995.
14. K. Hoffmann and S. T. Chiang, Computational Fluid Dynamics for Engineers, Vols. 1 and 2, Engineering Education System, 1993.

MATH-817 COMPUTATIONAL METHODS Credit Hours: 3(3+0)

Objective of Course:

A study and analysis of important numerical and computational methods for solving engineering and scientific problems. The course will include methods for solving linear and nonlinear equations, evaluating integrals, solving ordinary and partial differential equations, and determining eigenvalues and eigenvectors or matrices. The student will be required to write and run computer programs.

Course Outline:

Review of Numerical Methods (Bisection, Newton, Fixed point iteration), Review of Direct Methods for Linear Equations (Gauss, LUD, Tridiagonal), Cholesky

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Decomposition. Review of Matrix Algebra, Vector and Matrix Norms. Iterative Methods for solving linear equations (Jacobi, Gauss-Siedel, SOR methods), Eigen-value problems, Power method, Inverse power method and other techniques, Newton's method for system of non-linear equations, Numerical solution of Boundary Value Problems, Numerical solution of Partial differential equations.

RECOMMENDED BOOKS

1. R. L. Burden, J. D. Fairs;An Introduction to Numerical Analysis, 1993.
2. G. D. Smith, Numerical Solutions of P.D.Es, 1999.
3. J. H. Wilkinson, The Algebraic Eigenvlaue Problems, 1965.
4. U. Asher et al., Numerical solution of Boundary Value Problems in ODE's, 1986.

MATH-818 CONVOLUTION IN GEOMETRIC FUNCTION THEORY
Credit Hours: 3(3+0)

The duality principle, test sets, convolution invariance Application to Geometric Function Theory, univalence criteria via convolution and applications prestarlike functions, applications to close-to-convex and related functions.

RECOMMENDED BOOKS

3. Convolutions and Geometric Function Theory by Ruscheweyh (1982)
4. Univalent Functions" by Ch. Pommerenke (1975)

MATH-819 DIFFERENTIAL SUBORDINATION THEORY Credit Hours: 3(3+0)

Subordination, Hypergeometic Functions, classes of functions, Integral operators, Differential operator. Second order differential subordination some fundamental results. The open Door Lemma and Integral Existence theorem.Classical subordination.

RECOMMENDED BOOKS

3. "Differential Subordinations" (2000) by S. S. Miller and P. T. Mocanu.
4. "Univalent Functions" Vol I & II, by A. W. Goodman

MATH-820 GEOMETRIC FUNCTION THEORY Credit Hours: 3(3+0)

Riemann mapping theorem, conformal mappings and their properties, univalent functions and their subclasses, Functions with positive real part, Herglotz Formula, Some basic properties of univalent and multivalent functions. Radius Problems, Alexander Theorem, Integral Representation of Star like Function, Convex Function

RECOMMENDED BOOKS

4. Geometric function theory and non-linear analysis by Tadeusz Iwaniec, Gaven Martin.
5. Topics in geometric function theory By Carl Hanson FitzGerald.
6. A. W. Goodman, Univalent Functions, Vol I & II.

MATH-821 ADVANCED INTEGRAL EQUATIONS Credit Hours: 3(3+0)

Objective of Course:

This course unit consists of methods of solving various mathematical problems which arise in science. The method of Green's functions is a powerful tool in solving linear ordinary and partial differential equations, and the course starts with an introduction to this topic. There are situations where physical laws are better expressed as integral equations. On successful completion of this course students will be able to solve ordinary and partial differential equations.

Course Outline:

Existence Theorem; Integral Equations with L Kernels; Applications to Partial Differential Equations; Integral Transforms; Wiener-Hopf Techniques

RECOMMENDED BOOKS

2. H. H. Stad, Integral Equations, John Wiley, 1973.
2. I. Stakgold, Boundary Value Problems of Mathematical Physics, McMillan NY, 1968.

MATH-822 LARGE SCALE SCIENTIFIC COMPUTATION Credit Hours: 3(3+0)

Objective of Course:

The overall goal of the course is to provide a basic understanding of how to develop algorithms and how to implement them in distributed memory computers using the message-passing paradigm and some advance methods in numerical computations. The students will be prepared either for research in an area where computational techniques play a significant role, or for a career in business or industry.

Course Outline:

Prerequisites: Scientific Computing, Numerical Analysis, Numerical Linear Algebra

Large sparse linear systems, Storage schemes, Review of stationary iterative process, Krylov subspace methods, Conjugate gradients(CG), BiCG, MINRES and GMRES, The Lanczos iteration, From Lanczos to Gauss quadrature, Preconditioning, Error bounds for CG and GMRES, Effects of finite precision arithmetic, Multigrid methods, Multigrid as a preconditioner for Krylov subspace methods. Nonlinear systems, Newton's method and some of its variants, Newton GMRES, Continuation methods, Conjugate direction method, Davidon-Fletcher-Powell Algorithms.

