BOARD OF STUDIES MEMBERS

List of Board of study members for Department of Mathematics and Statistics, University of Swat

S.No	Name	Convener/Member
1	Dr. Ghaus Ur Rahman, Assistant Professor In-Charge, Deptt of Mathematics and Statistics, UoS	**Convener**
2	Prof. Dr. Mujahid Abbas, Chairman Department of Mathematics, Govt College University Lahore.	**Member**
3	Dr. Inayat Ali Shah, Professor Deptt: of Mathematics, Islamia Collage University Peshawar.	**Member**
4	Dr. Nasir Ahmad, Assistant Professor Centre for Education & Staff Training, UoS	**Member**
5	Dr. Ameen ur Rashid, Assistant Professor Deptt: of Applied Physics & Material Sciences, UoS	**Member**
6	Mr. Ahmad Zeb, Associate Professor GDC, Dagger, Bunir	**Member**
7	Mr. Liaqat Ali, Assistant Professor Deptt: of Mathematics GPG Jehanzeb College Saidu Sharif Swat.	**Member**
8	Miss. Shabana Farman, Lecturer Govt: Girls Degree College, Saidu Sharif Swat.	**Member**
9	Dr. Faiz Muhammad Khan, Assistant Professor Deptt: of Mathematics and Statistics, UoS	**Member**
10	Dr. Amir Khan, Lecturer Deptt: of Mathematics and Statistics, UoS	**Member**

CONTENTS

DETAILS AND JUSTIFICATION OF THE AGENDA ITEMS

S. No.	Agenda item and its justification	Remarks
1.	**Item One: Bachelor of Science (BS) in Mathematics** Approval/Renewal of the Scheme of Studies and Courses for Bachelor of Science in Mathematics for the ongoing sessions and session 2018-22 and onward **Annexure A** The 1st board of studies meeting of Mathematics was held on 17th November2016 in the committee room University of Swat in which approval was accorded to the scheme of studies and courses for the BS Mathematics. The department intends to modify the scheme of studies and courses for BS Mathematics according to HEC for the said program. In order to remove the repetition and keeping the international standard; the nomenclatures of some of the courses including some new courses are desired. This step will help to equip the students to the latest developments in the field of Mathematics.	
2.	**Item two: Master of Science (M. Sc) in Mathematics** The Scheme of Studies and Courses for Master of Science in Mathematics **Annexure B** The 1st board of studies meeting of Mathematics was held on 17th November2016 and approval was accorded to the scheme of studies and courses for the M. Sc Mathematics. The department intends to modify the scheme of studies and courses for M. Sc Mathematics according to HEC for the said program.	
3.	**Item Three: Master of Philosophy (M. Phil) in Mathematics** Approval of the Scheme of Studies and Courses for Master of Philosophy in Mathematics for the upcoming sessions 2018-20 and onward **Annexure C** The department of Mathematics and Statistics has 3 full time PhD and two M. Phil faculty members in Mathematics. The department also created new positions and it is expected that the number of PhDs will increase in next years. In order to deliver the quality education and research, this department intends to launch M. Phil program very soon. Therefore, the department is interested in approving the scheme of studies for M. Phil program in order to strengthen the program. This step will help to keep the research scholars integrated with the latest research and developments taking place in the field of Mathematics.	

4.

Item Four: Marks break down of Software Packages

Approval marks break up for the course "Software Packages" for BS-Math and MSc-Math

Annexure D

In the 1st board of studies, meeting the department offered a course by the name Software Packages to BS and M.Sc. Mathematics. According to the HEC curricula, the credit hour distribution for the said subject is 1+2. Now since 1CH is assigned to the theory and neither the semester rules has a section/subsection regarding the marks distribution of such course nor the university has any precedent in any of its department so far. The board of studies has left this distribution according to the practices for such courses in the university. It is worth mentioning that the Departmental Semester Committee after its meeting held on 07-06-2017 proposed and forwarded the following breakup for the marks to Registrar Office for approval.

Evaluation	Marks	% of total
Mid Term Exam	20	20%
Final Term Exam	40	40%
Quizzes / Assignments	10	10%
Practical / Viva	30	30%
Total	100	100%

In response, the Registrar office advised the department to follow the marks breakdown for the course according to 2+1 CH for the time being. According to the nature of the course, the department requests the board of studies members to suggest a suitable marks break up and paper pattern for the above-mentioned course.

5.

Item Five: Course coding for the offered courses

Approval of course codes in the directives of Honorable Vice Chancellor

FUNCTION OF BOARD OF STUDIES

THE FUNCTION OF BOARD OF STUDIES SHALL BE TO:

a) Advice the authorities on all academic matters concerning instructions, publications, research and examinations in the subjects concerned;

b) Propose the curricula and syllabi for all degree, diploma and certificate courses in the subjects concerned;

c) Suggest a panel of names of paper setters and examiners in the subjects concerned; and

d) To perform such other functions as may be prescribed by Bye-laws.

Item One Annexure A

Bachelor of Science in Mathematics

Degree Awarded: BS Mathematics

ELIGIBILITY CRITERIA: F.Sc (Pre-engineering) or F.A (with Mathematics) or Equivalent with at least 45% marks or 2nd division in FA/F.Sc or equivalent.

Duration of the Program: 4 years (8 Semesters)
Maximum duration allowed-six academic years

Total Credit Hours: 132

Total Marks: 4500

Note: Credit hours requirement for the award of BS-Mathematics degree 130-144

Scheme of Studies for the Four-year Bachelor Degree in BS-MATHEMATICS

	Categories	No. of Courses	Credit Hours
C	Compulsory Requirements (no choice)	9	25
G	General Courses (to be chosen from other departments)	8	24
F	Discipline Specific Foundation Courses	10	31
M	Major Courses including research project	12+Project	40
E	Electives	4	12
Total		43+Project	132

Acronyms

MCC	Mathematics Compulsory Course
MEC	Mathematics Elective Course
MFC	Mathematics Foundation Course
MGC	Mathematics General Course
MMC	Mathematics Major Course

Marks Breakdown for Courses

Item	**Maximum Marks for Course Without Laboratory (3-0)**	**Maximum Marks for Course With Laboratory (2-1)**
Mid Term Examination	30%	30%
Internal Marks (Assignments, Quizzes, Presentations)	20%	10%
Laboratory	----	10%
Final Term Examination	50%	50%
Total	100%	100%

MISSION OF THE BS PROGRAM

The mission of the program is to produce graduates who demonstrate an awareness of the importance about virtues and ethics, to promote research culture, and to stimulate Advanced learning methodologies and persistently strives to develop creative thinking skills in students in order to prepare them to take effective decisions in business and many other areas in the future.

VISION OF THE BS PROGRAM

The vision of the program is to impart a quality education and productive research in different fields of Mathematics. It focuses to produce highly skilled manpower, scholars and researchers to meet the contemporary and future challenges.

OBJECTIVES OF THE BS PROGRAM

- To use appropriate mathematical concepts and skills to solve problems in both familiar and unfamiliar situations including those in real-life contexts.
- To select and apply general rules correctly to solve problems including those in real-life contexts.
- To develop the knowledge, skills and attitudes necessary to pursue further studies in mathematics.
- To develop mathematical curiosity and use inductive and deductive reasoning when solving problems.

EXPECTED OUTCOME OF THE BS DEGREE PROGRAM

Graduates of the mathematics program will be able to:

1. Appreciate the importance of mathematics and its techniques to solve real life problems and provide the limitations of such techniques and the validity of the results.
2. Propose new mathematical questions and suggest possible software packages or computer programming to find solutions to these questions.
3. Serve on mathematical based position/field jobs/teaching jobs.
4. Take interest for higher education in various areas of Mathematics and in other areas related to Mathematics.
5. Identify fundamental concepts of Mathematics as applied to science and other areas of mathematics, and to interconnect the roles of pure and applied mathematics.

FRAME WORK FOR BS (4-YEAR) IN MATHEMATICS LAYOUT

Compulsory Requirements (the student has no choice)		**General Courses to be chosen from other departments**		**Discipline Specific Foundation Courses**	
9 courses		**8 courses**		**10 courses**	
25 Credit hours		**24 Cr. Hours**		**31 Credit hours**	
Subject	Cr. Hr.	Subject	Cr. Hr.	Subject	Cr. Hr.
1. English I (Functional English)	3(3-0)	1. Physics-I (Wave and Oscillation)	3(3-0)	1. Calculus-I	3(3-0)
2. English-II (Communication Skills)	3(3-0)	2. Physics-II (Thermodynamics and Statistical Mechanics)	3(3-0)	2. Calculus-II	3(3-0)
3. English-III (Technical Writing & Presentation Skills)	3(3-0)	3. Physics-III (Electricity and Magnetism)	3(3-0)	3. Calculus-III	3(3-0)
4. English-IV (Study Skills)	3(3-0)	4. Physics-IV(Modern Physics)	3(3-0)	4. Algebra-I	3(3-0)
5. Islamic Studies	2(2-0)	5. Computer Programming	3(3-0)	5. Algebra-II	3(3-0)
6. Pakistan Studies	2(2-0)	6. Introduction to Sociology	3(3-0)	6. Linear Algebra	3(3-0)
7. Discrete Mathematics	3(3-0)	7. Introduction to Political Science	3(3-0)	7. Complex Analysis	4(4-0)
8. Elements of Set Theory and Mathematical Logic	3(3-0)	8. Software Packages	3(3-0)	8. Ordinary Differential Equations	3(3-0)
9. Introduction to Computer	3(3-0)			9. Integral Equations	3(3-0)
				10. Affine and Euclidean Geometry	3(3-0)
	25		**24**		**31**

Major courses including research project/internship		**Elective Courses within the major**	
11-13 courses		**4 courses**	
36-42 Credit hours		**12 Credit Hours**	
Subject	Cr. Hr.	Subject	Cr. Hr.
1. Number Theory 2. Real Analysis-I 3. Real Analysis-II 4. Mathematical Methods 5. Basic Topology 6. Vector and Tensor Analysis 7. Probability Theory 8. General Topology 9. Numerical Analysis 10. Partial Differential Equations 11. Classical Mechanics 12. Functional Analysis 13. Research Project	3(3-0) 3(3-0) 3(3-0) 3(3-0) 3(3-0) 3(3-0) 3(3-0) 3(3-0) 3(3-0) 3(3-0) 4(4-0) 3(3-0) 3(3-0)	1. Elective-I 2. Elective-II 3. Elective-III 4. Elective-IV	3(3-0) 3(3-0) 3(3-0) 3(3-0)
	40		**12**

Elective Courses for BS(4 year) Program of Mathematics

S.No.	Course Name	Cr.Hr	Course Code
1.	Mathematical Modeling and Simulation	03(3-0)	MATH-455
2.	Fuzzy Set Theory and Applications	03(3-0)	MATH-456
3.	Fluid Mechanics	03(3-0)	MATH-457
4.	Dynamical Systems	03(3-0)	MATH-458
5.	Numerical Methods	03(3-0)	MATH-459
6.	Advanced Differential Geometry	03(3-0)	MATH-460
7.	Analytical Dynamics	03(3-0)	MATH-461
8.	Advanced Functional Analysis	03(3-0)	MATH-462
9.	Advanced Group Theory	03(3-0)	MATH-463
10.	Theory of Modules	03(3-0)	MATH-464
11.	Advanced Complex Analysis	03(3-0)	MATH-465
12.	Quantum Mechanics	03(3-0)	MATH-466
13.	Electrodynamics	03(3-0)	MATH-467
14.	Advanced Number Theory	03(3-0)	MATH-468
15.	Measure Theory	03(3-0)	MATH-469
16.	Mathematical Biology	03(3-0)	MATH-470
17.	Econometrics	03(3-0)	MATH-471
18.	Advanced Partial Differential Equations	03(3-0)	MATH-472
19.	Advanced Numerical Analysis	03(3-0)	MATH-473
20.	Fluid Dynamics	03(3-0)	MATH-474
21.	Graph Theory	03(3-0)	MATH-475
22.	Advanced Real Analysis	03(3-0)	MATH-476
23.	Numerical Solution of Partial Differential Equations	03(3-0)	MATH-477
24.	Optimization Theory	03(3-0)	MATH-478
25.	Stochastic Processes	03(3-0)	MATH-479
26.	Heat and Mass Transfer	03(3-0)	MATH-480
27.	Convex Analysis	03(3-0)	MATH-481
28.	History of Mathematics	03(3-0)	MATH-482
29.	Mathematical Physics	03(3-0)	MATH-483
30.	Galois Theory	03(3-0)	MATH-484
31.	Lie Algebra	03(3-0)	MATH-485
32.	Financial Mathematics	03(3-0)	MATH-486
33.	Operation Research	03(3-0)	MATH-487

Note: Any other subject depending upon the expertise available.

LIST OF BS-MATHEMATICS GENERAL COURSES

Course Code	Course Name	Credit Hours
PHY-105	Physics-I (Wave and Oscillation)	3(3-0)
PHY-155	Physics-II (Thermodynamics and Statistical Mechanics)	3(3-0)
PHY-205	Physics-III (Electricity and Magnetism)	3(3-0)
PHY-255	Physics-IV (Modern Physics)	3(3-0)
BIO-209	Introduction to Biology	3(3-0)
CHE-207	Introduction to Chemistry	3(3-0)
ACC-208	Introduction to Accounting	3(3-0)
PHI-158	Introduction to Philosophy	3(3-0)
ECO-157	Introduction to Economics	3(3-0)
SOC-156	Introduction to Sociology	3(3-0)
ENV-210	Introduction to Environmental Science	3(3-0)
PSY-159	Introduction to Psychology	3(3-0)
POL-206	Introduction to Political Science	3(3-0)
STAT-160	Statistics	3(3-0)
CS-204	Computer Programming	3(3-0)
MATH-405	Software Packages	3(3-0)

Note: Any other subject depending upon the expertise available.

CURRICULUM BS-MATHEMATICS

Semester Breakdown

First Year

Semester-1st

S.No	Courses		Course Code	Cr. Hr.
1	Calculus-I	MFC	MATH-101	03(3-0)
2	Discrete Mathematics	MCC	MATH -102	03(3-0)
3	English-I (Functional English)	MCC	ENG-103	03(3-0)
4	Islamic Studies	MCC	ISL-104	02(2-0)
5	Physics-I (Wave and Oscillation)	MGC	PHY-105	03(3-0)
6	Introduction to Computer	MCC	CS-106	03(2-1)
Total Credit Hrs				**17**

Semester-2nd

S.No	Courses		Course Code	Cr. Hr.
1	Calculus-II	MFC	MATH-151	03(3-0)
2	Number Theory	MMC	MATH-152	03(3-0)
3	English-II (Communication Skills)	MCC	ENG-153	03(3-0)
4	Pakistan Studies	MCC	PS-154	02(2-0)
5	Physics-II (Thermodynamics and Statistical Mechanics)	MGC	PHY-155	03(3-0)
6	Introduction to Sociology	MGC	SOC-156	03(3-0)
Total Credit Hrs				**17**

Second Year

Semester-3rd

S.No	Courses		Course Code	Cr. Hr.
1	Calculus-III	MFC	MATH-201	03(3-0)
2	Elements of Set Theory and Mathematical Logic	MCC	MATH-202	03(3-0)
3	English-III (Technical writing & Presentation Skills)	MCC	ENG-203	03(3-0)
4	Computer Programming	MGC	CS-204	03(2-1)
5	Physics-III (Electricity and Magnetism)	MGC	PHY-205	03(3-0)
6	Introduction to Political Science	MGC	POL-206	03(3-0)
Total Credit Hrs				**18**

Semester-4th

S.No	Courses		Course Code	Cr. Hr.
1	Algebra-I	MFC	MATH-251	03(3-0)
2	Vector and Tensor Analysis	MMC	MATH-252	03(3-0)
3	Basic Topology	MMC	MATH-253	03(3-0)
4	English-IV (Study Skills)	MCC	ENG-254	03(3-0)
5	Physics-IV (Modern Physics)	MGC	PHY-255	03(3-0)
Total Credit Hrs				**15**

Third Year

Semester-5th

S.No	Courses		Course Code	Cr. Hr.
1	Algebra-II	MFC	MATH-301	03(3-0)
2	Probability Theory	MMC	MATH-302	03(3-0)
3	Numerical Analysis	MMC	MATH-303	03(3-0)
4	Ordinary Differential Equations	MFC	MATH-304	03(3-0)
5	Real Analysis-I	MMC	MATH-305	03(3-0)
6	General Topology	MMC	MATH-306	03(3-0)
Total Credit Hrs				**18**

Semester-6th

S.No	Courses		Course Code	Cr. Hr.
1	Algebra-III(Linear Algebra)	MFC	MATH-351	03(3-0)
2	Partial Differential Equations	MMC	MATH-352	03(3-0)
3	Classical Mechanics	MMC	MATH-353	04(4-0)
4	Complex Analysis	MFC	MATH-354	04(4-0)
5	Real Analysis-II	MMC	MATH-355	03(3-0)
Total Credit Hrs				**17**

Fourth Year

Semester-7th

S.No	Courses		Course Code	Cr. Hr.
1	Functional Analysis	MMC	MATH-401	03(3-0)
2	Elective-I	MEC	MATH-402	03(3-0)
3	Elective-II	MEC	MATH-403	03(3-0)
4	Integral Equations	MFC	MATH-404	03(3-0)
5	Software Packages	MGC	MATH-405	03(1-2)
Total Credit Hrs				**15**

Semester-8th

S.No	Courses		Course Code	Cr. Hr.
1	Elective-III	MEC	MATH-451	03(3-0)
2	Elective-IV	MEC	MATH-452	03(3-0)
3	Affine and Euclidean Geometry	MFC	MATH-453	03(3-0)
4	Mathematical Methods	MMC	MATH-454	03(3-0)
5	Research Project	MMC	MATH-499	03(3-0)
Total Credit Hrs				**15**

Total Degree Credit Hours= 132

DETAIL OF COURSES CONTENTS

Compulsory Courses

Discrete Mathematics

Credit Hour: 03(3-0) **Course Code: MATH-102**

Prerequisites: Mathematics at intermediate level

Course Objectives:

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

Learning Outcomes: This is an introductory course on discrete mathematics. Students will learn:

- Some fundamental mathematical concepts;
- How to use and analyze recursive definitions;
- How to count some different types of discrete structures;
- Techniques for constructing mathematical proofs, illustrated by discrete mathematics examples.

Course Contents:

Week	Topics	Remarks
1.	**The Foundations:** Logic, propositional equivalences,	
2.	Predicates and quantifiers, method of proof,	Assignment related to the topics
3.	Sets, set operations, functions.	
4.	**Counting methods:** Basic methods: product, inclusion-exclusion formulae,	Quiz
5.	Permutations and combinations, Recurrence relations and their solutions, recursive algorithm.	Assignment related to the topics
6.	Generating functions, Double counting. Applications,	
7.	Pigeonhole principle, applications.	Quiz
8.	**Mid Term Exam**	
9.	**Relations:** Binary relations, n-ary Relations, Closures of relations,	Quiz
10.	Composition of relations, inverse relation.	Assignment related to the topics
11.	**Graphs:**Graph terminology. Representation of graphs. Graphs isomorphism.	Quiz
12.	Algebraic methods: the incidence matrix. Connectivity,	Assignment related to the topics
13.	Eulerian and Hamiltonian paths. Shortest path problem.	Quiz
14.	Trees and spanning trees.	Presentations

15.	Complete graphs and bivalent graphs.	Assignment related to the topics
16.	**Boolean algebra:**Boolean functions, representing Boolean functions	Presentations
17.	logic gates, minimization of circuits.	Presentations
18.	**Final Term Exam**	

Books Recommended

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

K.A. Ross, C.R.B. Wright, Discrete Mathematics, Prentice Hall, New Jersey, 2003.