Software Support: HOMPACK, LAPACK

RECOMMENDED BOOKS:

7. J. M. Ortega and W. C. Rheinboldt, Iterative Solution of Nonlinear Equations in Several Variables, Academic Press, 1970.
8. C. T. Kelly, Iterative Methods for Linear and Nonlinear Equations, SIAM, Philadelphia, 1995.

9. A. Greenbaum, Iterative Methods for Solving Linear Systems, SIAM, Philadelphia, 1997
10. O. Axelsson, Iterative Solution Methods, Cambridge University Press, 1994.
11. P. Wesseling, An Introduction to Multigrid Methods, John Wiley & Sons, 1992.
12. C. W. Ueberrhuber, Numerical Computation: Methods, Software and Analysis, Springer Verlag, 1997.

MATH-823 MATHEMATICAL LOGIC Credit Hours: 3(3+0)

Course Outline:

Introduction, propositional calculus, methods of proof, analysis of arguments, predicate calculus and quantifiers, boolean algebra to logic, boolean functions, boolean algebra and propositional logic. logic gates, combinational circuits.

RECOMMENDED BOOKS:

4. Irving m.copi, symbolic logic, collier macmillan publishers, 1973
5. Patric j. hurley, a concise introduction to logic, ward worth publishing company,
6. elliott mendelson, boolean algebra and switching circuits, mcgraw hill book company, 1970.

MATH-824 AVANCED MATHEMATICAL METHODS Credit Hours: 3(3+0)

Objective of Course:

The course will cover some mathematical techniques commonly used in theoretical physics. This is not a course in pure mathematics, but rather on the application of mathematics to problems of interest in the physical sciences.

The students will learn the following topics:

- Hilbert spaces: complete orthonormal sets of functions
- Special functions (Legendre polynomials, Fourier series and integrals, spherical harmonics)
- Sturm-Liouville systems: orthogonal polynomials
- Green's functions

Course Outline:

General solution of Bessel equation, Recurrence relations, Orthogonality of Bessel functions, Modified Bessel functions, Applications. General solution of Legendre equation, Legendre polynomials, Associated Legendre polynomials, Rodrigues formula, Orthogonality of Legendre polynomials, Application. Concept and calculation of Green's function, Approximate Green's function, Green's function method for differential equations, Fourier Series, Generalized Fourier series, Fourier Cosine series, Fourier Sine series, Fourier integrals. Fourier transform, Laplace transform, Z-transform, Hankel transform, Mellin transform. Solution of differential equation by Laplace and Fourier transform methods.

RECOMMENDED BOOKS


7. G. N. Watson, A Treatise on the Theory of Bessel Functions, Cambridge University Press, 1944.
8. G. F. Roach, Green's Functions, Cambridge University Press, 1995.
9. A. D. Poularikas, The Transforms and Applications – Handbook, CRC Press, 1996.
10. J. W. Brown and R. Churchill, Fourier Series and Boundary Value Problems, McGraw Hill, 1993.

MATH-825 MATHEMATICAL TECHNIQUES FOR BOUNDARY VALUE PROBLEMS Credit Hours: 3(3+0)

Objective of Course:

This course has a major focus on training analytical and logical thinking and learning fundamental methods for solving ordinary and partial differential equations. Both the knowledge about differential equations as well as the training of analytical faculties will be useful for the students in the course of their further studies. The course also explores the capacity and motivation for intellectual development through the solution of both simple and more complex mathematical problems from the important field of differential equations.

Course Outline:

Green's function method with applications to wave-propagation. Perturbation method: regular and singular perturbation techniques with applications. Variational methods.A survey of transform techniques; Wiener-Hopf technique with applications to diffraction problems.

RECOMMENDED BOOKS

1. A. Nayfeh, Perturbation methods.
2. I. Stakgold, Boundary Value Problems of Mathematical Physics.
3. B. Noble, Methods based on the Wiener-Hopf technique for the solution of Partial Differential Equations.
4. R. Mitra, S. W. Lee, Analytical Techniques in the Theory of Guided Waves.

MATH-826 MULTIVARIATE ANALYSIS-I Credit Hours: 3(3+0)

Objective of Course:

The course is designed to understand the statistical analysis of the data collected on more than one (response) variable. These variables may be correlated with each other, and their statistical dependence is often taken into account when analyzing such data. This consideration of statistical dependence makes multivariate analysis somewhat different in approach and considerably more complex than the corresponding univariate analysis, when there is only one response variable under consideration.