INTRODUCTION TO COMPUTER

Credit hours: 03(2-1) **Course Code: CS-106**

Objectives

This course will introduce the students to the basics of computer science including computer components, computer programs and basic applications.

Learning Outcomes: Upon completion of this course, students will:

- Be able to identify computer hardware and peripheral devices
- Be familiar with software applications
- Understand file management
- Accomplish creating basic documents, worksheets, presentations and databases
- Explore the Web and how to conduct research

Course Outlines:

Week	Topics	Remarks
1.	Introduction and Definition	
2.	Types and classification of computers.	Assignment related to the topics
3.	Hardware: Input Hardware,	
4.	Storage hardware	Quiz
5.	Processing hardware	Assignment related to the topics
6.	Output hardware	
7.	Software: Application software	Quiz
8.	**Mid Term Exam**	
9.	system software, software packages	Quiz

10.	Operating system (Windows),	Assignment related to the topics
11.	Internet, e-mail	Quiz
12.	Local Area Network	Assignment related to the topics
13.	Configurations	Quiz
14.	Introduction to MS-Word	Presentations
15.	Ms-Excel	Assignment related to the topics
16.	Ms-Power Point	Presentations
17.	Ms-Access	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Fundamentals of computer,6th Ed. Long l, Long N, Courter, G, Marquis A,1999,
2. Microsoft office 2000,BPB publication.

ISLAMIC STUDIES

Credit hours: 02(2-0) **Course Code: ISL-104**

Objectives:

This course is aimed at:

1. To provide Basic information about Islamic Studies
2. To enhance the skill of the students for understanding of issues related to faith and religious life.

Learning Outcomes: Upon successful completion of the course, students will be able to perform prayers and other worships and have some good knowledge about Islamic Civilization.

Course Outlines

Week	Topics	Remarks
1.	**Introduction to Quranic Studies** Basic Concepts of Quran, History of Quran, Uloom-ul–Quran	
2.	**Study of Selected Text of Holly Quran** 1) Verses of Surah Al-Baqra Related to Faith(Verse No-284-286) 2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18) 3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)	Assignment related to the topics
3.	4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77) 5) Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)	

4.	**Study of Selected Text of Holly Quran** 1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.) 2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment 3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)	Quiz
5.	**Seerat of Holy Prophet (S.A.W) I** 1) Life of Muhammad Bin Abdullah (Before Prophet Hood) 2) Life of Holy Prophet (S.A.W) in Makkah 3) Important Lessons Derived from the life of Holy Prophet in Makkah	Assignment related to the topics
6.	**Seerat of Holy Prophet (S.A.W) II** 1) Life of Holy Prophet (S.A.W) in Madina 2) Important Events of Life Holy Prophet in Madina 3) Important Lessons Derived from the life of Holy Prophet in Madina	
7.	**Introduction To Sunnah** 1) Basic Concepts of Hadith 2) History of Hadith 3) Kinds of Hadith 4) Uloom –ul-Hadith 5) Sunnah & Hadith 6) Legal Position of Sunnah	Quiz
8.	**Mid Term Exam**	
9.	**Selected Study from Text of Hadith** **Introduction To Islamic Law & Jurisprudence** 1) Basic Concepts of Islamic Law & Jurisprudence 2) History & Importance of Islamic Law & Jurisprudence 3) Sources of Islamic Law & Jurisprudence 4) Nature of Differences in Islamic Law 5) Islam and Sectarianism	Quiz
10.	**Islamic Culture & Civilization** 1) Basic Concepts of Islamic Culture & Civilization 2) Historical Development of Islamic Culture & Civilization 3) Characteristics of Islamic Culture & Civilization 4) Islamic Culture & Civilization and Contemporary Issues	Assignment related to the topics
11.	**Islam & Science** 1) Basic Concepts of Islam & Science 2) Contributions of Muslims in the Development of Science 3) Quranic & Science	Quiz

12.	**Islamic Economic System** 1) Basic Concepts of Islamic Economic System 2) Means of Distribution of wealth in Islamic Economics 3) Islamic Concept of Riba 4) Islamic Ways of Trade & Commerce.	Assignment related to the topics
13.	**Political System of Islam** 1) Basic Concepts of Islamic Political System 2) Islamic Concept of Sovereignty	Quiz
14.	3)Basic Institutions of Govt. in Islam	Presentations
15.	**Islamic History** 1) Period of Khlaft-E-Rashida	Assignment related to the topics
16.	2) Period of Ummayyads 3) Period of Abbasids	Presentations
17.	**Social System of Islam** 1) Basic Concepts of Social System of Islam 2) Elements of Family 3) Ethical Values of Islam	Presentations
18.	**Final Term Exam**	

Reference Books:

1) Hameed ullah Muhammad, "Emergence of Islam" , IRI,Islamabad
2) Hameed ullah Muhammad, "Muslim Conduct of State"
3) Hameed ullah Muhammad, 'Introduction to Islam'
4) Mulana Muhammad Yousaf Islahi,"5) Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
6) Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic ResearchInstitute, International Islamic University, Islamabad (1993).
7) Mir Waliullah, "Muslim Jrisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)
8) H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & DeepPublications New Delhi (1989)
9) Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia"Allama Iqbal Open University, Islamabad (2001)

PAKISTAN STUDIES

Credit hours: 02(2-0) **Course Code: PS-154**

Course Objectives

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and passing challenges to Pakistan.

Learning Outcomes: After completion of this course, the students are expected to:

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.
- Know current issues / challenges facing Pakistan

Course Outline

Week	Topics	Remarks
1.	**Historical Perspective** a. Ideological rationale with special reference to Sir Syed Ahmed Khan	
2.	b. Ideological rationale with special reference to Allama Muhammad Iqbal	Assignment related to the topics
3.	c. Ideological rationale with special reference to Quaid-i-Azam Muhammad Ali Jinnah	
4.	Factors leading to Muslim separatism	Quiz
5.	People and Land	Assignment related to the topics
6.	i. Indus Civilization ii. Muslim advent	
7.	iii. Location and geo-physical features.	Quiz
8.	**Mid Term Exam**	
9.	**Government and Politics in Pakistan** Political and constitutional phases: a. 1947-58	Quiz
10.	b. 1958-71 c. 1971-77 d. 1977-88	Assignment related to the topics
11.	e. 1988-99	Quiz
12.	f. 1999 onward	Assignment related to the topics
13.	**Contemporary Pakistan:** a. Economic institutions and issues	Quiz
14.	b. Society and social structure	Presentations

15.	c. Ethnicity	Assignment related to the topics
16.	d. Foreign policy of Pakistan and challenges	Presentations
17.	e. Futuristic outlook of Pakistan	Presentations
18.	**Final Term Exam**	

Books Recommended

f. Burki, ShahidJaved. *State & Society in Pakistan*, The Macmillan Press Ltd 1980.
g. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
h. S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
i. Mehmood, Safdar. *Pakistan Political Roots & Development*. Lahore, 1994.
j. Wilcox, Wayne.*The Emergence of Banglades*., Washington: American Enterprise, Institute of Public Policy Research, 1972.
k. Mehmood, Safdar. *Pakistan KayyunToota*, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
l. Amin, Tahir. *Ethno -National Movement in Pakistan*, Islamabad: Institute of Policy Studies, Islamabad.
m. Ziring, Lawrence. *Enigma of Political Development*. Kent England: WmDawson& sons Ltd, 1980.
n. Zahid, Ansar. *History & Culture of Sindh*. Karachi: Royal Book Company, 1980.
o. Afzal, M. Rafique. *Political Parties in Pakistan*, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
p. Sayeed, Khalid Bin. *The Political System of Pakistan*. Boston: Houghton Mifflin, 1967.
q. Aziz, K.K. *Party, Politics in Pakistan*, Islamabad: National Commission on Historical and Cultural Research, 1976.
r. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.

Haq, Noor ul.*Making of Pakistan: The Military Perspective*. Islamabad: National Commission on Historical and Cultural Research, 1993.

ENGLISH-I (FUNCTIONAL ENGLISH)

Credit hours: 03(3-0) **Course Code: ENG-103**

Objectives: Enhance language skills and develop critical thinking.

Learning Outcomes: In specific, the students are expected to learn:

- Grammar Principles
- Active and Passive Voice
- Direct and Indirect Narration
- Writing Paragraphs and Letters
- How to use Dictionary
- How to read for better comprehension
- How to make and deliver effective business presentations

Course Contents

Week	Topics	Remarks
1.	Basics of Grammar, Parts of speech and use of articles,	
2.	Sentence structure, active and passive voice	Assignment related to the topics
3.	Practice in unified sentence, Analysis of phrase	Assignment related to the topics
4.	clause and sentence structure	Quiz
5.	Transitive verbs	Assignment related to the topics
6.	intransitive verbs	Quiz
7.	Punctuation and spelling.	
8.	**Mid Term Exam**	
9.	**Comprehension:** Answers to questions on a given text	Quiz
10.	**Discussion** General topics and every-day conversation	Group Discussion
11.	topics for discussion to be at the discretion of the teacher keeping in view the level of students	Quiz
12.	**Listening:** To be improved by showing documentaries	Assignment related to the topics
13.	films carefully selected by subject teachers	Quiz
14.		Presentations
15.	**Translation skills:** Urdu to English	Assignment related to the topics
16.	**Paragraph writing:** Topics to be chosen at the discretion of the teacher	Presentations
17.	**Presentation skills:** Introduction	Presentations
18.	**Final Term Exam**	

Note: Extensive reading is required for vocabulary building

Recommended books:

1. **Functional English**

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1.Third edition.Oxford University Press. 1997. ISBN 0194313492
2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2.Third edition.Oxford University Press. 1997. ISBN 0194313506

b) Writing

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

c) Reading/Comprehension

1. Reading. Upper Intermediate.Brain Tomlinson and Rod Ellis.Oxford Supplementary Skills.Third Impression 1992.ISBN 0 19 453402 2.

d) Speaking

ENGLISH-II (COMMUNICATION SKILLS)

Credit hours: 03(3-0) **Course Code: ENG-153**

Objectives:

Enable the students to meet their real life communication needs.

Learning Outcomes: Upon completion of the course, student will be able to prepare their CV's and other academic letters.

Course Contents

Week	Topics	Remarks
1.	**Paragraph writing:** Practice in writing a good,	
2.	Unifiedparagraph	Assignment related to the topics
3.	coherent paragraph	
4.	**Essay writing:** Introduction	Quiz
5.	**CV and job application**	Assignment related to the topics
6.	Continue	
7.	Translation skills Urdu to English	Quiz
8.	**Mid Term Exam**	
9.	**Study skills:** Skimming and scanning,	Quiz
10.	intensive and extensive	Assignment related to the topics
11.	speed reading	Quiz
12.	summary and précis writing	Assignment related to the topics
13.	comprehension	Quiz
14.	**Academic skills:** Letter/memo writing	Presentations
15.	minutes of meetings	Assignment related to the topics

16.	use of library and internet	Presentations
17.	**Presentation skills:** Personality development (emphasis on content, style and pronunciation)	Presentations
18.	**Final Term Exam**	

Note: documentaries to be shown for discussion and review

Recommended books:

Communication Skills

a) **Grammar**

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2.Third edition.Oxford University Press 1986.ISBN 0 19 431350 6.

b) **Writing**

1. Writing. Intermediate by Marie-Chrisitine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) **Reading**

1. Reading. Advanced.Brian Tomlinson and Rod Ellis.Oxford Supplementary Skills.Third Impression 1991.ISBN 0 19 453403 0.
2. Reading and Study Skills by John Langan
3. Study Skills by Riachard Yorky.

ENGLISH-III (TECHNICAL WRITING AND PRESENTATION SKILLS)

Credit hours: 03(3-0) **Course Code: ENG-203**

Objectives: Enhance language skills and develop critical thinking.

Learning Outcomes: Upon completion of the course, student will be able to prepare different type of essays andacademic research papers.

Course Contents

Week	Topics	Remarks
1.	**Presentation skills**	
2.	Continue…	Assignment related to the topics
3.	**Essay writing**	
4.	Descriptive essay	Quiz
5.	Narrative essay	Assignment related to the topics
6.	discursive essay	
7.	argumentative essay	Quiz
8.	**Mid Term Exam**	

9.	**Academic writing:** How to write a proposal for research paper	Quiz
10.	How to write a term paper	Assignment related to the topics
11.	style, content and language of research paper/ Term Paper	Quiz
12.	form, clarity and consistency of research paper/ Term Paper	Assignment related to the topics
13.	**Technical Report writing**	Quiz
14.	Continue…	Presentations
15.	**Progress report writing**	Assignment related to the topics
16.	Continue…	Presentations
17.	Continue…	Presentations
18.	**Final Term Exam**	

Note: Extensive reading is required for vocabulary building

Recommended books:

Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing
   1. Writing. Advanced by Ron White.Oxford Supplementary Skills.Third Impression 1992.ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
   2. College Writing Skills by John Langan. Mc=Graw-Hill Higher Education. 2004.
   3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

b) Presentation Skills

c) Reading

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

ENGLISH-IV (STUDY SKILLS)

Credit Hour: 03(3-0) **Course Code: ENG-254**

Objectives:

Study Skills is a collection of study techniques that will make students' learning more effective. The subject, thus, will have its impact on the whole degree program of the students.

Learning Outcomes: Upon completion of the course, student will be able to prepare himself for tests, interviews etc.

Course Contents

Week	Topics	Remarks
1.	Study Habits, Study Place, Study Time (Time Management), Concentration, Motivation	
2.	**Note- Taking & Note Making Techniques** ---------Techniques: Symbols, abbreviations, mind maps etc. ---------Reading Notes ---------Lecture Notes	Assignment related to the topics
3.	**Using Library** -------- The Card Catalog -------- Using the Card Catalog Efficiently -------- The Call Slip -------- Reference Works ---------Encyclopedias -------- Yearbooks	
4.	-------- Dictionaries -------- Atlases ------- -Bibliographies ------- Some Common Reference Works -------- Periodicals ------- The Readers Guide	Quiz
5.	**Using Dictionary** -------- How to find a word -------- Word Grammar -------- Pronunciation -------- Idioms ------- Common Spelling Problems	Assignment related to the topics
6.	**Reading Skills** ---------Intensive Reading ---------Extensive Reading ---------Reading Surveys	
7.	■	Quiz
8.	**Mid Term Exam**	
9.	**Sub Skills in Reading** ■ Vocabulary ■ Inference ■ Coherence ■ Cohesion ■ Close exercises	Quiz
10.	Skimming, Scanning, Predicting, Organization	Assignment related to the topics
11.	**Writing Skill** -------Writing paragraph: Topic Sentence, Support, Conclusion.	Quiz

12.	-------Types of paragraph: Paragraph of Analysis, Paragraph of Description, Paragraph of Comparison and Contrast, Paragraph of analogy, Paragraph of Definition.	Assignment related to the topics
13.	------- Punctuation Marks ------ Discourse Markers ------ Essay: Definition & Types	Quiz
14.	**Writing an Outline** **Learning the Vocabulary of English** -------Word Formation ------Changing Parts of Speech ------Present and Past Participles as Adjectives	Presentations
15.	------Word Stems ------Guessing Meanings from Context ------Recording the Meanings of Words ------Fixing the Meanings of Words	Assignment related to the topics
16.	**Preparing for Examination** ------How to prepare for Examinations ------Physical Preparation ------Emotional Preparation	Presentations
17.	------Review Preparation ------How to take an Examination ------Types of Examinations ------Objective Examinations ------Subjective (or Essay-Type) Examinations	Presentations
18.	**Final Term Exam**	

Suggested Reading:

- Buzan, T. (1982) Use Your Head (Rev .Ed.)
- Grellete, F. (1981) Developing Reading Skills, Cambridge.
- Jordon. R.R Academic Writing Course, London: Collins.
- Nuttal. (1981) Teaching Reading Skills in a FL. London.
- Pineas, A (1982) Writing in English, New York: Macmillan.
- Wallace, M.J. (1980) Study Skills in English. Cambridge: Cup

Yorkey, R.C. (1970) Study Skills for Students of English as a Second Language

ELEMENTS OF SET THEORY AND MATHEMATICAL LOGIC

Credit Hours: 03(3-0) **Course Code: MATH-202**

Prerequisites: Knowledge of Intermediate Mathematics

Specific Objectives of course: Everything mathematicians do can be reduced to statements about sets, equality and membership which are basics of set theory. This course introduces these basic concepts.

Learning Outcomes: Upon successful completion of the course, students will be familiar with cardinals, relations and fundamentals of propositional and predicate logics.

Course Outlines:

Week	Topics	Remarks
1.	**Set theory:** Sets, subsets, operations with sets: union,	
2.	intersection, difference, symmetric difference, Cartesian product and disjoint union.	Assignment related to the topics
3.	**Computing cardinals:** Cardinality of Cartesian product, Cardinality of all functions from a set to another set.	
4.	Cardinality of all injective, surjective and bijective functions from a set to another set.	Quiz
5.	Infinite sets, finite sets.Countable sets, properties, examples (Z, Q). R is not countable. R, RxR, RxRxR have the same cardinal.	Assignment related to the topics
6.	Operations with cardinal numbers. Cantor-Bernstein theorem.	
7.	**Relations:** Equivalence relations, partitions, quotient set;	Quiz
8.	**Mid Term Exam**	
9.	examples, parallelism, similarity of triangles.	Quiz
10.	Order relations, min, max, inf, sup; linear order. Examples: N, Z, R, P(A).	Assignment related to the topics
11.	Well-ordered sets and induction. Inductively ordered sets and Zorn's lemma.	Quiz
12.	**Mathematical logic:** Beginning Mathematical Logic, Propositional Calculus. Truth tables. Predicate Calculus.	Assignment related to the topics
13.	First-Order Logic	Quiz
14.	First-Order Logic (continued)	Presentations
15.	Boolean Algebras	Assignment related to the topics
16.	Model Theory	Presentations
17.	Recursion Theory	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. M. Liebeck, A Concise Introduction to Pure Mathematics, CRC Press, 2011.
2. N. L. Biggs, Discrete Mathematics, Oxford University Press, 2002.
3. R. Garnier, J. Taylor, Discrete Mathematics, Chapters 1,3,4,5, CRC Press, 2010.
4. A.A. Fraenkal, Abstract Set Theory, North-Holland Publishing Company, 1966.
5. P. Suppes, Axiomatic Set Theory, Dover Publication, 1972.
6. P.R. Halmos, Naive Set Theory, New York, Van Nostrand, 1950.
7. B. Rotman, G.T. Kneebone, The Theory of sets and Transfinite Numbers, Oldbourne London, 1968.
8. D. Smith, M. Eggen, R.St. Andre, A Transition to Advanced Mathematics, Brooks/Cole, 2001.
9. Shashi Mohan Srivastava, A Course on Mathematical Logic, Springer, New York, NY, 2013

General Courses

Physics-I (Wave and Oscillations)

Credit Hours: 03(3-0) **Course Code: PHY-105**
Prerequisite(s): None
Objectives: The main objectives of this course are:

- To learn about oscillations and vibrations
- To understand the properties of waves and to learn about how to use waves scientifically.
- To understand the phenomenon of interference, diffraction and polarization.