Course Outline:

Introduction: Some multivariate problems and techniques. The data matrix Summary statistics. Normal distribution theory: characterization and properties linear forms. The Wish art distribution. The hostelling T^2 distribution. Distribution related to the multinomial.

Estimation and Hypothesis testing. Maximum likelihood estimation and other techniques. The Behrens Fisher problem. Simultaneous confidence intervals. Multivariate hypothesis testing design matrices of degenerate rank. Multiple correlation. Least squares estimation discarding of variables.

RECOMMENDED BOOKS

1. K. V. Mardia, J. T. Kent, J. M. Bibby, Multivariate Analysis, Academic Press London, 1982.
2. A. M. Kshirsagar, Multivariate Analysis, Marcell Dekker, New York, 1972.

MATH-827 MULTIVARIATE ANALYSIS-II Credit Hours: 3(3+0)

Objective of Course:

This is a course in multivariate statistical analysis, for students interested in quantitative methods of marketing research and more generally, for students of sciences. The aim of the course is to explore multivariate techniques used in modern marketing practice and in wider social research. Emphasis will be placed on case studies of marketing practice and on the practical application of the methods discussed. Topics to be drawn from: analysis of variance; regression analysis; principal components analysis; discriminant analysis; canonical correlation analysis; factor analysis; cluster analysis; multi-dimensional scaling.

Course Outline:

Principal component analysis: Definition and properties of principal comp . Hypotheses about principal components. Correspondence analysis. Discarding of variables. Principal component analysis in regression. Factor analysis. The factor model. Relationships between factor analysis and principal component analysis. Canonical correlation analysis, dummy variables and qualitative data. Qualitative and quantitative data. Discriminant analysis: discrimination when the populations are known. Fisher's linear discriminant function. Discrimination under estimation. Multivariate analysis of variance: formulation of multivariate one-way classification. Testing fixed contras is. Canonical variables and lest of dimensionality. Two-way classification.

RECOMMENDED BOOKS

1. K. V. Mardia, J. T. Kent, J. M. Bibby, Multivariate Analysis, Academic Press London, 1982.
2. A. M. Kshirsagar, Multivariate Analysis, Marcell Dekker, New York, 1972.

MATH-828 NUMERICAL ANALYSIS OF SPECTRAL METHODS

Credit Hours: 3(3+0)

Objective of Course:

This course is a mathematical introduction to appoximation theory, with a focus on spectral methods. The emphasis will be on both the analysis and the implementation of these methods. At the heart of both these methods is the same idea- the approximation of the solution by a (truncated) series expansion. The student will learn some basic theoretical results on spectral approximations for the issues of stability and convergence, on practical algorithms for implementing spectral methods, and on designing efficient and accurate spectral algorithms for solving PDEs of current interest.

Course Outline:

Introduction: Spectral Method: Survey of Approximation; Theory; Review of Convergence Theory; Algebraic Stability; Spectral Methods Using Fourier Series; Applications of Algebraic – Stability Analysis; Constant Coefficient HyperbolicEquations; Time Differencing Efficient Implementations of Spectral Methods; Numerical Results of Hyperbolic Problems.

RECOMMENDED BOOKS

2. D. Gottlies, S. A. Orszag, Numerical Analysis of Spectral Method (Theory an Applications) J. W. Arrowsmith Ltd., England.
2. C. Canunto, M. Y. Hussani, A Quarteroni, T. Zang, Spectral Method in Fluid Dynamics, Springer-Verlag, N.Y.

MATH-829 NUMERICAL LINEAR ALGEBRA Credit Hours: 3(3+0)

Objective of Course:

Students will learn the basic and advance direct methods for solving system of linear equations and linear least square equations, matrix factorization methods, basic computer arithmetic and the concepts of conditioning and stability of a numerical method, numerical methods for computing eigenvalues and their derivation, basic iterative methods, singular value decomposition. They will also improve their problem solving skills in computational linear algebra.

Course Outline:

Matrix-Vector operations, Orthogonal vectors and matrices, Matrix and vector norms, Singular value decomposition (SVD), Projectors and QR factorization, Gram-Schmidt orthogonalization process, Householder triangularization, Least-squares problems, Condition numbers, Gaussian elimination and LU factorization, Pivoting and LUP factorization, Stability of Gaussian elimination, Cholesky Factorization, Overview of eigenvalue problems, Reduction to upper-Heisenberg Tridiagonal form, Power and
inverse power iteration, QR algorithm without shifts, QR algorithm with shifts, Arnold iteration, GMRES method, Lanczos iteration Orthogonal polynomials and Gauss quadrature, Conjugate gradient (CG) method, Bi-Orthogonalization method.

RECOMMENDED BOOKS

5. L. N. Trefethen, D. Bau,Numerical linear algebra, SIAM, Philadelphia, 1997.
6. G. Allaire, S. M. Kaber, K. Trabelsi,Numerical Linear Algebra, Springer Science+Business Media, LLC.2008 ,
7. W. Brandal, Numerical Linear Algebra.
8. L. Fox, An introduction to numerical linear algebra.

MATH-830 NUMERICAL SOLUTIONS OF INTEGRAL EQUATIONS-I
Credit Hours: 3(3+0)

Objective of Course:

The course deals with integral equations, their origin, properties and solutions, both approximate and numerical.

Course Outline:

INTRODUCTION TO THE THEORY OF INTEGRAL EQUATIONS:

Definition; Existence Theorems; Integral Equations with L Kernels; Quadrature and Fourier Series; Function Spaces and Linear Operators; Basic Approximation Theory.

QUADRATURE METHODS FOR FREDHOLM EQUATIONS OF THE SECOND KIND

Introduction; Formulation of Discrete Equation; Choice of Quadrature Formula; Use of Finite Differences; Deferred Approach to the Limit; Nonlinear Equations; Singular Integral Equations; Removal of the Diagonal Term; Use of Peduct Integration Methods; Singularity in the Solution; Error Analysis of Quadrature Methods

EXPANSION METHODS

Nature of Approximating Function; Criteria for Determining the Approximation; Choice of (x), & (x)…..; Theory of Projection Methods; Other methods:

RAYLEIGH-RITZ-GALERKIN METHODS

Introduction; The Eigenvalue Problem; Inhomogeneous Equations; Error Estimates; Numerical Performance; Extension to Nonlinear Equations; Comparison with Other Methods

RECOMMENDED BOOKS

1. C. T. H. Baker, Integral Equations, Cleradon Press, 1977.
2. F. Smithies, Integral Equations, Cambridge University Press, 1958.
3. Squire, Numerical Integration for Engineer, American Elsevier Publishing Co., 1970.

MATH-831 NUMERICALSOLUTIONS OF INTEGRAL EQUATIONS-II
Credit Hours: 3(3+0)

Objective of Course:

This course is an introduction to fast solvers for integral equations, the course will concentrate mainly on integral equations arising from elliptic problems but, if time permits, the parabolic and hyperbolic cases will be briefly outlined. At the end of the

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course the student will be able to comfortably apply various numerical techniques for the solution of different kinds of integral equations.

Course Outline:

NUMERICAL SOLUTIONS OF THE EIGENVALUE PROBLEM

Methods based on Quadrature Rules; Treatment of Discontinuities Using Methods Based on Approximate Integration; Expansion Methods for Eigenproblem

VOLTTERRA EQUATIONS OF THE SECOND KIND

Introduction; Multistep Methods; Runge-Kutta Methods; Bock methods; Spline Approximations; Convergence and Stability;

METHODS FOR VELTERRA EQUATIONS OF THE FIRST KIND

Introduction; Conversion to Equations of the Second Kind; Numerical Methods of Solution; Use of Quadrature Rules in the Equation of the First Kind; higher Order Accuracy; Product Integration

FREDHOLM EQUATIONS OF THE FIRST KIND

Introduction; nature of the Problem, Singular Function Analysis; Fundamental Theorems; Applications; noise; need for Filtering; Methods of Expansion in Singular Functions; Use of Other Expansions; Methods of Regularization; Interactive Methods

RECOMMENDED BOOKS:

1. C. T. H. Baker, Integral Equations, Cleradon Press, 1977.
2. F. Smithies, Integral Equations, Cambridge University Press, 1958.
3. Squire, Numerical Integration for Engineer, American Elsevier Publishing Co., 1970.

MATH-832 NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS Credit Hours: 3(3+0)

Objective of Course:

This course will provide an overview of classical solution methods for ordinary equations. The focus will be on one step, multistep, finite–difference and shooting techniques and their stability and convergence. At the end of the course, the students will be able to implement several numerical techniques for finding approximate solutions to ordinary differential equations.

Course Outline:

PRELIMINARIES:

Some Theorems from the Theory of Differential Equations; Initial Value Problems for First Order Ordinary Differential Equations and for Systems of First Order Ordinary Differential Equations; Deduction of Higher Order Differential Equations to First-Order Linear System's with Constant Co-efficient; Linear Difference; Equations with Constant Co-efficient

LINEAR MULTISTEP METHODS:

The General Linear Multistep Methods; Derivation Through Taylor Expansions; Derivation Through Numerical Integration; Derivation Though Interpolation; Convergence; Order and Error Constant; Local and Global Truncation Error; Consistency and Numerical Stability; Attainable order of Stable Methods.