Learning Outcomes: At the end of this course, you should understand the motion of a harmonic oscillator, including both its free response from given starting conditions, and the response when driven at a single frequency. You will have an understanding of the properties of sound waves in gases, and on the possible acoustic waves that can propagate in solids. You will also understand the general conditions required for interference patterns to be observed, and be able to compute the interference patterns expected from thin films, and from cavities.
Contents:

Week	Topics	Remarks
1.	**Harmonic Oscillations:** Simple harmonic motion (SHM), Obtaining and solving the basic equations of motion $X(t), V(t), a(t)$.	
2.	Longitudinal and transverse Oscillations, Energy consideration in SHM.	Assignment related to the topics
3.	Applications of SHM, Torsional oscillator, Physical Pendulum, Simple Pendulum, SHM and uniform circular motion,	
4.	Combination of harmonic motions, Lissajous patterns, Damped harmonic motion, Equation of Damped Harmonic motion, Quality factor,	Quiz
5.	discussion of its solution, Forced oscillations and Resonances, Equation of forced oscillation, discussion of its solution,	Assignment related to the topics
6.	Natural frequency, Resonance, Examples of resonance.	
7.	**Waves in physical Media:** Mechanical waves, traveling waves, phase velocity of traveling waves, Sinusoidal waves,	Quiz
8.	**Mid Term Exam**	
9.	Group speed and dispersion, Waves speed, Mechanical analysis, Wave equation, Discussion of solution, Power and intensity in wave motion,	Quiz
10.	Derivation & discussion, Principle of Superposition (basic ideas), Interference of Waves, Standing Waves.	Assignment related to the topics
11.	**Interference:** Coherence of sources, Double slit Interference, Analytical treatment,	Quiz

12.	Adding of electromagnetic waves using phasors, Interference from thin films, Newton's ring(analytical treatment),	Assignment related to the topics
13.	**Diffraction:** Diffraction at single slit, intensity in single slit diffraction using phasor treatment and analytical treatment using addition of waves,	Quiz
14.	Double slit Interference & diffraction combined, Diffraction at a circular aperture, Diffraction from multiple slits, Discussion to include width of the maxima.	Presentations
15.	**Polarization:** Basic definition, Production of Polarization by polarizing sheets,	Assignment related to the topics
16.	by reflection, by double refraction and double scattering.	Presentations
17.	Description of polarization states. Linear, Circular, elliptical Polarization.	Presentations
18.	**Final Term Exam**	

Recommended Text Book

1. Halliday, D. Resnick, Krane, Physics, Vol. I & II, John Wiley, 5th ed. 1999
2. Halliday, D. Resnick and Walker, Fundamental of Physics, Extended ed. John Wiley, 10th ed. 2013
3. Ritz and Milford, Foundations of Electromagnetic Theory, 4th Edition, 1993.

PHYSICS-II (THERMODYNAMICS AND STATISTICAL MECHANICS)

Credit Hours: 03(3-0) **Course Code: PHY-155**

Prerequisite(s): Waves and oscillations.

Objectives: MGC-202 is an introduction to thermodynamics and statistical mechanics. This course will cover the fundamental topics of equilibrium thermodynamics -- entropy, temperature, energy, heat, reversible and irreversible processes -- and see applications to some simple systems. Moreover, it will develop a fundamental understanding of the connection between the macroscopic and microscopic worlds and will explore many body systems both in classical and in quantum mechanics.

Learning Outcomes: At the end of this module successful students will be able to:

- Define and explain fundamental concepts such as system, state function, quasi-static reversible process, thermodynamic equilibrium and equation of state
- Explain the concept of an ideal reversible heat engine, describe a Carnot cycle and derive the efficiency of a Carnot engine
- State the Laws of Thermodynamics and describe some of the consequences for the behavior of systems at low temperatures.
- Apply the definitions and results of statistical mechanics to deduce physical properties of the systems studied in the lectures and other systems of similar complexity, drawing

in part on your knowledge of the microstates of simple systems from core courses in quantum mechanics and solid state physics.

Contents:

Week	Topics	Remarks
1.	**Heat and temperature:** Temperature, kinetic theory of the ideal gas,	
2.	work done on an ideal gas, internal energy of an ideal gas.	Assignment related to the topics
3.	Equipartition of energy, Intermolecular forces.	
4.	Quantitative discussion. Van der waals equation of state.	Quiz
5.	**Statistical Mechanics:** Statistical distribution and mean values,	Assignment related to the topics
6.	Mean free path and microscopic calculation of mean free path	
7.	distribution of molecular speeds, distribution of energies	Quiz
8.	**Mid Term Exam**	
9.	Maxwell distribution, Maxwell Boltzmann energy distribution,	Quiz
10.	internal energy of an ideal gas, Brownian motion,	Assignment related to the topics
11.	qualitative description, diffusion, conduction and viscosity.	Quiz
12.	**Thermodynamics:** Review of previous concepts. First law of thermodynamics and its applications to adiabatic, isothermal, cyclic and free expansion	Assignment related to the topics
13.	Reversible and irreversible processes, second law of thermodynamics Carnot theorem, and Carnot engines,	Quiz
14.	Heat engine. Refrigerators.Calculation of efficiency of heat engines	Presentations
15.	Thermodynamic temperature scale: Absolute zero: Entropy, Entropy in reversible process, entropy in irreversible process	Assignment related to the topics
16.	Entropy & second law.Entropy & Probability. Thermodynamics functions: Thermodynamic functions (internal energy, Enthalpy, Gibb's function, Entropy, Helmholtz functions)	Presentations
17.	Maxwell's relations, Tds equations, Energy equations and their applications.	Presentations
18.	**Final Term Exam**	

Recommended Book:

1. Halliday, D. Resnick, Krane, Physics, Vol. I & II, John Wiley, 5th ed. 1999
2. Halliday, D. Resnick and Walker, Fundamental of Physics, Extended ed. John Wiley, 10th ed. 2013
3. R.A. Hashimi, A Textbook of Engineering and thermodynamics.
4. Marker, Zemausty, Richard H. Dittman, Heat and thermodynamics, 5th ed. McGraw Hill Inc, 1968.

PHYSICS-III (ELECTRICITY AND MAGNETISM)

Credit Hours: 03(3-0) **Course Code: PHY-205**

Prerequisite: Basic of Vector Analysis

Objectives: After the completion of the course, students will be able to explain how electric current can generate a magnetic field and how to create an electromagnet. Apart from other concepts in electricity and magnetism, students will be able to explain how electricity and magnetism work together in electric motors and generators.

Learning Outcomes: At the end of this module successful students will be able to

- Write down Maxwell's equations in differential form, defining all the variables
- Use the material in Electromagnetism I to solve problems in electrostatics
- Use the material in EM I to solve problems in magneto statics, and calculate the motion of charged particles in magnetic fields
- Use Ampere's Law to calculate the magnetic field of a current-carrying straight wire and a solenoid
- Calculate the force on a current-carrying wire in a magnetic field etc.

Course Contents:

Week	Topics	Remarks
1.	**Electric Field**: Field due to a point charge: due to several point charges.	
2.	Electric dipole.Electric field of continuous charge distribution e.g Ring of charge, Disc of charge, infinite line of charge.	Assignment related to the topics
3.	Point charge in an electric field. Dipole in an electric field, Torque and energy of a dipole in uniform fields. Electric flux: Gauss's law.; (integral and differential forms) and its application.	
4.	Charge on isolated conductors, conductor with a cavity, field near a charged conducting sheet.	Quiz
5.	Field of infinite line of charge, field of infinite sheet of charge, field of spherical shell and field of spherical charge distribution.	Assignment related to the topics
6.	**Electric Potential:** Potential due to point charge, potential due to collection of point charges, potential due to dipole,	
7.	Eletric Potential of continuous distribution charge. Poisson's and Laplace equation without solution.Field as the gradient or derivative of Potential.Potential and field inside and outside an isolated conductor.	Quiz
8.	**Mid Term Exam**	
9.	**Capacitors and dielectrics**: Capacitance, calculating the electric field in a capacitor. Capacitors of various shapes, cylindrical, spherical etc, and calculation of their capacitance.	Quiz
10.	Energy stored in an electric field. Energy per unit volume.Capacitor with dielectric, Electric field of	Assignment related to the topics

	dielectric.An atomic view. Application of Gauss's law to capacitor with dielectric.	
11.	**Magnetic field effects and magnetic properties of Matter:**Magnetic force on a charged particle, magnetic force on a current, recall the previous results. Do not derive. Torque on a current loop. Magnetic dipole: energy of magnetic dipole in field.	Quiz
12.	Discuss quantitatively, Lorentz force with its application in CRO. Biot-Savart Law: Analytical treatment and applications to a current loop, force on two parallel current changing conductors.	Assignment related to the topics
13.	Ampere's law, integral and differential forms, applications to solenoids and toroids. (integral form).	Quiz
14.	**Introductance:** Faraday's Law of electromagnetic induction, review of emf	Presentations
15.	Faraday law and Lenz's Law, induced electric fields,	Assignment related to the topics
16.	calculation and application using differential and integral form, inductance" Basic definition"	Presentations
17.	Inductance of a solenoid: Toroid	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Halliday, D. Resnick, Krane, Physics, Vol. I & II, John Wiley, 5th ed. 1999
2. Halliday, D. Resnick and Walker, Fundamental of Physics, Extended ed. John Wiley, 10th ed. 2013.
3. Ritz and Milford, Introduction to Electromagnetic Field and Waves
4. Reitz, John R. and Milford Fredrick, J. Foundations to Electromagnetic Theory, 3rd ed. Addison-Wesley Publishing Co. 1975.

PHYSICS-IV (MODERN PHYSICS)

Credit Hours: 03(3-0) **Course Code: PHY-255**
Prerequisite(s): Physics-I and physics-III

Objectives: The course will provide an introduction to the principles and mathematical implementation of two revolutionary developments of the 20th Century – Relativity and Quantum Mechanics. The resulting understanding of everything from the structure of the atom to the evolution of the universe will be explored.

Learning outcomes: The course illustrates the fundamental aspects of modern Physics, and we will use quantum mechanics at different levels to understand the structure and dynamics of both atoms and molecules. A lab exercise will be part of the course. After having taken "modern

Physics" the student should have sufficient knowledge in atomic and molecular physics to follow courses at the advanced level have knowledge of the most common atomic and molecular spectroscopic methods and the atomic and molecular properties derived from those.

Contents:

Week	Topics	Remarks
1.	**Origin of quantum theory:** Black body radiation, Stefan Boltzmann-, Wiens- and Planck's law, consequences.	
2.	The quantization of energy, Photoelectric and Compton effect, Line spectra, Explanation using quantum theory.	Assignment related to the topics
3.	**Wave Nature of Matter:** Wave behavior of particle (wave function etc) its definition Germer Experiment and J.P. Thomson experiment,	
4.	Wave Packets and particles, localizing a wave in space and time.	Quiz
5.	**Atomic Physics:** Bohr's theory (review), Frank-Hertz experiment, energy levels of electron,	Assignment related to the topics
6.	Atomic spectrum, Angular momentum of electrons, vector atom model, Orbital angular momentum. Spin quantization, Bohr's Magneton.	
7.	X-ray spectrum (Continuous and Discrete) Moseley's law, Pauli's exclusion principle and its use in developing the periodic table.	Quiz
8.	**Mid Term Exam**	
9.	**Nuclear Physics:** Basic properties of a nucleus, Mass and Atomic Numbers, Isotopes, mass and size of a nucleus, Nuclear force (Basic Idea),	Quiz
10.	Nuclear Radii, Nuclear masses, Binding energy, mass defect, Nuclear Spin and Magnetism.	Assignment related to the topics
11.	**Natural Radioactivity:** Laws of radioactive decay, half-life, mean life,	Quiz
12.	chain disintegration; Alpha- Beta and Gamma decays (Basics idea	Assignment related to the topics
13.	Measuring ionizing radiation (units i.e. Curie, Rad etc.)	Quiz
14.	**Nuclear Reactions:** Basic Nuclear reaction,	Presentations
15.	Q-value, Exothermic,	Assignment related to the topics
16.	Endothermic Nuclear model, Nuclear Fusion,	Presentations
17.	Thermonuclear Fusion.	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Halliday, D. Resnick, Krane, Physics, Vol. I & II, John Wiley, 5th ed. 1999
2. Halliday, D. Resnick and Walker, Fundamental of Physics, Extended ed. John Wiley, 10th ed. 2013.
3. A. Beiser, Concepts of Modern Physics, 6th ed., McGraw-Hill book Co., 1994.

COMPUTER PROGRAMMING

Credit Hours: 03(2-1) **Course Code: CS-204**
Prerequisite(s): Introduction to Computer
Specific Objectives of the Course:
The purpose of this course is to introduce students to operating systems and environment.
Learning Outcomes: Upon successful completion of the course, student will be able:

- To define appropriate uses of programming application languages.
- To use recording procedures, if applicable, to create functions in an application.
- To use pre-packaged application language applets, objects, procedures or functions.

Contents:

Week	Topics	Remarks
1.	Programming and problem analysis.	
2.	Continue…	Assignment related to the topics
3.	Development of basic algorithms	
4.	Continue…	Quiz
5.	Translation of algorithms into programs.	Assignment related to the topics
6.	Standard Data Types.	
7.	Basic control structures.	Quiz
8.	**Mid Term Exam**	
9.	Functions.	Quiz
10.	Structured data types; Arrays, Structures,	Assignment related to the topics
11.	Continue….	Quiz
12.	Pointers and Files.	Assignment related to the topics
13.	Continue….	Quiz
14.	Debugging of programs	Presentations
15.	Continue….	Assignment related to the topics
16.	testing programs	Presentations
17.	Continue….	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Aho, AV Ulman JD, Foundation of Computer Science, computer Science Press, WH Freeman New York, 1995.
2. Timothy AB, An Introduction to Objected-Oriented Programming, Addison Wesley Longman, 2002.
3. Behrouz A. Forouzan, Firouz Mosharraf, Foundations of Computer Science, Cengage Learning EMEA, 2008.

INTRODUCTION TO SOCIOLOGY

Credit hours: 03(3-0) **Course Code: SOC-156**

Objective:

The course is designed to introduce the students with sociological concepts and the discipline. The focus of the course shall be on significant concepts like social systems and structures, socio-economic changes and social processes. The course will provide due foundation for further studies in the field of sociology.

Learning Outcomes: After completion of the course, students will exhibit knowledge of sociological perspective of sport in society and the influences sports and society have on one another. Students will demonstrate the ability to discuss sociological theories, concepts, and ideas related to sport and society in small and large group settings and to express empirically as well as theoretically based opinions. Students will also exhibit knowledge of the primary institutions of family, education, religion, economic, and political structures in relation to sport and its impact on society.

Course Outline

Week	Topics	Remarks
1.	**Introduction** a. Definition, Scope, and Subject Matter b. Sociology as a Science c. Historical back ground of Sociology	
2.	**Basic Concepts** o Group, Community, Society o Associations o Non-Voluntary o Voluntary	Assignment related to the topics
3.	a. Organization i. Informal ii. Formal b. Social Interaction i. Levels of Social Interaction ii. Process of Social Interaction 1. Cooperation 2. Competition	
4.	3. Conflict 4. Accommodation 5.Acculturation and diffusion 6. Assimilation 7.Amalgamation	Quiz
5.	**Social Groups** a. Definition & Functions b. Types of social groups ii. In and out groups iii. Primary and Secondary group iv. Reference groups	Assignment related to the topics

	v. Informal and Formal groups vi. Pressure groups	
6.	**Culture** a. Definition, aspects and characteristics of Culture i. Material and non-material culture ii. Ideal and real culture b. Elements of culture i. Beliefs ii. Values iii. Norms and social sanctions	
7.	c. Organizations of culture i. Traits ii. Complexes	Quiz
8.	**Mid Term Exam**	
9.	Patterns Ethos Theme	Quiz
10.	**Other related concepts** Cultural Relativism Sub Cultures	Assignment related to the topics
11.	Ethnocentrism and Xenocentrism Cultural lag	Quiz
12.	**Socialization & Personality** Personality, Factors in Personality Formation	Assignment related to the topics
13.	Socialization, Agencies of Socialization Role & Status	Quiz
14.	**Deviance and Social Control** a. Deviance and its types b. Social control and its need	Presentations
15.	Forms of Social control Methods & Agencies of Social control	Assignment related to the topics
16.	**Collective Behavior** a. Collective behavior, its types b. Crowd behavior c. Public opinion d. Propaganda e. Social movements f. Leadership	Presentations
17.	Continue…	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Anderson, Margaret and Howard F. Taylor. 2001. *Sociology the Essentials*. Australia: Wadsworth.
2. Brown, Ken 2004. *Sociology*. UK: Polity Press

3. Gidden, Anthony 2002. *Introduction to Sociology*. UK: Polity Press.
4. Macionis, John J. 2006. 10th Edition *Sociology* New Jersey: Prentice-Hall
5. Tischler, Henry L. 2002. *Introduction to Sociology* 7th ed. New York: The Harcourt Press.
6. Frank N Magill. 2003. *International Encyclopedia of Sociology*. U.S.A: Fitzroy Dearborn Publishers
7. Macionis, John J. 2005. *Sociology* 10th ed. South Asia: Pearson Education
8. Kerbo, Harold R. 1989. *Sociology: Social Structure and Social Conflict*. New York: Macmillan Publishing Company.
9. Koening Samuel. 1957. *Sociology: An Introduction to the Science of Society*. New York: Barnes and Nobel..
10. Lee, Alfred Mclung and Lee, Elizabeth Briant 1961. *Marriage and The family*. New York: Barnes and Noble, Inc.
11. Leslie, Gerald et al. 1973. *Order and Change: Introductory Sociology* Toronto: Oxford University Press.
12. Lenski, Gevbard and Lenski, Jeam. 1982. *Human Societies*. 4th edition New York: McGraw-Hill Book Company.
13. James M. Henslin. 2004. *Sociology: A Down to Earth Approach*. Toronto: Allen and Bacon.

INTRODUCTION TO POLITICAL SCIENCE

Credit Hour: 03(3-0) **Course Code: POL-206**

Course Objectives:

Political science deals with system of government and the analysis of political and political behaviors. It will the students for careers in politics, or to give then awareness of the political process that might be useful in some other career.

Learning Outcomes: Students completing the Political Science will be able to:

1. write clearly and with purpose on issues of international and domestic politics and public policy;
2. participate as a civically engaged member of society;
3. analyze political and policy problems and formulate policy options;
4. use electronic and traditional library resources to research key local, state, national and international policy issues and present results.

Course Contents

Week	Topics	Remarks
1.	Definition, Nature, Scope and Sub-fields of Political Science.	
2.	Approaches to study of Political Science: Traditional and Modern.	Assignment related to the topics
3.	Basic concepts of Political Science: Power, Authority, Legitimacy,	
4.	Nation and Sovereignty. Political System: Definition,	Quiz

5.	Characteristics and Functions. State: its origin and evolution;	Assignment related to the topics
6.	Western and Islamic concepts of State.	
7.	Law: Definition, Sources,	Quiz
8.	**Mid Term Exam**	
9.	Kinds; its relationship with Morality	Quiz
10.	individual Liberty and Rights & Duties.	Assignment related to the topics
11.	Organs of Government: Legislature,	Quiz
12.	Executive, Judiciary.	Assignment related to the topics
13.	Forms of Government: Unitary,	Quiz
14.	Federal, Parliamentary and Presidential.	Presentations
15.	Political Parties, Interest Groups,	Assignment related to the topics
16.	Public Opinion,	Presentations
17.	Electoral process.	Presentations
18.	**Final Term Exam**	

Note: Sub-fields of Political Science include: Political Philosophy/Theory; Comparative Politics; International Relations; Public Administrations/ Public Policy; Local Government.

Recommended Books:

1. Rodee, Anderson etc. Introduction to Political Science, Islamabad, National Book Foundation, Latest Edition.
2. Mazher ul Haq, Theory and Practice in Political Science, Lahore Bookland, 2010.
3. Mohammad Sarwar, Introduction to Political Science, Lahore Ilmi Kutub Khana, 1996.
4. Ahmad Shafi Choudhry, Usul-e-Siyasiat, Lahore Standard Book Depot, 1996.
5. Bashir Ahmad Sheikh, (Sindhi) Riyasat Jo Ilm (Science of State), Jamshoro, Institute of Sindhalogy, University of Sindh, 1985.
6. Ian Mackenzi (Ed.), Political Concepts: A Reader and Guide, Edinburgh, University Press, 2005.
7. R. C. Agarwal, Political Theory (Principles of Pol. Science), New Delhi, S. Chand & Co., 2006.

SOFTWARE PACKAGES

Credit Hour: 03(1-2) **Course Code: MATH-402**

Pre-requisite: Computer Programming, Basic Calculus, ODEs and PDEs knowledge

Objectives: Students are expected to be able to apply techniques, routines and processes involving rational and real arithmetic, algebraic manipulation, equation solving, graph sketching, differentiation and integration with and without the use of technology, as applicable.

Learning Outcomes: On completion of this course, the students should be able to select and appropriately use a computer algebra system and other technology to develop mathematical ideas, produce results and carry out analysis in situations requiring problem-solving, modeling or investigative techniques or approaches.

Contents:

Week	Topics	Remarks
1.	**Computer Algebra System (CAS):** Numerical Calculation	
2.	Exact and approximate results of linear and non-linear system,	Assignment related to the topics
4.	Complex Numbers, Algebraic Calculations,	
5.	Limits, Differentiation,	Quiz
6.	Integrations, Sum and Products,	Assignment related to the topics
7.	Solving Equation, Defining functions, Vector and Matrices, Two and Three dimensional graphics	
8.	Determinant, eigenvalues and eigenvectors, singular values, matrix factorization, solution of linear system	Quiz
9.	**Mid Term Exam**	
10.	Introduction to MATLAB windows, the use of command window, Power Series, Integral transforms	Quiz
11.	Numerical Solutions (Differentiation, Integrations, Sum and Products,)	Assignment related to the topics
12.	Numerical Solutions (Solving Equation, Solving ODEs and PDEs), Parametric and density plots, Polar plots.	Quiz
13.	**Programming in MATLAB:** Built in Functions, Arrays, Matrices, Script files,	Assignment related to the topics
14.	Plots, Functions and function file, Loops	Quiz
15.	Selection Statements, Polynomials, Curve fitting and interpolation.	Presentations
16.	Introduction to MAPLE	Assignment related to the topics
17.	Continue…	Presentations
18.	Introduction to MATHEMATICA.	Presentations
19.	**Final Term Exam**	

Recommended Books:

1. Martha L. Abel, James P. Braselton, Mathematica by Examples, 3rd Edition, Elsevier Academic press, 2004.
2. Stephen Wolfram, Mathematica, 5th Edition, Wolfram Media, 2003.
3. Calculus with Maple V by John S. Devitt 1993.
4. Rudra Partap, Getting started with MATLAB, Oxford University Press, 2006.

OTHER COURSES FROM GENERAL POLE:

INTRODUCTION TO ECONOMICS

Credit Hours: 03(3-0)
Prerequisite(s): None

Objectives: Upon successful completion of this course, students should be able to:

- Describe basic economic theories that explain economic outcomes of the aggregate economy
- Explain economic events in individual markets and the aggregate economy using basic economic theory and tools
- Outline the implications of various economic policies on individuals and on the economy

Learning outcomes: At the end of the course and having completed the Essential reading and activities, you should be able to:

- Define the main concepts and describe the models and methods used in economic analysis
- Formulate real world issues in the language of economic modeling
- Apply and use economic models to analyze these issues
- Assess the potential and limitations of the models and methods used in economic analysis.

Contents:

Week	Topics	Remarks
1.	**Introduction:** Definition, Nature, Scope and Importance (Micro and Macro Economics)	
2.	Description, Analysis and Policy	Assignment related to the topics
3.	Economic Methodology.	
4.	**Consumer Behavior:** Definition and meaning, Marginal Utility:	Quiz
5.	Law of Diminishing Marginal Utility Consumer's Surplus Indifference curve approach	Assignment related to the topics
6.	**Demand:** Definition, Laws of Demand, Changes in Demand,	Quiz
7.	Elasticity of Demand and its measurement	
8.	**Mid Term Exam**	
9.	**Supply:** Supply, Changes in supply, Demand and Supply Relationship	Quiz
10.	**Equilibrium Analysis**. **Production:** Concept of Factor of Production, Land Labor, Capital &Entrepreneur. Laws of Returns and their application to Agriculture Sector	Assignment related to the topics
11.	**Costs:** Costs over time period Fixed, Variable, Total, Average and Marginal	Quiz
12.	**Market:** Perfect and Imperfect Competition. Price and output determination under perfect and Imperfect competition. Market price and Normal price	Assignment related to the topics

13.	Monopoly, Oligopoly, Duopoly and Price Control (Basic Concepts) **Factor Pricing:** Rent, Wages, Interest and Profit	Quiz
14.	**National Income:** Concepts of National Income-GNP, Circular flow of national Income. Measurement of National Income: National Income at market price, at factor Cost; Measurement of national Product in current rice and in constant prices	Presentations
15.	**Money:** Evolution, Forms, Functions, Importance and Role of Money. **Value of Money:** Quantity Theory of Money, Cash Balance Theory of money, Measurement of Value of Money, Devaluation of Money	Assignment related to the topics
16.	**Trade Cycle:** Phases, Causes & Remedies, Theory of Trade Cycles. **Inflation:** Kinds, Causes, & Remedies **Balance of Payments:** Balance of Trade, Balance of Payments, Causes of Disequilibrium and Measures	Presentations
17.	**Public Finance:** Meaning, Difference between Private and Public Finance, Income and Expenditure of Public Bodies, Kinds of Taxes and Cannons of Taxes **Economics in Islam:** Economic role of State in Islam, Zakat and Ushr	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Muhammad Irshad, Economics, Naveed Publications Lahore.
2. Sh Manzoor Ali, Economics, Ilmi Kutab Khana, Urdu Bazar, Lahore.
3. Lioyd G Reynolds Irwin, Micro Economics — Analysis & Policy, Irwin Homwood Illinois.
4. Nancy Smith Barrett, The Theory of Macro Economics Policy, Prentice Hall.
5. Edward Shapiro, Macro Economic Analysis, Harcourt Brace Jovanovich, 1982.
6. Saeed Nasir M A, Textbook of Economics, Ilmi Kutab Khana, Lahore.
7. Salman Rizavi, Economics.
8. Paul A. Samuelson, William D. Nordhaus, Economics, 19th edition, 2009.

INTRODUCTION TO PSYCHOLOGY

Credit Hour:: 03(3-0)
Pre-requisite: None
Course Objectives

Describe psychology with major areas in the field, and identify the parameters of this discipline. Distinguish between the major perspectives on human thought and behavior. Appreciate the variety of ways psychological data are gathered and evaluated. Gain insight into human behavior 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 behavior.

Learning Outcomes: Students are expected to demonstrate full knowledge and understanding of important psychological concepts and principles as well as the major theories, methods, and applications of psychology covered in the textbook and other required instructional resources. You will receive a handout containing specific learning objectives for each chapter in the textbook. Careful attention to this handout will aid your progress.

Course Contents

Week	Topics	Remarks
1.	**Introduction to Psychology:** Nature and Application of Psychology with special reference to Pakistan.	
2.	Historical Background and Schools of Psychology (A Brief Survey)	Assignment related to the topics
3.	**Methods of Psychology**: Observation, Case History Method Experimental Method, Survey Method, Interviewing Techniques	
4.	**Biological Basis of Behavior**: Neuron: Structure and Functions, Central Nervous System and Peripheral Nervous System, Endocrine Glands	Quiz
5.	**Sensation:** Characteristics and Major Functions of Different Sensations, Vision: Structure and functions of the Eye. Audition: Structure and functions of the Ear.	Assignment related to the topics
6.	**Perception:** Nature of Perception, Factors of Perception: Subjective, Objective and Social, Kinds of Perception: Spatial Perception (Perception of Depth and Distance),Temporal Perception; Auditory Perception.	
7.	**Attention:** Factors, Subjective and Objective, Span of Attention, Fluctuation of Attention, Distraction of Attention (Causes and Control)	Quiz
8.	**Mid Term Exam**	
9.	**Motives:** Definition and Nature, Classification	Quiz
10.	**Primary**(Biogenic) Motives: Hunger, Thirst, Defection and Urination, Fatigue, Sleep, Pain, Temperature, Regulation, Maternal Behavior, Sex	Assignment related to the topics
11.	**Secondary** (Sociogenic) Motives: Play and Manipulation, Exploration and Curiosity, Affiliation, Achievement and Power, Competition, Cooperation, Social Approval and Self Actualization	Quiz
12.	**Emotions:** Definition and Nature**,** Physiological changes during Emotions (Neural, Cardial, Visceral, Glandular), Galvanic Skin Response; Pupilliometrics**,** Theories of Emotion, James Lange Theory; Cannon-Bard Theory, Schachter –Singer Theory	Assignment related to the topics
13.	**Learning:** Definition of Learning**,** Types of Learning: Classical and Operant Conditioning Methods of Learning: Trial and Error;	Quiz

	Learning by Insight; Observational Learning	
14.	**Memory:** Definition and Nature**,** Memory Processes: Retention, Recall and Recognition**,** Forgetting: Nature and Causes	Presentations
15.	**Thinking:** Definition and Nature**,** Tools of Thinking: Imagery; Language; Concepts**,** Kinds of Thinking**,** Problem Solving;	Assignment related to the topics
16.	Decision Making; Reasoning, Definition concepts of Individual differences, Intelligence	Presentations
17.	personality, aptitude, achievement	Presentations
18.	**Final Term Exam**	

RECOMMENDED BOOKS

I. Atkinson R. C., & Smith E. E. (2000).*Introduction to psychology* (13thed.). Harcourt Brace College Publishers.

II. Fernald,L.D.,&Fernald,P.S.(2005). *Introduction to Psychology*. USA: WMCBrown Publishers.

III. Glassman, W. E. (2000). *Approaches to psychology*. Open University Press.

IV. Hayes, N. (2000). *Foundation of psychology* (3rd ed.).Thomson Learning.

V. Lahey, B. B. (2004). *Psychology: An introduction* (8th ed.). McGraw-Hill Companies, Inc.

VI. Leahey, T. H. (1992). *A history of psychology: Main currents in psychological thought*. New Jersey: Prentice-Hall International, Inc.

VII. Myers, D. G. (1992). *Psychology*. (3rd ed.). New York: Wadsworth Publishers.

VIII. Ormord, J. E. (1995). *Educational psychology*: *Developing learners*. Prentice- Hall, Inc.

FOUNDATION COURSES

CALCULUS-I

Credit hours: 03(3-0) **Course Code: MATH-101**

Prerequisites: Knowledge of Intermediate Calculus

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.

Learning Outcomes: Upon successful completion of Calculus I, a student will be able to:

- Compute limits and derivatives of algebraic, trigonometric, and piece-wise defined functions,
- Compute definite and indefinite integrals of algebraic and trigonometric functions using formulas and substitution,
- Use the derivative of a function to determine the properties of the graph of the function and use the graph of a function to estimate its derivative,
- Solve problems in a range of mathematical applications using the derivative or the integral,
- Apply the Fundamental Theorem of Calculus,
- Determine the continuity and differentiability of a function at a point and on a set, and
- Use appropriate modern technology to explore calculus concepts.

Course Contents:

Week	Topics	Remarks
1.	**Equations and inequalities:** Solving linear and quadratic equations, linear inequalities. Division of polynomials, synthetic division.	
2.	Roots of a polynomial, rational roots; Viete Relations. Descartes rule of signs. Solutions of equations with absolute value sign. Solution of linear and non-linear inequalities with absolute value sign.	Assignment related to the topics
3.	**Functions and graphs:** Domain and range of a function. Examples: polynomial, rational, piecewise defined functions,	
4.	Absolute value functions, and evaluation of such functions	Quiz
5.	Operations with functions: sum, product, quotient and composition. Graphs of functions: linear, quadratic, piecewise defined functions	Assignment related to the topics

6.	**Lines and systems of equations:** Equation of a straight line, slope and intercept of a line, parallel and perpendicular lines	
7.	Systems of linear equations, solution of system of linear equations. Nonlinear systems: at least one quadratic equation	Quiz
8.	**Mid Term Exam**	
9.	**Limits and continuity:** Functions, limit of a function, Graphical approach, Properties of limits, Theorems of limits,	Quiz
10.	Limits of polynomials, rational and transcendental functions, Limits at infinity, infinite limits, one-sided limits. Continuity	Assignment related to the topics
11.	**Derivatives:** Definition, techniques of differentiation	Quiz
12.	Derivatives of polynomials and rational, exponential, logarithmic and trigonometric functions, the chain rule, Implicit differentiation	Assignment related to the topics
13.	Rates of change in natural and social sciences. Related rates. Linear approximations and differentials. Higher derivatives, Leibnitz's theorem	Quiz
14.	**Applications of derivatives:** Increasing and decreasing functions. Relative extrema and optimization. First derivative test for relative extrema. Convexity and point of inflection	Presentations
15.	The second derivative test for extrema. Curve sketching. Mean value theorems. Indeterminateforms and L'Hopitals rule. Inverse functions and their derivatives	Assignment related to the topics
16.	**Integration:**Anti derivatives and integrals. Riemann sums and the definite integral	Presentations
17.	Properties of Integral. The fundamental theorem of calculus	Presentations
18.	**Final Term Exam**	

Books Recommended

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.

CALCULUS-II

Credit Hour: 03(3-0) **Course Code: MATH-151**

Prerequisites: Calculus I

Course Objectives:

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**.**

Learning Outcomes: Upon successful completion of Calculus II, a student will be able to:

- Define, graph, compute limits of, differentiate, and integrate transcendental functions,
- Examine various techniques of integration and apply them to definite and improper integrals,
- Approximate definite integrals using numerical integration techniques and solve related problems,
- Model physical phenomena using differential equations,
- Define, graph, compute limits of, differentiate, integrate and solve related problems involving functions represented parametrically or in polar coordinates,
- Distinguish between the concepts of sequence and series, and determine limits of sequences and convergence and approximate sums of series, and
- Define, differentiate, and integrate functions represented using power series expansions, including Taylor series, and solve related problems.

Course Contents:

Week	Topics	Remarks
1.	**Techniques of integration:** Integrals of elementary, hyperbolic, trigonometric, logarithmic and exponential functions.	
2.	Integration by parts, substitution and partial fractions.	Assignment related to the topics
3.	Approximate integration, Improper integrals, Gamma functions	
4.	**Applications of integrals**: Area between curves, average value. Volumes, Arc length	Quiz
5.	Area of a surface of revolution. Applications to Economics, Physics, Engineering and Biology	Assignment related to the topics
6.	**Infinite series:** Sequences and series. Convergence and absolute convergence	
7.	Tests for convergence: divergence test	Quiz

8.	**Mid Term Exam**	
9.	Integral test, p-series test, comparison test, limit comparison test, alternating series test, ratio test, root test. Power series	Quiz
10.	Convergence of power series. Representation of functions as power series. Differentiation and integration of power series.	Assignment related to the topics
11.	Taylor and McLaurin series, Approximations by Taylor polynomials	Quiz
12.	**Conic section, parameterized curves and polar coordinates:** Curves defined by parametric equations	Assignment related to the topics
13.	Calculus with parametric curves: tangents, areas, arc length.	Quiz
14.	Polar coordinates.	Presentations
15.	Polar curves,	Assignment related to the topics
16.	Tangents to polar curves	Presentations
17.	Areas and arc length in polar coordinates	Presentations
18.	**Final Term Exam**	

Books Recommended

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

CALCULUS-III

Credit Hour: 03(3-0) **Course Code: MATH-201**

Prerequisites: Calculus II

Course Objectives: 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.

Learning Outcomes: Upon successful completion of Calculus III, a student will be able to:

- Represent vectors analytically and geometrically, and compute dot and cross products for presentations of lines and planes,
- Analyze vector functions to find derivatives, tangent lines, integrals, arc length, and curvature,
- Compute limits and derivatives of functions of 2 and 3 variables,
- Apply derivative concepts to find tangent lines to level curves and to solve optimization problems,
- Evaluate double and triple integrals for area and volume,
- Differentiate vector fields,
- Determine gradient vector fields and find potential functions,
- Evaluate line integrals directly and by the fundamental theorem, and
- Use technological tools such as computer algebra systems or graphing calculators for visualization and calculation of multivariable calculus concepts.

Course Contents:

Week	Topics	Remarks
1.	**Vectors and analytic geometry in space:** Coordinate system. Rectangular, cylindrical and spherical coordinates.	
2.	The dot product, the cross product. Equations of lines and planes.Quadric surfaces.	Assignment related to the topics
3.	Vector-valued functions: Vector-valued functions and space curves.	
4.	Derivatives and integrals of vector valued functions. Curvature, normal and bi-normal vectors.	Quiz
5.	**Multivariable functions and partial derivatives:** Functions of several variables. Limits and Continuity. Partial derivatives, composition and chain rule.	Assignment related to the topics
6.	Directional derivatives and the gradient vector, Implicit function theorem for several variables. Maximum and minimum values.	
7.	Optimization problems, Lagrange Multipliers	Quiz
8.	**Mid Term Exam**	
9.	**Multiple integrals:** Double integrals over rectangular domains and iterated integrals.	Quiz
10.	Non-rectangular domains, double integrals in polar coordinates.	Assignment related to the topics
11.	Triple integrals in rectangular, cylindrical and spherical coordinates	Quiz
12.	Applications of double and triple integrals.	Assignment related to the topics
13.	Change of variables in multiple integrals.	Quiz

14.	**Vector calculus:** Vector fields. Line integrals. Green's theorem.	Presentations
15.	Curl and divergence, Surface integrals over scalar and vector fields.	Assignment related to the topics
16.	Divergence theorem.	Presentations
17.	Stokes' theorem.	Presentations
18.	**Final Term Exam**	

Books Recommended

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

ALGEBRA-I (GROUP THEORY)

Credit Hour: 03(3-0) **Course Code: MATH-251**

Prerequisites: Elements of Set Theory and Mathematical Logic

Course Objectives:

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

Learning Outcomes: Demonstrate knowledge of basic concepts such as Abelian groups, normal subgroups, quotient groups and Permutations. Demonstrate knowledge of group homomorphisms and the role of homomorphism as a unifying principle in Group Theory. And to concentrate on Lagrange's theorem, some basic structure of algebra and uses.