Problems in Applying Linear Multistep Methods; Starting Values; A Bound for the Local Truncation Error; Weak Stability; General Methods for Finding Intervals of Absolute and Relative Stability; Predictor-Corrector Methods; The Local Truncation Error of Predictor-Corrector Methods; Weak Stability of Predictor-Corrector Methods. Introduction; Order and Convergence of the General Explicit One-Step Method; Derivation of Classical Runge-Kutta Methods; Runge-Kutta Methods of order Greater Than Four; Error Estimates and Error Bounds for Runge Kutta Methods; Comparison with P Predictor-Corrector Methods; Implicit Runge-Kutta Methods.

RECOMMENDED BOOKS

1. Greenspan, Numerical solutions of ODE's for classical Relativistic and Nanosystems, 2006.
2. C. E. Froberg, Numerical mathematics, The Benjamin Cummings Pub. Com. Inc., 1985.
3. G. M. Phillips, P. J. Taylor, Theory and Applications of Numerical Analysis, Academic Press, 1973.
4. W. E. Pre et al., Numerical Recipes, Cambridge University Press, 1986.
5. M. K. Jain, Numerical Solution of Differential Equations, Wiley Eastern Ltd.
6. W. E. Milne, Numerical Solution of Differential Equations, Dover Pub. Inc., N.Y.

MATH-834 ADVANCED OPTIMIZATION THEORY-I Credit Hours: 3(3+0)

Objective of Course:

This course deals with the mathematical theory of optimization. Theory and algorithms for nonlinear optimization, focusing on optimization. Quasi-Newton methods; conjugate-gradient and methods for large-scale problems; algorithms for least-squares problems linear and nonlinear equations; constrained optimization. Upon successful completion of this course, the student will be able to understand:

(1) basic theoretical principles in optimization;
(2) formulation of optimization models;
(3) solution methods in optimization.

Course Outline:

Statement of the problem, condition for optimality, concept of direction of search, alternating direction and steepest descent methods, conjugate direction method, conjugate gradient method, Newton's method, Quasi-Newton equation, derivation of updating formulae for Quasi-Newton equation, The Gauss-Newton method, The Levenberg-Marquart method, The corrected Gauss-Newton method, Methods for large scale problems.

RECOMMENDED BOOKS:

2. P. E. Gill, E. Murray, H. H. Wright, Practical Optimization, Academic Press, 1981.
2. R. Fletcher, Practical Methods of Optimization Vol.I & II, John Wiley and Sons, 1980.
3. S. S. Rao, Optimization Theory and Application, Wiley Eastern Ltd., 1984.
4. D. G. Luenberger, Optimization by Vector Space Methods, John Wiley & Sons, 1968.
5. D. G. Luenberger, Introduction to Linear & Nonlinear Programming. Addison Wesley Publishing Co. Sydney, 1965.
11. M. S. Bazara, C. M. Shetty, Nonlinear Programming: Theory and Algorithms, John Wiley, 1979.

MATH-835 ADVANCED OPTIMIZATION THEORY-II Credit Hours: 3(3+0)

Objective of Course:

This course deals with theory and algorithms for nonlinear optimization, focusing on unconstrained optimization. Algorithms for problems and nonlinear equations; gradient projection algorithms for bound-constrained problems; Lagrange's multiplier methods for nonlinearly constrained optimization.

Course Outline:

Theory of constrained optimization, condition of optimality, methods for minimizing a general function subject to linear equality constraints, active set strategies for linear inequality constraints, special forms of the objectives functions, Lagrange multiplier estimates, Changes in working set, Barries function methods, Penalty functions methods, Methods based on Lagrangian functions reduced gradient and gradient projection methods.

RECOMMENDED BOOKS:

3. P. E. Gill, E. Murray, H. H. Wright, Practical Optimization, Academic Press, 1981.
4. R. Fletcher, Practical Methods of Optimization Vol.I & II, John Wiley and Sons, 1980.
3. S. S. Rao, Optimization Theory and Application, Wiley Eastern Ltd., 1984.
4. D. G. Luenberger, Optimization by Vector Space Methods, John Wiley & Sons, 1968.
5. D. G. Luenberger, Introduction to Linear & Nonlinear Programming. Addison Wesley Publishing Co. Sydney, 1965.
12. M. S. Bazara, C. M. Shetty, Nonlinear Programming: Theory and Algorithms, John Wiley, 1979.