Course Contents

Week	Topics	Remarks
1.	**Groups:** Definition of a group, subgroup,	
2.	subgroup generated by a set	Assignment related to the topics
3.	The cyclic groups, cosets	
4.	Lagrange's theorem	Quiz

5.	Normalizer centralizer. The center of a group	Assignment related to the topics
6.	Equivalence relation in a group, conjugacy classes	
7.	Normal subgroups, quotient group.	Quiz
8.	**Mid Term Exam**	
9.	**Group homomorphism's:** Homomorphism and isomorphism	Quiz
10.	Automorphism	Assignment related to the topics
11.	Kernel and image of homomorphism	Quiz
12.	Isomorphism theorems	Assignment related to the topics
13.	Permutation groups	Quiz
14.	The cyclic decomposition of a permutation group	Presentations
15.	Cayley's theorem	Assignment related to the topics
16.	Direct product of two groups and examples	Presentations
17.	Continue…	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. J. Rose, A Course on Group Theory, Cambridge University Press, 2012.
2. I. N. Herstein, Topics in Algebra, Xerox Publishing Company, 2nd edition, Wiley & Sons, 1975.
3. P. M. Cohn, Basic Algebra, John Wiley and Sons, London, 2003 edition.
4. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, 1986.
5. J. B. Fraleigh, A First Course in Abstract Algebra, Addison Wesley Publishing Company, 2002.
6. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
7. D. S. Dummit and R. M. Foote, Abstract Algebra, 3rd Edition, Addison-Wesley Publishing Company, 2004.

ALGEBRA-II (RING AND FIELDS)

Credit Hour: 03(3-0) **Course Code: MATH-301**

Prerequisites: Algebra I

Course Objectives:

This is a course in Advanced abstract algebra, which builds on the concepts learnt in Algebra I. The objectives of the course are to introduce students to the basic ideas and methods of modern algebra and enable them to understand the idea of a ring and an integral domain, and be aware

of examples of these structures in mathematics; appreciate and be able to prove the basic results of ring theory; appreciate the significance of unique factorization in rings and integral domains.
Learning Outcomes: Demonstrate understanding of the idea of a ring, field and an integral domain, and be aware of examples of these structures in mathematics. Appreciate and be able to prove the basic results of ring theory and field extensions. Appreciate the significance of unique factorization in rings and integral domains. Apply the theory in the course to solve a variety of problems at an appropriate level of difficulty. Demonstrate skills in communicating mathematics orally and in writing.

Course Contents:

Week	Topics	Remarks
1.	**Rings**: Definition, examples. Quadratic integer rings. Examples of non-commutative rings. The Hamilton quaternions	
2.	Polynomial rings. Matrix rings. Units, zero-divisors, nilpotents, idempotents. Subrings	Assignment related to the topics
3.	Ideals.Maximal and prime Ideals.	
4.	Left, right and two-sided ideals; Operations with ideals. The ideal generated by a set.	Quiz
5.	Quotient rings. Ring homomorphism	Assignment related to the topics
6.	The isomorphism theorems, applications	
7.	Finitely generated ideals. Rings of fractions	Quiz
8.	**Mid Term Exam**	
9.	**Integral Domain:** The Chinese remainder theorem	Quiz
10.	Divisibility in integral domains, greatest common divisor,	Assignment related to the topics
11.	least common multiple. Euclidean domains	Quiz
12.	The Euclidean algorithm. Principal ideal domains	Assignment related to the topics
13.	Prime and irreducible elements in an integral domain	Quiz
14.	Gauss lemma, irreducibility criteria for polynomials	Presentations
15.	Unique factorization domains. Finite fields	Assignment related to the topics
16.	Polynomials in several variables. Symmetric polynomials	Presentations
17.	The fundamental theorem of symmetric polynomials	Presentations
18.	**Final Term Exam**	

Books Recommended

1. J. Rose, A Course on Group Theory, Cambridge University Press, 2012.
2. I. N. Herstein, Topics in Algebra, Xerox Publishing Company, 2nd edition, Wiley & Sons, 1975.
3. P. M. Cohn, Basic Algebra, John Wiley and Sons, London, 2003 edition.
4. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, 1986.

5. J. B. Fraleigh, A First Course in Abstract Algebra, AddisonWesley Publishing Company, 2002.
6. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
7. D. S. Dummit and R. M. Foote, Abstract Algebra, 3rd Edition, Addison-Wesley Publishing Company, 2004.

ORDINARY DIFFERENTIAL EQUATIONS

Credit Hour: 03(3-0) **Course Code: MATH-304**
Prerequisites: Calculus I
Course Objectives:
Specific Objectives of course: To introduce students to the formulation, classification of differential equations and existence and uniqueness of solutions. To provide skill in solving initial value and boundary value problems. To develop understanding and skill in solving first and second order linear homogeneous and non homogeneous differential equations and solving differential equations using power series methods.

Learning Outcomes: Upon successful completion of Differential Equations, a student will be able to:

- Solve differential equations of first order using graphical, numerical, and analytical methods,
- Solve and apply linear differential equations of second order (and higher),
- Solve linear differential equations using the Laplace transform technique,
- Find power series solutions of differential equations, and
- Develop the ability to apply differential equations to significant applied and/or theoretical problems.

Upon successful completion of Theory of Ordinary Differential Equations, a student will be able to:

- Solve problems in ordinary differential equations, dynamical systems, stability theory, and a number of applications to scientific and engineering problems,
- Demonstrate their ability to write coherent mathematical proofs and scientific arguments needed to communicate the results obtained from differential equation models,
- Demonstrate their understanding of how physical phenomena are modeled by differential equations and dynamical systems,

- Implement solution methods using appropriate technology, and
- Investigate the qualitative behavior of solutions of systems of differential equations and interpret in the context of an underlying model.

Course Contents:

Week	Topics	Remarks
1.	**Preliminaries**: Introduction and formulation, classification of differential equations,	
2.	existence and uniqueness of solutions, introduction of initial value and boundary value problems	Assignment related to the topics
3.	**First order ordinary differential equations:** Basic concepts, formation and solution of differential equations.	
4.	Separable variables, Exact Equations, Homogeneous Equations,	Quiz
5.	Linear equations, integrating factors. Some nonlinear first order equations with known solution,	Assignment related to the topics
6.	differential equations of Bernoulli and Ricaati type, Clairaut equation, modeling with first-order ODEs,	
7.	Basic theory of systems of first order linear equations, Homogeneous linear system with constant coefficients, Non homogeneous linear system	Quiz
8.	**Mid Term Exam**	
9.	**Second and higher order linear differential equations**: Initial value and boundary value problems, Homogeneous and non-homogeneous equations	Quiz
10.	Superposition principle, homogeneous equations with constant coefficients, Linear independence and Wronskian	Assignment related to the topics
11.	Non-homogeneous equations, undetermined coefficients method, variation of parameters, Cauchy-Euler equation, Modeling.	Quiz
12.	**Sturm-Liouville problems:** Introduction to eigenvalues problem, adjoint and self adjoint operators,	Assignment related to the topics
13.	self adjoint differential equations, eigen values and eigen functions,	Quiz
14.	Sturm-Liouville (S-L) boundary value problems, regular and singular S-L problems, properties of regular S-L problems	Presentations
15.	**Series Solutions:** Power series, ordinary and singular points, Existence of power series solutions, power series solutions,	Assignment related to the topics
16.	types of singular points, Frobenius theorem, Existence of Frobenius series solutions, solutions about singular points,	Presentations
17.	The Bessel, modified Bessel Legendre and Hermite equations and their solutions**.**	Presentations
18.	**Final Term Exam**	

Books Recommended

1. Dennis G. Zill and Michael R., Differential equations with boundary-value problems by Cullin 7th Edition Brooks/Cole, 2009.
2. William E. Boyce and Richard C. Diprima, Elementary differential equations and boundary value problems, John Wiley & Sons, Inc, 9th Edition, 2008.
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.

ALGEBRA-III (LINEAR ALGEBRA)

Credit Hour: 03(3-0) **Course Code: MATH-351**

Prerequisites: Basic Algebra

Course Objectives:

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

Learning Outcomes: On successful completion of this course students will be able:

- To solve systems of linear equations by using Gaussian elimination to reduce the augmented matrix to row echelon form or to reduced row echelon form.
- To understand the basic ideas of vector algebra: linear dependence and independence and spanning;
- To apply the basic techniques of matrix algebra, including finding the inverse of an invertible matrix using Gauss-Jordan elimination;
- To know how to find the row space, column space and null space of a matrix, and be familiar with the concepts of dimension of a subspace and the rank and nullity of a matrix, and to understand the relationship of these concepts to associated systems of linear equations.
- To find the eigenvalues and eigenvectors of a square matrix using the characteristic polynomial and will know how to diagonalize a matrix when this is possible be able to recognize and invert orthogonal matrices be able to orthogonally diagonalize symmetric matrices be able to find the change-of-basis matrix with respect to two bases of a vector space be familiar with the notion of a linear transformation and its matrix.

Course Contents:

Week	Topics	Remarks
1.	**System of Linear Equations:** Representation in matrix form. Matrices. Operations on matrices.	
2.	Echelon and reduced echelon form. Inverse of a matrix (by elementary row operations).Solution of linear system.	Assignment related to the topics
3.	Gaussian elimination. Gauss-Jordan method.	
4.		Quiz
5.	**Determinants:** Permutations of order two and three and definitions of determinants of the same order.	Assignment related to the topics
6.	Computing of determinants. Definition of higher order determinants.	
7.	Properties. Expansion of determinants.	Quiz
8.	**Mid Term Exam**	
9.	**Vector Spaces:** Definition and examples, subspaces. Linear combination and spanning set.	Quiz
10.	Linearly Independent sets. Finitely generated vector spaces. Bases and dimension of a vector space.	Assignment related to the topics
11.	Operations on subspaces, Intersections, sums and direct sums of subspaces. Quotient Spaces. **Linear mappings:** Definition and examples.	Quiz
12.	Kernel and image of a linear mapping. Rank and nullity.	Assignment related to the topics
13.	Reflections, projections, and homotheties. Change of basis.	Quiz
14.	Eigen-values and eigenvectors. Theorem of Hamilton-Cayley.	Presentations
15.	**Inner product Spaces:** Definition and examples. Properties, Projection.	Assignment related to the topics
16.	Cauchy inequality. Orthogonal and orthonormal basis.	Presentations
17.	Gram Schmidt Process. Diagonalization	Presentations
18.	**Final Term Exam**	

Recommended Books:

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

COMPLEX ANALYSIS

Credit Hour: 03(3-0) **Course Code: MATH-354**

Prerequisites: Real Analysis I

Course Objectives:

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.

Learning Outcomes: Upon successful completion of Complex Analysis, a student will be able to:

- Represent complex numbers algebraically and geometrically,
- Define and analyze limits and continuity for complex functions as well as consequences of continuity,
- Apply the concept and consequences of analyticity and the Cauchy-Riemann equations and of results on harmonic and entire functions including the fundamental theorem of algebra,
- Analyze sequences and series of analytic functions and types of convergence,
- Evaluate complex contour integrals directly and by the fundamental theorem, apply the Cauchy integral theorem in its various versions, and the Cauchy integral formula, and represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.

Course Contents:

Week	Topics	Remarks
1.	**Introduction:** The algebra of complex numbers,	
2.	Geometric representation of complex numbers,	Assignment related to the topics
3.	Powers and roots of complex numbers.	
4.	**Functions of Complex Variables:** Definition, limit and continuity, Branches of functions, Differentiable and analytic functions.	Quiz
5.	The Cauchy-Riemann equations, Entire functions,	Assignment related to the topics
6.	Harmonic functions, Elementary functions: The exponential, Trigonometric,	
7.	Hyperbolic, Logarithmic and Inverse elementary functions, Open mapping theorem. Maximum modulus theorem.	Quiz
8.	**Mid Term Exam**	

9.	**Complex Integrals:** Contours and contour integrals,	Quiz
10.	Cauchy-Goursat theorem,	Assignment related to the topics
11.	Cauchy integral formula,	Quiz
12.	Lioville's theorem, Morerea's theorem.	Assignment related to the topics
13.	**Series:** Power series, Radius of convergence and analyticity,	Quiz
14.	Taylor's and Laurent's series, Integration and differentiation of power series Singularities,	Presentations
15.	Poles and residues: Zero, singularities, Poles and Residues, Types of singular points,	Assignment related to the topics
16.	Calculus of residues, contour integration, Cauchy's residue theorem with applications.	Presentations
17.	Mobius transforms, Conformal mappings and transformations.	Presentations
18.	**Final Term Exam**	

Books Recommended

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, 4th edition, 2003.
4. R. Remmert, Theory of Complex Functions, Springer-Verlag, 1991.
5. W. Rudin, Real and Complex Analysis, McGraw-Hill, 3rd edition, 1987.

INTEGRAL EQUATIONS

Credit Hour: 03(3-0) **Course Code: MATH-404**

Prerequisites: Ordinary Differential Equations

Course Objectives:

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

Learning Outcomes: On completion of the module the learner will be able to:

- use Fourier transforms for solving a wide range of differential and integral equations
- formulate and solve initial and boundary value problems for the heat and wave equations in spherical and cylindrical coordinates
- solve linear Volterra and Fredholm integral equations using appropriate methods

- understand the relationship between integral and differential equations and transform one type into another.

Course Contents:

Week	Topics	Remarks
1.	Linear integral equations of the first kind,	
2.	Linear integral equations of the second kind	Assignment related to the topics
3.	Relationship between differential equation and Volterra integral equation	
4.	Neumann series.	Quiz
5.	Fredholm Integral equation of the second kind with separable Kernels	Assignment related to the topics
6.	Eigenvalues and eigenvectors	
7.	Iterated functions.	Quiz
8.	**Mid Term Exam**	
9.	Quadrature methods.	Quiz
10.	Least square methods.	Assignment related to the topics
11.	Homogeneous integral equations of the second kind.	Quiz
12.	Fredholm integral equations of the first kind	Assignment related to the topics
13.	Fredholm integral equations of the second kind	Quiz
14.	Abel's integral equations	Presentations
15.	Hilbert Schmidt theory of integral equations with symmetric Kernels.	Assignment related to the topics
16.	Continue…	Presentations
17.	Regularization and filtering techniques.	Presentations
18.	**Final Term Exam**	

Books Recommended

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.

AFFINE AND EUCLIDEAN GEOMETRY

Credit Hours: 03(3-0) **Course Code: MATH-453**

Prerequisites: Linear Algebra

Specific Objectives of course: To familiarize mathematics students with the axiomatic approach to geometry from a logical, historical, and pedagogical point of view.

Learning Outcomes:

Upon successful completion of the course, students will understand the basic concepts of Affine Geometry, Affine spaces and Platonic Ployhedra.

Course Outline:

Week	Topics	Remarks
1.	**Vector spaces and affine geometry:** Collinearity of three points, ratio AB/BC.	
2.	Linear combinations and linear dependent set versus affine combinations and affine dependent sets.	Assignment related to the topics
3.	Classical theorems in affine geometry:	
4.	Thales, Menelaus, Ceva, Desargues. Affine subspaces, affine maps.	Quiz
5.	Dimension of a linear subspace and of an affine subspace.	Assignment related to the topics
6.	**Euclidean geometry:** Scalar product, Cauchy-Schwartz inequality.	
7.	norm of a vector	Quiz
8.	**Mid Term Exam**	
9.	distance between two points, angles between two non-zero vectors	Quiz
10.	Pythagoras theorem, parallelogram law, cosine and sine rules.	Assignment related to the topics
11.	Elementary geometric loci.	Quiz
12.	**Orthogonal transformations:** Isometries of plane (four types),	Assignment related to the topics
13.	Isometries of space (six types). Orthogonal bases.	Quiz
14.	Platonic polyhedral.	Presentations
15.	Euler theorem on finite planar graphs.	Assignment related to the topics
16.	Classification of regular polyhedra in space.	Presentations
17.	Isometries of regular polygons and regular polyhedra.	Presentations
18.	**Final Term Exam**	

Recommended Books:

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

MAJOR COURSES

Number Theory

Credit Hour: 03(3-0) **Course Code: MATH-152**

Prerequisites: Discrete Structures

Course Objectives:

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.

Learning Outcomes: Upon successful completion of Number Theory, a student will be able to:

- Define and interpret the concepts of divisibility, congruence, greatest common divisor, prime, and prime-factorization,
- Apply the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues,
- Formulate and prove conjectures about numeric patterns, and
- Produce rigorous arguments (proofs) centered on the material of number theory, most notably in the use of Mathematical Induction and/or the Well Ordering Principal in the proof of theorems.

Course Contents:

Week	Topics	Remarks
1.	**Preliminaries:** Well-ordering principle. Principle of finite induction.	
2.	**Divisibility theory:** The division algorithms. Basis representation theorem.	Assignment related to the topics
3.	Prime and composite numbers. Canonical decomposition. The greatest common divisor	
4.	The Euclidean algorithm. The fundamental theorem of arithmetic. Least common multiple.	Quiz
5.	**Linear Diophantine equations**: Congruences. Linear congruences.	Assignment related to the topics
6.	System of linear congruences.	
7.	The Chinese remainder theorem. Divisibility tests. Solving polynomial congruences.	Quiz
8.	**Mid Term Exam**	
9.	Fermat's and Euler's theorems. Wilson's theorem.	Quiz
10.	**Arithmetic functions:** Euler's phi-function	Assignment related to the topics
11.	The functions of J and sigma. The Mobius function	Quiz
12.	The sieve of Eratosthenes. Perfect numbers. Fermat and Mersenne primes.	Assignment related to the topics

13.	**Primitive Roots and Indices:** The order of an integer mod n. Primitive roots for primes.	Quiz
14.	Composite numbers having primitive roots. Quadratic residues: Legendre symbols and its properties	Presentations
15.	The quadratic reciprocity law. Quadratic	Assignment related to the topics
16.	congruences with composite moduli. Pythagorean triples.	Presentations
17.	Representing numbers as sum of two squares.	Presentations
18.	**Final Term Exam**	

Books Recommended

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

VECTOR AND TENSOR ANALYSIS

Credit Hours:03(3-0) **Course Code: MATH-252**

Prerequisite(s): Calculus I & II

Background and Goals:

This course shall assume background in calculus. It covers basic principles of vector analysis, which are used in mechanics.

Learning Outcomes: Upon completion the course, students will be able to solve different problem in vector analysis. Students will also be familiar with tensor analysis as well. Students can easily use and successfully apply green's theorem, stock's theorem and Gauss divergence theorem to other science and engineering problems.

Contents:

Week	Topics	Remarks
1.	3-D vectors, basic notions and definitions, dot and cross product, linear dependence and independence	
2.	vectors as quantities transforming under rotations with notation,	Assignment related to the topics
3.	scalar-and vector-triple products, scalar- and vector-point functions,	
4.	differentiation and integration of vectors	Quiz

5.	line integrals, path independence, surface integrals	Assignment related to the topics
6.	volume integrals, gradient	
7.	divergence and curl with physical significance and applications	Quiz
8.	**Mid Term Exam**	
9.	vector identities, Green's theorem in a plane	Quiz
10.	divergence theorem, Stokes' theorem	Assignment related to the topics
11.	coordinate systems and their bases, the spherical-polar- and the cylindrical-coordinate meshes,	Quiz
12.	summation convention, kronecker delta, Levi-Caveat symbol, alternating symbol, relation between alternating symbol and kronecker delta	Assignment related to the topics
13.	tensors of first, second and higher orders, algebra of tensors	Quiz
14.	contraction of tensor, quotient theorem, quotient theorem, symmetric and skew-symmetric tensors	Presentations
15.	invariance property, isotropic tensors, differentiation of tensors, application of tensors in modeling anisotropic systems	Assignment related to the topics
16.	study of physical tensors (moment of inertia, index of refraction, etc.),	Presentations
17.	diagnolization of inertia tensor as aligning coordinate frame with natural symmetries of the system	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Bourne DE, Kendall PC, *Vector Analysis and Cartesian Tensors* (2nd edition), Thomas Nelson, 1992.
2. Shah NA, *Vector and Tensor Analysis*, A-One Publishers, Lahore, 2005.
3. Smith GD, *Vector Analysis*, Oxford University Press, Oxford
4. Spiegel MR, *Vector Analysis*, McGraw Hill, New York, 1974.
5. Murray Spiegel and Seymour Lipschutz, Schaum's Outline of Vector Analysis, 2nd edition, 2009.