MATH-836 PERTURBATION METHODS-I Credit Hours: 3(3+0)

Objective of Course:

The aim of the course is to lay an introduction to the perturbation theory to solve ordinary differential equations, partial differential equations as well as integral equations. The emphasis in this course is on the adaptation of several mathematical methods and techniques to their swift and effective application in solving advanced problems in applied mathematics and theoretical physics.

Course Outline:

Difference equations, Dimensional analysis, Expansions, Approximate solutions of linear differential equations, order symbols, Asymptotic series, Quadratic and cubic algebraic equations and its solutions by perturbation method, Straightforward expansion, Lindsted-Poincar Technique, Method of Renormalization, Method of multiple scales, dominant balance method, WKB method, Method of strained parameters.

RECOMMENDED BOOKS

5. Alan W. Bush, Perturbation methods for engineers and scientists,CRC Press.
6. C. Bender, S. Orszag, Advanced mathematical methods for scientists and engineers,MGH, 1978.
7. E. Zauderer, Partial Differential Equations of Applied Mathematics, T 2nd edition ,1998.
8. Ali Hasan Nayfeh, Introduction to perturbation techniques, A wiley-Interscience Publication, John Wiley & SONS, INC.

MATH-837 PERTURBATION METHODS-II Credit Hours: 3(3+0)

Objective of Course:

The goal of the course is to study some advance method to the perturbation theory to solve ordinary differential equations, partial differential equations as well as integral equations.

Course Outline:

Regular perturbation, Singular perturbation, Boundary layer, The method of matched asymptotic expansion, equations with large parameter, , Solution of partial differential equations by perturbation methods, Asymptotic expansion of integrals Laplace's method, Watson's Lemma, Riemann-Lebesgue lemma.

RECOMMENDED BOOKS

5. Alan W. Bush, Perturbation methods for engineers and scientists, CRC Press.
6. C. Bender, S. Orszag, Advanced mathematical methods for scientists and engineers, MGH, 1978.
7. E. Zauderer, Partial Differential Equations of Applied Mathematics, T 2nd edition, 1998.
8. Ali Hasan Nayfeh, Introduction to perturbation techniques, A wiley-Interscience Publication, John Wiley & SONS, INC.

MATH-838 PROBABILITY AND PROBABILITY DISTRIBUTIONS-I

Credit Hours: 3(3+0)

Objective of Course:

The objective of the course is to study some important topics of probability theory. It focuses on probability distributions and estimation methods.

Course Outline:

Historical origin of term Probability, Conditional Probability, Baye'stheorem, Chebyshev inequality. Random variables, Distribution function, Probability density function, Probability distribution of two variables, Binomial, Poisson, Hyper geometric, Negative Binomial, Geometric, Uniform, Exponential, Beta, Gamma and Normal distributions, Bivariate Normal distribution, Multivariate normal distribution, Central, limit Theorem, Probability as based of estimation, Properties of good estimator, Unbaised, Consistent, Sufficient, Efficient estimators, Minimum variance unbiased estimators,

RECOMMENDED BOOKS

1. A. Stuarts, Ord, J. K. Kendalls, Advanced theory of mathematics (Vol I), CharlesCoriffi & Co, London.
2. A. M. Mood, Graybill, D.C.Boes, Introduction to the theory of statistics, McGraw Hill, NY.
8. R. M. Hogg, A. T. Craig, Introduction to mathematical statistics, McMillan Co., New York.
9. A. S. Hirai, Estimation of statistical parameters, Ilmi Kitab Khana, Lahore, Pakistan.
10. R. E. Walpole, Introduction to mathematical statistics.

MATH-839 PROBABILITY AND PROBABILITY DISTRIBUTIONS-II

Credit Hours: 3(3+0)

Objective of Course:

This course introduces the basic notions of probability theory and develops them to the stage where one can apply the probabilistic ideas in statistical inference and modeling, and the study of stochastic processes.

Course Outline:

Moments generating function and characteristic functions, Cauchy distribution, Laplace distribution, Weiball distribution, Maxwell distribution, Pareto distribution, Raleigh distribution, Lag normal distribution, Inversion and uniqueness theorems, Convolution of function, Sampling distribution, Distribution of mean, median, rang and quartiles, Central and Non Central t, F and F and Chi-Square distribution, Neyman Pearson theorem, Uniform most

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powerful tests, like hood ratio tests, The sequential probability ratio test, Interval estimation for different parameters.

RECOMMENDED BOOKS

1. A. Stuarts, Ord, J. K. Kendalls, Advanced theory of mathematics (Vol I), Charles Coriffi & Co, London.
2. A. M. Mood, Graybill, D.C.Boes, Introduction to the theory of statistics, McGraw Hill, NY.
3. R. M. Hogg, A.T.Craig, Introduction to mathematical statistics, McMillan Co., New York.
4. A. S. Hirai, Estimation of statistical parameters, Ilmi Kitab Khana, Lahore, Pakistan.
5. R. E. Walpole, Introduction to mathematical statistics.