BASIC TOPOLOGY

Credit Hour: 03(3-0) **Course Code: MATH-253**

Prerequisites: Set Theory

Course Objectives:

The aim of this course is to introduce the students to metric spaces and topological spaces. They would be able to determine whether a function defined on a metric or topological space is continuous or not and what homeomorphisms are.

Learning Outcomes: After completion of this course, they would be familiar with some important concepts like open set, closed set, interior, limit point etc.

Course Contents:

Week	Topics	Remarks
1.	**Metric Spaces:** Metric on sets, Open balls	
2.	open sets and neighborhoods	Assignment related to the topics
3.	Interior, Closed sets, closure in metric spaces	
4.	subspaces, sequences in metric spaces.	Quiz
5.	**Topological spaces: Topologies and topological spaces,** Examples; open and closed subsets	Assignment related to the topics
6.	Continue…	
7.	Bases and sub-bases, neighborhoods in topological spaces	Quiz
8.	**Mid Term Exam**	
9.	Limit points and accumulation points.	Quiz
10.	Interior, Closure, Dense subsets,	Assignment related to the topics
11.	Frontier and exterior,	Quiz
12.	subspaces, relative closure.	Assignment related to the topics
13.	**Continuity and Homeomorphism:** Continuity in Metric Spaces	Quiz
14.	Continuity in Topological Spaces	Presentations
15.	Continue…	Assignment related to the topics
16.	Homeomorphism	Presentations
17.	Continue…	Presentations
18.	**Final Term Exam**	

Books Recommended

1. J. Kelly, General Topology, Springer, 2005.
2. K. Janich, Topology, Springer, 1994.
3. J. Hocking, G. Young, Topology, Dover Publications, 1961.
4. J. R. Munkres, Topology - A First Course, Prentice-Hall, 2003.

5. G. Simmons, Topology and modern analysis, McGraw-Hill, 1963.
6. S. Lipschutz, General Topology, McGraw-Hill, 2004.
7. J. Dugundji, Topology, Allyn and Bacon, 1966.

PROBABILITY THEORY

Credit Hour: 03(3-0) **Course Code: MATH-302**

Prerequisites: Intermediate level Mathematics

Course Objectives:

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

Learning Outcomes: Upon successful completion of Probability, a student will be able to:

- Recognize the role of probability theory, descriptive statistics and inferential statistics in the applications of many different fields,
- Define and illustrate the concepts of sample space, events and compute the probability and conditional probability of events, and use Bayes' Rule,
- Define, illustrate and apply the concepts of discrete and continuous random variables, the discrete and continuous probability distributions and the joint probability distributions,
- Apply Chebyshev's theorem,
- Define, illustrate and apply the concept of the expectation to the mean, variance and covariance of random variables,
- Define, illustrate and apply certain frequently used discrete and continuous probability distributions, and
- Illustrate and apply theorems concerning the distributions of functions of random variables and the moment-generating functions.

Course Contents:

Week	Topics	Remarks
1.	**Finite probability spaces:** Basic concept, probability and related frequency, combination of events, examples, Independence, Random variables, Expected value.	

2.	Standard deviation and Chebyshev's inequality. Independence of random variables.	Assignment related to the topics
3.	Multiplicativity of the expected value	
4.	Additivity of the variance	Quiz
5.	Discrete probability distribution	Assignment related to the topics
6.	**Probability as a continuous set function:** sigma-algebras, examples.	
7.	Continuous random variables	Quiz
8.	**Mid Term Exam**	
9.	Expectation and variance	Quiz
10.	Normal random variables	Assignment related to the topics
11.	Continuous probability distribution	Quiz
12.	Continue…	Assignment related to the topics
13.	**Applications:** de Moivre-Laplace limit theorem	Quiz
14.	Week and strong law of large numbers	Presentations
15.	The central limit theorem,	Assignment related to the topics
16.	Markov chains and continuous	Presentations
17.	Markov process.	Presentations
18.	**Final Term Exam**	

Books Recommended

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

NUMERICAL ANALYSIS

Credit Hour: 03(3-0) **Course Code: MATH-303**

Prerequisites: Calculus I

Course Objectives:

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.

Learning Outcomes: Upon successful completion of Numerical Analysis I, a student will be able to:

- Derive numerical methods for approximating the solution of problems of continuous mathematics,
- Analyze the error incumbent in any such numerical approximation,
- Implement a variety of numerical algorithms using appropriate technology, and
- Compare the viability of different approaches to the numerical solution of problems arising in roots of solution of non-linear equations, interpolation and approximation, numerical differentiation and integration, solution of linear systems.

Course Contents:

Week	Topics	Remarks
1.	**Error analysis:** Floating point arithmetic	
2.	approximations and errors	Assignment related to the topics
3.	**Methods for the solution of nonlinear equations**: Bisection method,	
4.	regula-falsi method, fixed point iteration method,	Quiz
5.	Newton-Raphson method, secant method, error analysis for iterative methods.	Assignment related to the topics
6.	**Interpolation and polynomial approximation:** Lagrange interpolation, Newton's divided difference formula,	
7.	forward, backward and centered difference formulae, interpolation with a cubic spline,	Quiz
8.	**Mid Term Exam**	
9.	Hermite interpolation, least squares approximation.	Quiz
10.	**Numerical differentiation**: Forward, backward and central difference formulae, Richardson's extrapolation.	Assignment related to the topics

11.	**Numerical integration:** Rectangular rule, trapezoidal rule, Simpson's 1/3 and 3/8 rules,	Quiz
12.	Boole's and Weddle's rules, Newton-Cotes formulae, Gaussian quadrature.	Assignment related to the topics
13.	**Numerical solution of a system of linear equations**: Direct methods: Gaussian elimination method, Gauss-Jordan method;	Quiz
14.	matrix inversion; LU-factorization;	Presentations
15.	Doolittle's, Crout's and Cholesky's methods,	Assignment related to the topics
16.	Iterative methods: Jacobi, Gauss-Seidel and SOR.	Presentations
17.	The use of software packages/programming languages for above mentioned topics.	Presentations
18.	**Final Term Exam**	

Books Recommended

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.

REAL ANALYSIS-I

Credit Hour: 03(3-0) **Course Code: MATH-305**

Prerequisites: Calculus I

Course Objectives:

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

Learning Outcomes: Upon successful completion of Real Analysis I, students will be able to:

- Describe the real line as a complete, ordered field,
- Determine the basic topological properties of subsets of the real numbers,
- Use the definitions of convergence as they apply to sequences, series, and functions,
- Determine the continuity, differentiability, and integrability of functions defined on subsets of the real line,
- Apply the Mean Value Theorem and the Fundamental Theorem of Calculus to problems in the context of real analysis, and
- Produce rigorous proofs of results that arise in the context of real analysis.

Course Contents:

Week	Topics	Remarks
1.	**Number Systems:** Ordered fields.	
2.	Rational, real and complex numbers.	Assignment related to the topics
3.	Archimedean property,	
4.	supremum, infimum and completeness.	Quiz
5.	**Topology of real numbers:** Convergence, completeness, completion of real numbers.	Assignment related to the topics
6.	Open sets, closed sets, compact sets.	
7.	Heine Borel Theorem. Connected sets.	Quiz
8.	**Mid Term Exam**	
9.	**Sequences and Series of Real Numbers**: Limits of sequences, algebra of limits.	Quiz
10.	Bolzano Weierstrass Theorem. Cauchy sequences, liminf, limsup.	Assignment related to the topics
11.	Limits of series, convergences tests, absolute and conditional convergence. Power series.	Quiz
12.	**Continuity:** Functions, continuity and compactness, existence of minimizers and maximizers,	Assignment related to the topics
13.	uniform continuity. Continuity and connectedness,	Quiz

14.	Intermediate mean Value Theorem. Monotone functions and discontinuities.	Presentations
15.	**Differentiation:** Mean Value Theorems,	Assignment related to the topics
16.	L'Hopital's Rule,	Presentations
17.	Taylor's theorem, Maclaurin theorem	Presentations
18.	**Final Term Exam**	

Books Recommended

1. G. Boros, V. Moll, Irresistible Integrals: Symbolics, Analysis an Experiments in the Evaluation of Integrals, Cambridge University Press, 2004.
2. B. S. Thomson, J. B. Bruckner and A. M. Bruckner, Elementary Real Analysis, 2nd Ed. 2008.
3. J. Borwein, D. Bailey, R. Girgenson, Experimentation in Mathematics: Computational Paths to discovery, Wellesley, MA, A.K. Peters, 2004.
4. G. Bartle , R. Sherbert , Introduction to Real Analysis, 3rd edition, John Wiley, New York, 1999.
5. S. Lang, Analysis I, Addison-Wesley Publ. Co., Reading, Massachusetts, 1968.
6. W. Rudin, Principles of Mathematical Analysis, 3rd ed., Mc.Graw-Hill, 1976.

GENERAL TOPOLOGY

Credit Hour: 03(3-0) **Course Code: MATH-306**

Prerequisites: Basic Topology

Course Objectives: The aim of this course is to introduce the students to metric spaces and topological spaces.

Learning Outcomes: After completion of this course, they would be familiar with some important concepts like compactness, connectedness, completeness etc.

Course Contents:

Week	Topics	Remarks
1.	Topological Spaces: Review of basic concepts	
2.	Bases and Sub-basis, Local Basis,	Assignment related to the topics
3.	Continuous Maps, Open and Closed Maps,	
4.	Induced Topology	Quiz
5.	Topological Product, Hausdorff Spaces,	Assignment related to the topics
6.	Regular Spaces and Completely Regular Spaces,	
7.	Normal Spaces, Metric Spaces	Quiz

8.	**Mid Term Exam**	
9.	Continuity in Metric Spaces, Properties of Metric Spaces.	Quiz
10.	Metrizability, Compact Spaces	Assignment related to the topics
11.	Open Cover,	Quiz
12.	Finite Intersection Property	Assignment related to the topics
13.	Locally Compact Spaces	Quiz
14.	Compactness in Metric Spaces	Presentations
15.	Connected Spaces, Topological Product of Connected Spaces	Assignment related to the topics
16.	Locally Connected Spaces, Pathwise and Arcwise Connected Spaces.	Presentations
17.	Complete Metric Spaces, Concept of Category and Bair's Category Theorem.	Presentations
18.	**Final Term Exam**	

Books Recommended

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

PARTIAL DIFFERENTIAL EQUATIONS

Credit Hour: 03(3-0) **Course Code: MATH-352**

Prerequisites: Ordinary Differential Equations

Course Objectives:

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.

Learning Outcomes: Upon successful completion of Partial Differential Equations, a student will:

- Be familiar with the modeling assumptions and derivations that lead to PDEs,
- Recognize the major classification of PDEs and the qualitative differences between the classes of equations, and
- Be competent in solving linear PDEs using classical solution methods.

Course Contents:

Week	Topics	Remarks
1.	**First order PDEs:** Introduction, formation of PDEs,	
2.	solutions of PDEs of first order, The Cauchy's problem for quasilinear first order PDEs,	Assignment related to the topics
3.	First order nonlinear equations, Special types of first order equations	
4.	**Second order PDEs:** Basic concepts and definitions, Mathematical problems, Linear operators,	Quiz
5.	Superposition, Mathematical models: The classical equations, the vibrating string, the vibrating membrane, conduction of heat solids,	Assignment related to the topics
6.	canonical forms and variable, PDEs of second order in two independent variables with constant and variable coefficients,	
7.	Cauchy's problem for second order PDEs in two independent variables	Quiz
8.	**Mid Term Exam**	
9.	**Methods of separation of variables:** Solutions of elliptic, parabolic and hyperbolic PDEs in Cartesian and cylindrical coordinates	Quiz
10.	Continue…	Assignment related to the topics
11.	**Laplace transform:** Introduction and properties of Laplace transform, transforms of elementary functions,	Quiz
12.	periodic functions, error function and Dirac delta function, inverse Laplace transform, convolution theorem,	Assignment related to the topics
13.	solution of PDEs by Laplace transform, Diffusion and wave equations	Quiz
14.	**Fourier transforms:** Fourier integral representation, Fourier sine and cosine representation,	Presentations
15.	Fourier transform pair, transform of elementary functions and Dirac delta function,	Assignment related to the topics
16.	finite Fourier transforms, solutions of heat, wave and Laplace equations by Fourier transforms.	Presentations
17.	Continue…	Presentations
18.	**Final Term Exam**	

Books Recommended

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

CLASSICAL MECHANICS

Credit Hour: 04(4-0) **Course Code: MATH-353**

Prerequisites: Calculus I, Basic Physics

Course Objectives:

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

Learning Outcomes: On successful completion of the course, students will be able to use the techniques of calculus of variation to find an optimal system from a given system. Apart this, students will be able to find Lagrangian and Hamiltonian for a given mechanical system.

Course Contents:

Week	Topics	Remarks
1.	**Kinematics:** Rectilinear motion of particles. Uniform rectilinear motion, uniformly accelerated rectilinear motion.	
2.	Curvilinear motion of particle, rectangular components of velocity and acceleration.	Assignment related to the topics
3.	Tangential and normal components. Radial and transverse components. Projectile motion.	
4.	**Kinetics:** Work, power, kinetic energy, conservative force fields. Conservation of energy, impulse, torque.	Quiz
5.	Conservation of linear and angular momentum. Non-conservative forces.	Assignment related to the topics
6.	**Central Forces and Planetary Motion:** Central force fields, equations of motion, potential energy, orbits.	
7.	Kepler's law of planetary motion. Apsides and apsidal angles for nearly circular orbits. Motion in an inverse square field.	Quiz

8.	**Mid Term Exam**	
9.	**Planer Motion of Rigid Bodies:** Introduction to rigid and elastic bodies, degree of freedom, translations, rotations, instantaneous axis and center of rotation, motion of the center of mass.	Quiz
10.	Lagrangian Mechanics, Lagrange's equations,	Assignment related to the topics
11.	Conservation laws, ignorable co-ordinates,	Quiz
12.	Explicit form of Lagranges equation in terms of tensors	Assignment related to the topics
13.	Hamiltons principle, principle of least action	Quiz
14.		Presentations
15.	Hamiltons equations of motion	Assignment related to the topics
16.	Hamilton-Jacobi Method.	Presentations
17.	Poisson Brackets (P.Bs); Poissons theorem;	Presentations
18.	Solution of mechanical problems by algebraic technique based on (P.Bs).	
19.	Small oscilations and normal modes,	

Books Recommended

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

REAL ANALYSIS-II

Credit Hour: 03(3-0) **Course Code: MATH-355**

Prerequisites: Real Analysis I

Course Objectives:

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.

Learning Outcomes: Upon successful completion of Real Analysis II, a student will be able to:

- Determine the Riemann integrability and the Riemann-Stieltjes integrability of a bounded function and prove a selection of theorems concerning integration,
- Recognize the difference between pointwise and uniform convergence of a sequence of functions,
- Illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability, and integrability, and
- Illustrate the convergence properties of power series.

Course Contents:

Week	Topics	Remarks
1.	**The Riemann Integrals:** Definition and existence of integrals.	
2.	Properties of integrals.	Assignment related to the topics
3.	Fundamental theorem of calculus and its applications	
4.	Change of variable theorem. Integration by parts.	Quiz
5.	**Functions of Bounded Variation:** Definition and examples	Assignment related to the topics
6.	Properties of functions of bounded variation. Riemann-Stieltjes Integral and related results	
7.	**Improper Integrals:** Types of improper integrals (theoretical aspects)	Quiz
8.	**Mid Term Exam**	
9.	tests for convergence of improper integrals.	Quiz
10.	Continue…	Assignment related to the topics
11.	Beta and gamma functions.	Quiz
12.	Continue…	Assignment related to the topics
13.	Absolute and conditional convergence of improper integrals.	Quiz
14.	**Sequences and Series of Functions:** Power series, definition of point-wise and uniform convergence. Pointwise convergence	Presentations
15.	Uniform convergence and continuity	Assignment related to the topics
16.	Uniform convergence and differentiation.	Presentations
17.	Properties and examples of uniform convergence.	Presentations
18.	**Final Term Exam**	

Books Recommended

1. K. R. Davidson and A. P. Donsig, Real Analysis with Real Applications, Prentice Hall Inc., Upper Saddle River, 2002.
2. G. Bartle , R. Sherbert , Introduction to Real Analysis, 3rd edition, John Wiley, New York, 1999.
3. S. Lang, Analysis I, II, Addison-Wesley Publ. Co., Reading,Massachusetts,1968,1969.

4. W. Rudin, Principles of Mathematical Analysis, 3rd Ed., McGraw-Hill, 1976.
5. G. B. Folland, Real Analysis, 2nd Edition, John Wiley and Sons, New York, 1999.
6. E. Hewitt and K. Stromberg, Real and Abstract Analysis, Springer-Verlag, Berlin Heidelberg New York, 1965.
7. H. L. Royden, Real Analysis, 3rd Edition, Macmillan, New York, 1988.

FUNCTIONAL ANALYSIS

Credit Hour: 03(3-0) **Course Code: MATH-401**

Prerequisites: Real Analysis I, General Topology, Linear Algebra

Course Objectives:

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.

Learning Outcomes: Upon completion of functional analysis, students will be able to discuss various problems in different space: vector space, inner product space and Hilbert Spaces.

Course Contents:

Week	Topics	Remarks
1.	**Metric Space:** Review of metric spaces,	
2.	Convergence in metric spaces,	Assignment related to the topics
3.	Complete metric spaces,	
4.	Dense sets and separable spaces, No-where dense sets,	Quiz
5.	**Normed Spaces:** Normed linear spaces,	Assignment related to the topics
6.	Banach spaces,	
7.	Equivalent norms,	Quiz
8.	**Mid Term Exam**	
9.	Linear operator,	Quiz
10.	Bounded and unbounded operators	Assignment related to the topics
11.	Finite dimensional normed spaces, ,	Quiz
12.	Continuous and bounded linear operators	Assignment related to the topics
13.	Dual spaces and its examples,	Quiz
14.	**Inner Product Spaces:** Definition and examples, Orthonormal sets and bases,	Presentations
15.	Annihilators and projections, importance of orthonrmal sets, projection theorem	Assignment related to the topics
16.	Linear functionals on Hilbert spaces.	Presentations
17.	Reflexivity of Hilbert spaces.	Presentations
18.	**Final Term Exam**	

Books Recommended

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

MATHEMATICAL METHODS

Credit Hours: 03(3-0) **Course Code: MATH-454**

Prerequisites: Calculus III, ODE

Specific Objectives of course: The main objective of this course is to provide the students with a range of mathematical methods that are essential to the solution of Advanced problems encountered in the fields of applied physics and engineering.

Learning Outcomes: This course will prepare the students with mathematical tools and techniques that are required in Advanced courses offered in the applied physics and engineering programs.

Course Outline:

Week	Topics	Remarks
1.	**Fourier Methods:** The Fourier transforms.	
2.	Continue…	Assignment related to the topics
3.	Fourier analysis of the generalized functions.	
4.	Continue…	Quiz
5.	The Laplace transforms.	Assignment related to the topics
6.	Hankel transforms for the solution of PDEs and their application to boundary value problems.	
7.	Green's Functions and Transform Methods:	Quiz
8.	**Mid Term Exam**	
9.	Expansion for Green's functions.	Quiz
10.	Transform methods.	Assignment related to the topics
11.	Closed form Green's functions.	Quiz
12.	**Variational Methods:** Euler-Lagrange equations.	Assignment related to the topics

13.	Integrand involving one, two, three and n variables. Special cases of Euler-Lagrange's equations.	Quiz
14.	Necessary conditions for existence of an extremum of a functional. Constrained maxima and minima.	Presentations
15.	**Perturbation Techniques:** Perturbation methods for algebraic equations.	Assignment related to the topics
16.	Perturbation methods for differential equations.	Presentations
17.	Continue…	Presentations
18.	**Final Term Exam**	

Recommended Books:

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

RESEARCH PROJECT

Credit Hour: 03(3-0) **Course Code: MATH-499**

With accompanying written report and presentation

BS Mathematics Elective Courses

MATHEMATICAL MODELING

Credit Hour: 03(3-0) **Course Code: MATH-403**
Prerequisite(s): ODE, PDE.
Course Objectives:

The aim of this course is to: (1) Teach students how to mathematically model engineering/ real world problems and (2) Teach students how to use computer tools to solve the resulting mathematical models. The computer tool used is MATLAB and Maple and the focus will be on developing and solving models of problems encountered in engineering/ real world phenomenon.
Learning Outcomes: After completing the course, students are expected to construct and solve both analytically and numerically mathematical models obtained from various real world phenomenon.

Contents:

Week	Topics	Remarks
1.	Concept of models, modeling and simulation functions,	
2.	Continue	Assignment related to the topics
3.	**ODE:** modeling with first order differential equations: Newton's law of cooling,	
4.	radioactive decay, Growth and decay problems,	Quiz
5.	half-life, motional in the gravitational field,	Assignment related to the topics
6.	Modeling with 2^{nd} order differential equation: Vibrations,	
7.	Modeling with system of 1^{st} order differential equations.	Quiz
8.	**Mid Term Exam**	
9.	**PDE:** Methodology of Mathematical modeling,	Quiz
10.	objective, background, approximation and idealization,	Assignment related to the topics
11.	model validation, compounding,	Quiz
12.	modeling waves phenomenon (Wave equation)	Assignment related to the topics
13.	Modeling the heat equation	Quiz
14.	Modeling the potential equation (Laplace equation	Presentations
15.	Equation of continuity,	Assignment related to the topics
16.	Application in fluid Mechanics.	Presentations
17.	Continue	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Giordano F.R. Weir M.D. Differential Equations, A modeling Approach, Addison-Weslly, Reading, Ma, USA, 2001
2. Zill, D.G. Cullen, M.R. Differential Equation with boundary Value Problem, 2003.
3. Erwin Kreszig, Advanced Engineering Mathematics, John Willey and Sons, 2001.
4. Myint U.T. Debnath L, Partial Differential Equations for Scientist and Engineers 3rd Ed North Holland, Amsterdam. 1987.

FUZZY SET THEORY AND APPLICATIONS

Credit Hour: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): Algebra I, Algebra II

Aims and Objectives

The aim of the course is to introduce fuzzy set theory and their mathematical properties. This is designed for graduate students and the graduate student will learn the basic properties of fuzzy set theory and they will able to apply fuzzy set theory to algebraic structures, Differential equations and partial differential equations.

Learning Outcomes: On successful completion of this course students will be able to

Gain the main subject of fuzzy sets learns crips and fuzzy set theory and to decide the difference between crips set and fuzzy set theory. Moreover, the course aim is to make calculation on fuzzy set theory and to gain the methods of fuzzy logic. Recognize fuzzy semigroups and fuzzy ideals using membership function. Further, to make applications on Fuzzy membership function and fuzzy set theory.

Course Contents

Week	Topics	Remarks
1.	**Set Theory review:** Sets, Operation of Sets, Characteristics of Crisp Set.	
2.	**Fuzzy Sets**: Brief History of Fuzzy set, Introduction of Fuzzy sets,	Assignment related to the topics
3.	Examples of fuzzy sets,	
4.	Properties of Fuzzy sets.	Quiz
5.	Applications of Fuzzy sets in other fields.	Assignment related to the topics
6.	**Standard Operation of Fuzzy Sets:** Fuzzy Complement, Fuzzy Union,	
7.	Fuzzy Intersection Other Operations in Fuzzy Set.	Quiz
8.	**Mid Term Exam**	
9.	**Fuzzy Relation and Composition:** Crisp Relation,	Quiz
10.	Properties of Relation on a Single Set,	Assignment related to the topics
11.	Fuzzy Relation and Extension of Fuzzy Set,	Quiz

12.	Properties of Fuzzy Relations,	Assignment related to the topics
13.	Fuzzy Equivalence Relations.	Quiz
14.	**Fuzzy Ideals of Semigroups :** Review of ideals of semigroups, Definitions of Fuzzy Left,	Presentations
15.	Fuzzy right and Fuzzy two sided ideals of semigroups,	Assignment related to the topics
16.	Fuzzy generalized bi-ideals,	Presentations
17.	Fuzzy bi-ideals, Fuzzy interior ideals and Fuzzy quasi-ideals.	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer Berlin Heidelberg NewYork, 2005.
2. J. N. Mordeson, D. S. Malik, N. Kuroki, Fuzzy Semigroups, Springer-Verlag Berlin Heidelberg, 2003.
3. H.-J. Zimmermann, *Fuzzy Set Theory and its Applications*, 3rd edition, International Series in Management Science Operation Research, Kluwer-Nijhoff Publishing, Dordrecht, 1988.
4. J.M. Howie, *An Introduction to Semigroup Theory*, Academic Press, London, 1976.

FLUID MECHANICS

Credit Hours: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): Mechanics or Classical Mechanics or Analytical Mechanics.

Objectives: To know the fundamentals of Fluid Mechanics and its applications.

Learning Outcomes: Upon successful completion of the course, students will be able to use computational aspect for solving diffusion equation.

Contents:

Week	Topics	Remarks
1.	Introduction, Real fluids and ideal fluids,	
2.	velocity of a fluid at a point,	Assignment related to the topics
3.	streamlines and path lines,	
4.	steady and unsteady flows	Quiz
5.	velocity potential,	Assignment related to the topics
6.	vorticity vector,	
7.	local and particle rates of change,	Quiz
8.	**Mid Term Exam**	
9.	equation of continuity.	Quiz

10.	Acceleration of a fluid,	Assignment related to the topics
11.	conditions at a rigid boundary,	Quiz
12.	general analysis of fluid motion.	Assignment related to the topics
13.	Euler's equations of motion,	Quiz
14.	Bernoulli's equation steady motion under conservative body forces,	Presentations
15.	some potential theorems,	Assignment related to the topics
16.	Impulsive motion	Presentations
17.	Sources, sinks and doublets	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Chorlton, F., Textbook of fluid Dynamics, CBS Publishers & Distributors Pvt. Ltd., 2004.
2. Batchelor, G.K., An Introduction to Fluid Dynamics, Cambridge University Press, 2000.
3. Thomson, M., Theoretical Hydrodynamics, Macmillan Press, 1979.
4. Jaunzemics, W, Continuum Mechanic, Machmillan Company, 1967.
5. Landau, L.D., and Lifshitz, E.M., Fluid Mehanics, Pergamon Press, 1966.

DYNAMICAL SYSTEMS

Credit Hours: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): Ordinary Differential Equations, Real Analysis, Linear Algebra, Mathematical Modeling

Objectives:

In mathematics, a dynamical system is a system in which a function describes the time dependence of a point in a geometrical space. Examples include the mathematical models that describe the swinging of a clock pendulum, the flow of water in a pipe, and the number of fish each spring time in a lake. The aim of this course is to familiarize students with dynamical system. It uses notions from Real Analysis, Linear Algebra.

Learning Outcomes: Since this subject is widely used is many branches of Mathematics e.g. Fluid Mechanics, Mathematics Biology, Chemical Kinematics, Epidemiology, Physics etc. Therefore, upon successful completion students will be able tosolve such dynamical system.

Course outline:

Week	Topics	Remarks
1.	**Linear Systems**: Basic tools, Phase space, phase portrait, trajectories, Uncoupled Linear Systems,	

2.	Diagonalization, Exponentials of Operators, The Fundamental Theorem for Linear Systems,	Assignment related to the topics
3.	Complex eigenvalues, Multiple eigenvalues, Non-homogeneous linear systems,	
4.	**Nonlinear Systems:** Local Theory: Some Preliminary Concepts and Definitions,	Quiz
5.	The Fundamental Existence-Uniqueness Theorem, Dependence on Initial Conditions and Parameters, The Maximal Interval of Existence,	Assignment related to the topics
6.	The Flow Defined by a Differential Equation, Linearization, The Stable Manifold Theorem, The Hartman-Grobman Theorem,	
7.	Stability and Lyapunov Functions, Saddles, Nodes, Foci and Centers Non-hyperbolic Critical Points in R2, Center Manifold Theory.	Quiz
8.	**Mid Term Exam**	
9.	**Nonlinear Systems Global Theory**: Dynamical Systems and Global Existence Theorems,	Quiz
10.	Limit Sets and Attractors, Periodic Orbits, Limit Cycles and Separatrix Cycles,	Assignment related to the topics
11.	The Poincare Map, The Stable Manifold Theorem for Periodic Orbits,	Quiz
12.	Hamiltonian Systems with Two Degrees of Freedom ,	Assignment related to the topics
13.	The Poincare-Bendixson Theory in R2 , Lienard Systems, Bendixson's Criteria.	Quiz
14.	**Bifurcation Theory:** Structural Stability and Peixoto's Theorem, Bifurcations at Non-hyperbolic Equilibrium Points,	Presentations
15.	Hopf Bifurcations and Bifurcations of Limit Cycles from multiple focus	Assignment related to the topics
16.	Bifurcations at Non-hyperbolic Periodic Orbits	Presentations
17.	Homoclinic Bifurcations, Melnikov's Method, Global Bifurcations of Systems in R2	Presentations
18.	**Final Term Exam**	

References:

1. Lawrence Perko, Differential Equations and Dynamical Systems, Springer-Verlag New York, Inc. 2nd 1996
2. J. P .Lassale, The Stability of Dynamical System, Brown University, Hamilton Press Berlin, New Jersey, USA.
3. Hal. L . Smith, Horst R. Thieme, Dynamical System and Population Persistence, Graduate Study in Mathematics Vol: 118, American Mathematical Society, Providence Rhode Island.

NUMERICAL METHODS

Credit Hours: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): NumericalAnalysis.

Objectives:

- To gain knowledge on numerical and computational techniques used in solving common engineering problems.
- To understand the advantages and disadvantages of the different methods and to be able to choose adequate methods for different classes of problems.
- To be able to formulate a solution strategy for manual or computer implementation.

Learning Outcomes: Upon successful completion of Numerical Analysis II, a student will be able to:

- Derive numerical methods for approximating the solution of problems of continuous mathematics,
- Analyze the error incumbent in any such numerical approximation,
- Implement a variety of numerical algorithms using appropriate technology, and
- Compare the viability of different approaches to the numerical solution of problems arising in roots of solution of non-linear equations, interpolation and approximation, numerical differentiation and integration, solution of linear systems.

Contents:

Week	Topics	Remarks
1.	Differentiation and integration in multi-dimension.	
2.	Ordinary differential equations: Predictor methods,	Assignment related to the topics
3.	Modified Eulers method,	
4.	Truncation error and stability,	Quiz
5.	The Taylor series method,	Assignment related to the topics
6.	Runge-Kutta methods	
7.	Differential equations of higher order: System of differential equations;	Quiz
8.	**Mid Term Exam**	
9.	Shooting methods, finite difference methods.	Quiz
10.	Partial differential equations: Elliptic hyperbolic and parabolic equations;	Assignment related to the topics
11.	Continue	Quiz
12.	Explicit and implicit finite difference methods, stability, convergence and consistency analysis,	Assignment related to the topics
13.	The method of characteristic.	Quiz
14.	Eigen value problems; Estimation of eigen values and corresponding error bounds,	Presentations

15.	Gerschgorins theorem and its applications Schurs theorem,	Assignment related to the topics
16.	Power method, Shift of origin,	Presentations
17.	Deflation method for the subdominant eigen values.	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Conte, S.D., and De Boor., Elementary Numerical Analysis, McGraw-Hill 1972.
2. Gerald, C.F., Applied Numerical Analysis, 7th edition Pearson, 2004.
3. Froberg, C.E., Introduction to Numerical Analysis, Addison Wesely, 1972.
4. Gourlay, A.R. and Watson, G.A., Compitational Methods for Matrix Eigene Problems. John Wiley & Sons 1973.
5. Ahmad, F. and Rana, M.A., Elements of Numerical Analysis, National Book Foundation, Islamabad, 1995.
6. Zurmuhl, R., Numerical Analysis for Engineers and Physicists, Springer-Verlag 1976.

ADVANCED DIFFERENTIAL GEOMETRY

Credit Hours: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): Differential Geometry.

Specific Objectives of course: After having completed this course, the students would be expected to understand more Advanced concepts in the local theory of curves and surfaces including normal, principal, mean, curvature, and geodesics.

Learning Outcomes: On satisfying the requirements of this course, students will have the knowledge and skills to:

- Explain the concepts and language of differential geometry and its role in modern mathematics
- Analyze and solve complex problems using appropriate techniques from differential geometry
- Apply problem-solving with differential geometry to diverse situations in physics, engineering or other mathematical contexts
- Apply differential geometry techniques to specific research problems in mathematics or other fields

Contents:

Week	Topics	Remarks
1.	Definition and examples of manifolds;	
2.	Differential maps; Sub-manifolds;	Assignment related to the topics
3.	Tangents; Coordinate vector fields;	
4.	Tangent spaces; Dual spaces;	Quiz

5.	Multilinear functions; Vector fields;	Assignment related to the topics
6.	Tensor fields; Integral curves;	
7.	Flows; Lie derivatives;	Quiz
8.	**Mid Term Exam**	
9.	Brackets; Differential forms;	Quiz
10.	Introduction to integration theory on manifolds;	Assignment related to the topics
11.	Riemannian and semi-Riemannian metrics;	Quiz
12.	Flat spaces;	Assignment related to the topics
13.	Affine connextions; Parallel translations;	Quiz
14.	Covariant differentiation of tensor fields; Curvature and torsion tensors;	Presentations
15.	Connexion of a semi-Riemannian tensor;	Assignment related to the topics
16.	Killing equations and Killing vector fields;	Presentations
17.	Geodesics; Sectional curvature.	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Bishop, R.L. and Goldberg, S.I., Tensor Analysis on Manifolds, Dover Publications, Inc. N.Y., 1980.
2. Do Carmo, M.P., Riemannian Geometry, Birkhauser, Boston, 1992.
3. Lovelock, D. and Rund, H. Tensors., Differential Forms and Variational Principles,John-Willey, 1975.
4. Langwitz, D., Differential and Riemannian Geometry, Academic Press, 1970.
5. Abraham, R., Marsden, J.E. and Ratiu, T., Manifolds, Tensor Analysis and Applications, Addison-Wesley, 1983.

ANALYTICAL DYNAMICS

Credit Hours: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): Analytical Mechanics.

Objectives: This course aims to develop an understanding of the principles governing the motion of mechanical systems modeled as rigid bodies. The course also aims to develop an understanding of the fundamental concepts in *analytical dynamics*, and the ability to use them to formulate the equations of motion for rigid bodies and systems.

Learning Outcomes: Upon successful completion of this course, the student will be able to: *(Knowledge based)*

- derive equation of motions of rigid bodies,
- derive and apply the Lagrange's equation;*(Skills)*

- demonstrate good knowledge of the use of the Lagrange's equation for deriving equation of motions; and
- apply the knowledge in Dynamics at higher levels.

Contents:

Week	Topics	Remarks
1.	Introduction, Constraints,	
2.	generalized co-ordinates, generalized forces,	Assignment related to the topics
3.	general equation of dynamics,	
4.	Lagrange's equations,	Quiz
5.	conservation laws, ignorable co-ordinates,	Assignment related to the topics
6.	Explicit form of Lagranges equation in terms of tensors	
7.	Hamiltons principle, principle of least action	Quiz
8.	**Mid Term Exam**	
9.	Hamiltons equations of motion	Quiz
10.	Hamilton-Jacobi Method.	Assignment related to the topics
11.	Poisson Brackets (P.Bs); Poissons theorem;	Quiz
12.	Solution of mechanical problems by algebraic technique based on (P.Bs).	Assignment related to the topics
13.	Small oscilations and normal modes,	Quiz
14.	vibrations of strings, transverse vibrations,	Presentations
15.	normal modes, forced vibrations and damping,	Assignment related to the topics
16.	reflection and transmission at a discontinuity,	Presentations
17.	Iongitudinal vibrations, Rayleighs principle.	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Chorlton, F., Textbook of dynamics, Van Nostrand, 1963.
2. Chester, W., Mechanics, George Allen and Unwin Ltd., London 1979.
3. Goldstein, H., Classical Mechanics, Cambridge, Mass Addison-Wesley, 1980. (latest edition).
4. G. Meirovitch. L., Methods of Analytical Dynamics, McGraw-Hill, 1970.

ADVANCED FUNCTIONAL ANALYSIS

Credit Hours: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): Functional Analysis.

Course Objectives:

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.

Learning Outcomes: Upon completion of advanced functional analysis, students will be able to discuss various advanced problems in different space: vector space, inner product space and Hilbert Spaces.

Contents:

Week	Topics	Remarks
1.	The Hahn-Banach theorem,	
2.	principle of uniform boundedness,	Assignment related to the topics
3.	Continue	
4.	open mapping theorem,	Quiz
5.	Continue	Assignment related to the topics
6.	closed graph theorem	
7.	Continue	Quiz
8.	**Mid Term Exam**	
9.	Week topologies	Quiz
10.	Operators on Hilbert spaces, adjoint Operator	Assignment related to the topics
11.	Self adjoint operators, Normal operator, unitary operators, porjections	Quiz
12.	Continue	Assignment related to the topics
13.	The dual and bidual spaces	Quiz
14.	Continue	Presentations
15.	reflexive spaces, compact operators	Assignment related to the topics
16.	Spectrum and eigenvalues of an operator,	Presentations
17.	Elementary spectral theory	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Kreyszing, E., Introductory Functional Analysis and Applications, John Wiley, 2001.
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.

ADVANCED GROUP THEORY

Credit Hours: 03(3-0) **Course Code: MATH-405**

Prerequisite(s): Group Theory

Objectives: This course aims to further polish the knowledge of the students in the field of Group Theory by introducing some new concepts. Several Theorems and results are discussed so that the students can apply those notions to other fields also.

Learning Outcomes: A student who completes this course successfully will be able to: Define the main concepts and theorems of group theory understand the fundamental results on group theory apply group theoretic reasoning to group actions, symmetry in space apply structural results for abelian, soluble and nilpotent groups prove results in group theory using abstract and rigorous reasoning present an advanced topic in group theory.