MATH-840 SEMIGROUP THEORY Credit Hours: 3(3+0)

Objective of Course:

The aim of the course is to familiar the student with the concepts of semi group theory. The formal study of semi groups began in the early 20th century. Semi groups are important in many areas of mathematics because they are the abstract algebraic underpinning of "memoryless" systems: time-dependent systems that start from scratch at each iteration. In applied mathematics, semi groups are fundamental models for linear time-invariant systems. In partial differential equations, a semi group is associated to any equation whose spatial evolution is independent of time. The theory of finite semi groups has been of particular importance in theoretical computer science since the 1950s because of the natural link between finite semi groups and finite automata. In probability theory, semi groups are associated with Markov Process.

Course Outline:

Introductory Ideas; Basic Definitions; Cyclic Semi groups; Order Sets; Semi Lattices and lattices; Binary Relations; Equivalences; Congruence; Free Semi groups; Green's Equivalences; L,R,H,J and D, Regular Semi groups; O–Simple Semi groups; Simple and O–Simple Semi groups; Rees's Theorem; Primitive Idempotent; Completely O–Simple Semi groups; Finite Congruence–Free Semi groups; Union of Groups; Bands; Free Bands; Varieties of Bands; Inverse Semi groups; Congruence on Inverse Semi groups; Fundamental Inverse Semi groups; Bisimple and Simple Inverse Semi groups; Orthodox Semi groups.

RECOMMENDED BOOKS

3. A. H. Clifford, G. B. Preston, The Algebraic Theory of Semigroups Vol. I & II, AMS Math, Survey, 1961 & 1967
4. J. M. Houie, An Introduction to Semigroups Theory, Academic Press, 1967.

MATH-841 VISCOUS FLUID-I Credit Hours: 3(3+0)

Objective of Course:

This course explores viscous fluid and its applications. The course material can be used as a reference source for future real world situations. After successful completion of this course, students will be able to understand the concept and solve viscous fluid problems.

Course Outline:

Eulerian approach, Lagrangian description, Properties of fluids, Transport properties, Kinematic properties, thermodynamics properties, Boundary conditions for viscous flows and heat conducting flows problems, Conservation of mass (equation of continuity), conservation of momentum (equations of Navier-Stokes), conservation of energy (energy equations), Dimensionalization and dimensionless parameters in viscous flow, Vorticity transport equation, Stream function, Steady flow, unsteady flow, creeping flow and boundary layer flow, Couette flows, Poiseuille flow, Couette Poiseuille flow between parallel plates, Stokes first problem, Stokes second problem,

Unsteady flow between two infinite plates, Asymptotic suction flows: uniform suction on a plane, flow between parallel plates with top suction and bottom injection.

RECOMMENDED BOOKS

4. Frank M. White ,Viscous Fluid Flow, Second Edition, McGRAW-HILL, Inc.
5. Hermann Schlichting,Boundary-layer Theory ,Seventh Edition, McGraw-Hill Series in Mechanical Engineering.
6. G.K. Batchelor, An introduction to fluid dynamics, Cambridge University Press.

MATH-842 VISCOUS FLUID-II Credit Hours: 3(3+0)

Objective of Course:

This course deals with the advance methods for the solution of viscous fluid problems. After successful completion of this course, students will be able to solve viscous fluid problems in higher dimensions.

Course Outline:

Similarity solution, Berman problem, Plane stagnation flow, axisymmetric stagnation flow, flow near an infinite rotating disk, Jeffery Hammel flow in a wedge shaped region and it solution for small wedge angle, Stokes solution for an immersed sphere, Derivation of boundary-layer equations for two-dimensional flow, The laminar boundary layer equations, The approximate method due to the von Karman and K. Pohlhausen for two dimensional flows, Blasius problem of flat plate flow, Falker-Skan wedge flows, Heat transfer for Falker-Skan flows, two dimensional steady free convection, viscous flows over a stretching sheet, thin film flows

RECOMMENDED BOOKS

4. Frank M. White ,Viscous Fluid Flow, Second Edition, McGRAW-HILL, Inc.
5. Hermann Schlichting, Boundary-layer Theory ,Seventh Edition, McGraw-Hill Series in Mechanical Engineering.
6. G. K. Batchelor, An introduction to fluid dynamics, Cambridge University Press.

Controller of Examinations
Bacha Khan University
Charsadda

Chairman
Deptt. of Mathematics & Statistics
Bacha Khan University
Charsadda

Bacha Khan University Charsadda
Assistant Registrar
Academics

MATH-843 FUZZY LOGIC AND ALGEBRA Credit Hours: 3(3+0)

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 fuzzy sets

Course Outline:

Logics, sets, subsets, Functions and relations, Partially ordered sets ,The lattice of subsets of a set, characteristic functions, fuzzy Sets, definitions and examples ,Lattice theoretical operations on fuzzy sets,Fuzzy sets, functions and fuzzy relations, Types of fuzzy sets, intuitionistic fuzzy sets, picture fuzzy sets Algebraic operators, fuzzy measure, fuzzy relations, fuzzy analysis and Applications of fuzzy algebra.

Recommended Books

(4) Fuzzy Set Theory by R. LOWEN.
(5) Fuzzy set theory and its applications by H. J. Zimmermann.
(6) Fuzzy Semi groups by J. N. Mordeson, D. S. Malik, N. Kuroki.

MATH-851 NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS-I Credit Hours: 3(3+0)

Objective of Course:

This course explores an introduction to various numerical methods for partial differential equations with emphasis on finite difference type methods. The course also illustrates, via numerics, the distinguishing mathematical properties of various commonly occurring partial differential equations.

Course Outline:

Numerical Methods for Parabolic PDEs; review of finite difference methods, explicit methods, Crank-Nicolson implicit method, Local Truncation Error, Stability, Consistency and convergence, Fourier stability methods, alternating directions implicit method, higher level schemes, nonlinear equations, predictor corrector methods, computer problems,Two dimensional parabolic equations and finite difference schemes,computer problems. Numerical methods for hyperbolic PDEs; method of characteristics, finite-difference methods-Lax-Wendroff method, Courant-Friedrichs-Lewy method, two-space Hyperbolic equations, computer implementations. Numerical Methods for Elliptic PDEs; finite-difference methods, Poisson Equation, Laplace Equations, Curved boundary, finite-differences in Polar co-ordinates.

RECOMMENDED BOOKS

4. C. Jhonson, Numerical Solutions of Partial Differential Equations by the finite methods, Cambridge University Press
5. W. F. Ames, Numerical methods for P.D.Es, Academic Press.
6. G. D. Smith, Numerical Solutions of P.D.Es finite difference methods, Clarendon Press, Oxford.
4. G. W. Thomas, Numerical Solutions of P.D.E's.

MATH-853 SPECIAL RELATIVITY Credit Hours: 3(3+0)

Course Outline: Historical background and fundamental concepts of Special theory of Relativity. Lorentz transformations (for motion along one axis). Length contraction, Time dilation and simultaneity. Velocity addition formulae. 3-dimensional Lorentz transformations. Introduction to 4-vector formalism. Lorentz transformations in the 4-vector formalism. The Lorentz and Poincare groups. Introduction to classical Mechanics. Minkowski spacetime and null cone. 4-velocity, 4-momentum and 4-force. Application of Special Relativity to Doppler shift and Compton effect. Particle scattering. Binding energy, particle production and decay. Electromagnetism in Relativity. Electric current. Maxwell's equations and electromagnetic waves. The 4-vector formulation of Maxwell's equations. Special Relativity with small acceleration.

Recommended Books:

1. Qadir, A. Relativity, An Introduction to the Special Theory, World Scientific, 1989.
2. D' Inverno. R., Introducing Einstein's Relativity, Oxford University Press, 1992.
3. Goldstein, H., Classical Mechanics, Addison Wesley, New York, 1962.
4. Jackson, J.D., Classical Electrodynamics, John Wiley, New York, 1962.
5. Rindler, W., Essential Relativity, Springer-Verlag, 1977.

MATH-854 GENERAL RELATIVITY Credit Hours: 3(3+0)

Course Outline: The Einstein field equations. The principles of general relativity. The stress-energy momentum tensor. The vacuum Einstein equations and the Schwarzschild solution. The three classical tests of general relativity. The homogeneous sphere and the interior Schwarzschild solution. Birkhoff's theorem. The Reissner-Nordstrom solution and the generalised Birkhoff's theorem. The Kerr and Kerr-Newman solution. Essential and coordinate singularities. Event horizon and black holes. Eddington-Finkelstein. Kruskal-Szekres coordinates. Penrose diagrams for Schwarzschild, Reissner-Nordstrom solutions.

Recommended Books:

1.Wald, R.M., Introduction to General Relativity, University of Chicago Press, Chicago,1984.
2.Adler, R., Bazine, M., and Schiffer, M., Introduction to General Relativity, McGraw- Hill

Inc.,1965.
3.Rindler, W., Essential Relativity, Springer Verlag 1977.