Contents:

Week	Topics	Remarks
1.	Isomorphism Theorems,	
2.	Conjugacy classes,	Assignment related to the topics
3.	Generating systems for finite symmetric	
4.	Alternating groups,	Quiz
5.	Endomorphism and sutomorphism of a group,	Assignment related to the topics
6.	Characteristic and fully invariant subgroups,	
7.	Direct product of a group,	Quiz
8.	**Mid Term Exam**	
9.	Syllow theory and its applications,	Quiz
10.	Continue	Assignment related to the topics
11.	Simple group, simplicity of A_n for 5,	Quiz
12.	Zessanhaus lemma, normal series,	Assignment related to the topics
13.	Composition series,	Quiz
14.	Jardon Holder theorem,	Presentations
15.	Solvable groups,	Assignment related to the topics
16.	the derived series of a group,	Presentations
17.	the lower and upper central series of a group and Nilpotent groups, Free group.	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Rose, J.S., A course on group theory, Cambridge University Press, 1978.
2. Magnus, W., Karrass, A., and Solitar., Combinatorial group theory, Dover publication,1966.
3. Husain Taqdir., Introduction to topological groups, W.B. Saunder's Company-Philadelphia and London, 1966.

THEORY OF MODULES

Credit Hours: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): Group Theory.

Objectives: This course aims to introduce some new notions in pure Mathematics. Modules play an important role in Mathematics. After completion of the course, students will be able to solve several problems of Homological Algebra.

Learning Outcomes: A student who completes this course successfully will be able to: The structure of module, sub module, quotient, cyclic modules etc. He will be able to apply these concepts in the homological algebra. A student will also know noetherian rings, semi-simple rings and basic theorems of modules. He will also be able to construct examples using these notions.

Contents:

Week	Topics	Remarks
1.	Elementary notions and examples,	
2.	Continue…	Assignment related to the topics
3.	Continue…	
4.	Modules	Quiz
5.	Sub-modules	Assignment related to the topics
6.	Continue…	
7.	quotient modules,	Quiz
8.	**Mid Term Exam**	
9.	finitely generated and cyclic modules	Quiz
10.	Continue…	Assignment related to the topics
11.	Continue…	Quiz
12.	exact sequences	Assignment related to the topics
13.	elementary notions of homological algebra	Quiz
14.	Continue…	Presentations
15.	Noetherian and Artinian rings and modules	Assignment related to the topics
16.	Radicals	Presentations
17.	semi-simple rings and modules	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Adamson, J., Rings and modules, Blyth, T.S., Module theory, Oxford University Press, 1977.
2. Hartley, B. and Hawkes, T.O., Rings, Modules and Linear algebra, Chapman and Hall, 1980.
3. Herstein, I.N., Topics in Algebra, John Wiley and Sons, 1975.

ADVANCED COMPLEX ANALYSIS

Credit Hours: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): Complex Analysis.

Course Objectives:

This is an advanced course in complex analysis, giving advanced level theory of complex analysis along with applications, with an emphasis on applications of complex analysis and especially conformal mappings.

Learning Outcomes: Upon successful completion of this course, the student will be able to:

- Manipulate complex numbers in various representations, define fundamental topological concepts in the context of the complex plane, and define and calculate limits and derivatives of functions of a complex variable.
- State and prove fundamental results, including: Cauchy's Theorem and Cauchy's Integral Formula, the Fundamental Theorem of Algebra, Morera's Theorem and Liouville's Theorem. Use them to prove related results.
- Represent analytic functions as power series on their domains and verify that they are well-defined. Define a branch of the complex logarithm. Classify singularities and find Laurent series for meromorphic functions.

Contents:

Week	Topics	Remarks
1.	Conformal mapping	
2.	Preservation of mapping,	Assignment related to the topics
3.	Scale Factors	
4.	Local inverses	Quiz
5.	Harmonic Conjugates,	Assignment related to the topics
6.	Transformation of Harmonic functions	
7.	Transformation of boundary conditions	Quiz
8.	**Mid Term Exam**	
9.	Application of conformal mapping	Quiz
10.	The Schwarz-Christoffel transformation	Assignment related to the topics
11.	Integral formula	Quiz
12.	the Poisson type, Dirichlet problem for a disk	Assignment related to the topics
13.	Schwarz integral formula	Quiz
14.	Neumann problems	Presentations
15.	mapping by elementary functions,	Assignment related to the topics
16.	linear frictional transformation, linear functional, the function $\frac{1}{Z}$	Presentations
17.	the transformation $w = \exp(z)$ and $w = \sin z$ Analytic continuation	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Churchill, R.V. Verhey and Brown R., Complex Variables and Applications McGraw-Hill, 1996.
2. Marsden, J.E., Basic Complex Analysis, W.H.Freeman and Co, 1982.
3. Hille, E., Analytic Function Theory, Vols.I and II, Chelsea Publishing Co. New York, 1974.
4. Shaums Outlines Complex Variables.

QUANTUM MECHANICS

Credit Hours: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): Analytical Mechanics or Modern Physics.

Objectives:

This course will help in understanding the behavior of quantum mechanical particle and development of Schrodinger equation in one and three dimensions. Also the course aims to introduce the quantum mechanical operators and to determinate the angular momentum of a quantum mechanical particle.

Learning Outcomes: Students who have completed this course should

- Have a deep understanding of the mathematical foundations of quantum mechanics,
- Be able to solve the Schrodinger equation for simple configurations,
- Understand the effect of symmetries in quantum mechanics.

Contents:

Week	Topics	Remarks
1.	Wave-Particle	
2.	Plan-Einstein relation,	Assignment related to the topics
3.	Debroglie relations	
4.	Schrodinger equation, Normalization of wave function	Quiz
5.	Waves-Pocket,	Assignment related to the topics
6.	Heisenberg indeterminacy or UIXCER Taint principal	
7.	Phase velocity	Quiz
8.	**Mid Term Exam**	
9.	Group velocity, Stationary states, Properties of a waves function	Quiz
10.	Linear operators, Orthogonal basis in waves equation, Closure relation,	Assignment related to the topics
11.	Parseval relation, Orthonormalization relation, Delta functions, Ketand Bro vectors,	Quiz
12.	the adjoint operators,Eigen value equations and observables	Assignment related to the topics
13.	Projection operation, Basic postulates of Quantum theory	Quiz

14.	Implementations of the Schrödinger Equations, Conservative system,	Presentations
15.	Angular momentum, Time-Energy Uncertainty	Assignment related to the topics
16.	Raising operators, Spin Observable, Hormonic oscillator,	Presentations
17.	Hydrogenic atoms, Pavli Exclusion Principal.	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Richard L. Liboff Introductory Quantum Mechanics 4th Ed.
2. David J. Griffith. Introduction to Quantum Mechanics 2nd Ed.
3. Quantum Mechanics Schaum out line series.

ELECTRODYNAMICS

Credit Hours: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): Physics-III

Objectives:

The main objective of this course is to understand the Physics of Electromagnetism and to develop simple mathematical formalisms to analyze the electromagnetic fields and interactions. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.

Learning Outcomes: Students who completed this course should

- Have a deep understanding of the theoretical foundations of electromagnetic phenomena,
- Be able to solve the Maxwell equations for simple configurations,
- Have a working knowledge of special relativity.

Contents:

Week	Topics	Remarks
1.	The electromagnetic law of force, Potential and field for several charges,	
2.	Equipotential and lines of force,	Assignment related to the topics
3.	Gauss's flux theorem, electronics potential energy of a system of charges,	
4.	energy of a system of conductors,	Quiz
5.	dielectrics, the magneto static law of forces,	Assignment related to the topics
6.	magnetic doublets, magnetic shells,	
7.	forces on magnetic doublets,	Quiz
8.	**Mid Term Exam**	
9.	magnetic induction,	Quiz

10.	electric current, conductivity,	Assignment related to the topics
11.	resistance, Kirchhoff's laws,	Quiz
12.	maximum energy theorem,	Assignment related to the topics
13.	magnetic field and energy law of electromagnetic induction, Current of A.C.	Quiz
14.	Maxwell's equations in free space and in material,	Presentations
15.	media and their solution in simple cases,	Assignment related to the topics
16.	Continue…	Presentations
17.	Electromagnetic waves, reflection, refraction and polarization.	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Ferroro, Electromagnetism Theory.
2. Ramsy, A.S. Electricity and Magnetism.

ADVANCED NUMBER THEORY

Credit Hours: 03(3-0) **Course Code: MATH-303**

Prerequisite(s): Number Theory.

Course Objectives:

The focus of the course is to study more advance properties of integers and develops ability to prove advance level theorems.

Learning Outcomes: Upon successful completion of Math 319 - Number Theory, a student will be able to:

- Define and interpret the concepts of divisibility, congruence, greatest common divisor, prime, and prime-factorization,
- Apply the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues,
- Formulate and prove conjectures about numeric patterns, and
- Produce rigorous arguments (proofs) centered on the material of number theory, most notably in the use of Mathematical Induction and/or the Well Ordering Principal in the proof of theorems.

Contents:

Week	Topics	Remarks
1.	Review of Basic Algorithm, Congruence,	
2.	Residue classes and Euler's ϕ function,	Assignment related to the topics
3.	Linear Congruence and Congruence of higher degree,	
4.	the theorem of Fermat's,	Quiz
5.	Euler and Wilson's. Primitive roots and indices,	Assignment related to the topics
6.	Integers belonging to a given exponent, composite module,	
7.	Indices, Quadratic Residues, Composite module, Legendre Symbols,	Quiz
8.	**Mid Term Exam**	
9.	laws of Quadratic reciprocity, the Jacobi symbol,	Quiz
10.	Number theoretic functions, Mobius functions,	Assignment related to the topics
11.	Diophantine equation and Fermat's conjecture,	Quiz
12.	for $N = 2$, $N = 4$, Algebraic number and integers, Units and primes R(V) Ideals,	Assignment related to the topics
13.	Arithmetic of Ideals, the norm of prime Ideals, Unit of Algebraic number field.	Quiz
14.	Applications to Rational Number Theory,	Presentations
15.	Equivalence and Class number Cyclotomic field K. Fermat's equations,	Assignment related to the topics
16.	Kummer's Theorem, Pure Cubic field,	Presentations
17.	Distribution of primes and Riemes and Riemann function, the prime number theorem.	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. The Theory of Algebraic Numbers, John Wiley.
2. Hardy and Wright, Number Theory, Clarendon presses.
3. Grass Wald E. Topics from the theory of Numbers, the Mc. Millen Company, New York.
4. Leveque W.J. Topics in Number Theory Vol: I and II, (Addison-Wesley Publisher Company)

MEASURE THEORY

Credit Hours: 03(3-0) **Course Code: MATH-303**
Prerequisite(s): Real Analysis-I

Objectives: This course aims to

- Give a more rigorous introduction to the theory of measure.
- Develop the ideas of Lebesgue integration and its properties.

Learning Outcomes: Student s will be able to:

- Recall the concepts of probability theory and consider them from a measure theoretic point of view.
- Prove the Central Limit Theorem using these methods.

Contents:

Week	Topics	Remarks
1.	Foundation of Analysis, A development of integral,	
2.	real and complex number system from the Peano axioms,	Assignment related to the topics
3.	Denumerable and non Denumerable sets,	
4.	Cardinal and ordinal number,	Quiz
5.	Partial ordered sets and Totally ordered sets,	Assignment related to the topics
6.	well order sets, Transfinite induction,	
7.	axiom of choice and well ordering theorem,	Quiz
8.	**Mid Term Exam**	
9.	theory of set of points, covering theorems,	Quiz
10.	theory of Measure, Measurable functions,	Assignment related to the topics
11.	the Lebesgue integral convergence theorem,	Quiz
12.	the fundamental theorem of the integral calculus,	Assignment related to the topics
13.	derivative, non differentiable functions,	Quiz
14.	function of bounded variation,	Presentations
15.	the Lebesgue class L^p , strong convergence,	Assignment related to the topics
16.	simple treatment of Riemann- Stieltjes	Presentations
17.	simple treatment Lebesgue- Stieltjes integral.	Presentations
18.	**Final Term Exam**	

Recommended Books:

1. Royden HL, Real Analysis, Macmillan,1968.
2. Cohan DL, Measure Theory, Birkhauser, 1980.
3. Halmos PR, Measure Theory, D. Van Nostran, 1950.

4. Natonson, Theory of Functions of Real Variables.
5. Burkill, Lebesgue Integral.
6. Titchmarsh, Theory of Functions.
7. Edmon Landou, Foundation of the Analysis.
8. Inder k. Rana. An Introduction to Measure and Integration 2nd Ed. Narosa.

GRAPH THEORY

Credit Hours: 03(3-0) **Course Code: MATH-452**

Prerequisite(s): Discrete Structure or basic knowledge in graph theory

Objectives: Our aims in this course are twofold. First, its aim is to discuss some of the major results of graph theory and to provide an introduction to the language, methods and terminology of the subject. Second, to emphasize various approaches (algorithmic, probabilistic, etc) that have proved fruitful in modern graph theory: these modes of thinking about the subject have also proved successful in other areas of mathematics

Learning Outcomes: We hope that after completion of the course the students will find the techniques learnt in this course to be useful in other areas of mathematics.

Contents:

Week	Topics	Remarks
1.	Introduction, Basic definitions and examples,	
2.	Subgraphs, adjacency matrix of a graph,	Assignment related to the topics
3.	Graph isomorphism,	
4.	Connectivity	Quiz
5.	Paths and cycles	Assignment related to the topics
6.	Eulerian graphs, Hamiltonian graphs	
7.	Trees and spanning trees	Quiz
	Mid Term Exam	
8.	Labeling of trees, minimum spanning trees	Quiz
9.	Kruskal's and prim's algorithm for finding minimum spanning trees	Assignment related to the topics
10.	Bipartite graphs and multipartite graphs	Quiz
11.	Planar graphs, line graphs,	Assignment related to the topics
12.	Euler's formula, Dual graphs	Quiz
13.	Product of graphs	Presentations
14.	Coloring of graphs	Assignment related to the topics

15.	Graphs labeling	Presentations
16.	Bandwidth labeling of graphs	Presentations
	Final Term Exam	

Recommended Books:

9. Natonson, Theory of Functions of Real Variables.
10. Burkill, Lebesgue Integral.
11. Titchmarsh, Theory of Functions.
12. Edmon Landou, Foundation of the Analysis.
13. Inder k. Rana. An Introduction to Measure and Integration 2nd Ed. Narosa.

ITEM TWO

Annexure B

Master Program in Mathematics

(Semester System)

Degree Awarded: Master of Science in Mathematics
(M.Sc Mathematics)

Entrance Requirements: BA/BSc (Mathematics-A and Mathematics-B) with at least 45 % marks in Mathematics B course

Duration: Two-Year (4-Semester)

Total Credit Hours: **66 (22 Courses)**

Note: Credit Hours required for the award of Master Degree is 60-72.

Marks Breakdown for Courses

Item	**Maximum Marks for Course Without Laboratory (3+0)**	**Maximum Marks for Course With Laboratory (2+1)**
Mid Term Examination	30%	30%
Internal Marks (Assignments, Quizzes, Presentations)	20%	10%
Laboratory	----	10%
Final Term Examination	50%	50%
Total	100%	100%

The M. Sc Scheme of Studies

Structure

S. No	Categories	No. of Course	Credit Hr.
1	Compulsory Courses (No Choice)	**12**	**36**
2	Optional Course (to be chosen from the list of optional course)	**10**	**30**
Total		**22**	**66**

MISSION OF THE MASTER PROGRAM

The mission of the Master program is to impart knowledge of Mathematics to our students in order to develop their analytical approach, logical reasoning, generalization, abstractions and to stimulate Advanced learning methodologies and persistently strives to develop creative thinking skills in students in order to prepare them to take effective decisions in business and many other areas in the future.

VISION OF THE MASTER PROGRAM

The vision of the program is to impart a quality education and productive research in different fields of Mathematics. It focuses to produce highly skilled manpower, scholars and researchers to meet the contemporary and future challenges.

OBJECTIVES OF THE MASTER PROGRAM

- To impart analytical capabilities and critical thinking.
- To select and apply general rules correctly to solve problems including those in real-life contexts.
- To develop the true understanding of the basis of Mathematics.
- To develop mathematical curiosity and use inductive and deductive reasoning when solving problems.

EXPECTED OUTCOME OF THE MASTER DEGREE PROGRAM

Graduates of the mathematics program will be able to:

1. Explain the importance of Mathematics and its techniques to solve real life problems and provide the limitations of such techniques and the validity of the results.
2. Propose new mathematical questions and suggest possible software packages and/or computer programming to find solutions to these questions.

3. Serve on Mathematical based position/field jobs/teaching jobs.
4. Take interest for higher education in various areas of Mathematics and in other areas related to Mathematics.
5. Identify fundamental concepts of Mathematics as applied to science and other areas of Mathematics, and to interconnect the roles of pure and applied Mathematics.

The M.Sc scheme of studies: Framework

Compulsory Requirements			
S. No.	**Course Title**	**Course Codes**	**Credit Hr.**
1.	Set Topology	**MATH-502**	03(3-0)
2.	Software Packages	**MATH-551**	03(1-2)
3.	Advanced Calculus	**MATH-504**	03(3-0)
4.	Linear Algebra	**MATH-505**	03(3-0)
5.	Complex Analysis	**MATH-503**	03(3-0)
6.	Abstract Algebra	**MATH-556**	03(3-0)
7.	Real Analysis	**MATH-553**	03(3-0)
8.	Numerical Analysis	**MATH-606**	03(3-0)
9.	Ordinary Differential Equations	**MATH-501**	03(3-0)
10.	Vector and Tensor Analysis	**MATH-552**	03(3-0)
11.	Partial Differential Equations	**MATH-603**	03(3-0)
12.	Mathematical Statistics	**MATH-555**	03(3-0)
Total			**36**

Optional Courses Offered

Optional Course			
S. No.	**Course Title**	**Course Code**	**Credit Hr.**
1.	Mathematical Methods	**MATH-602**	03(3-0)
2.	Measure Theory	**MATH-602**	03(3-0)
3.	Rings and Fields	**MATH-604**	03(3-0)
4.	Functional Analysis	**MATH-605**	03(3-0)
5.	Mathematical Modeling	**MATH-601**	03(3-0)
6.	Advanced Functional Analysis	**MATH-651**	03(3-0)
7.	Mathematical Biology	**MATH-652**	03(3-0)
8.	Advanced Group Theory	**MATH-653**	03(3-0)
9.	Differential Geometry	**MATH-654**	03(3-0)
10.	Computational Mathematics	**MATH-655**	03(3-0)
Total			**30**

List of elective courses

	Optional Courses		
S. No.	**Course Title**	**Course Code**	**Credit Hr.**
1.	Measure Theory	**MATH-602**	03(3-0)
2.	Rings and Fields	**MATH-604**	03(3-0)
3.	Functional Analysis	**MATH-605**	03(3-0)
4.	Mathematical Modeling	**MATH-601**	03(3-0)
5.	Fuzzy set Theory and Applications	**MATH-607**	03(3-0)
6.	Dynamical Systems	**MATH-608**	03(3-0)
7.	Mathematical Methods	**MATH-554**	03(3-0)
8.	Fluid Mechanics	**MATH-656**	03(3-0)
9.	Analytical Mechanics	**MATH-609**	03(3-0)
10.	Differential Geometry	**MATH-654**	03(3-0)
11.	Advanced Numerical Analysis	**MATH-657**	03(3-0)
12.	Advanced Partial Differential Equations	**MATH-658**	03(3-0)
13.	Advanced Mathematical Statistics	**MATH-659**	03(3-0)
15.	Analytical Dynamics	**MATH-660**	03(3-0)
16.	Modeling and Simulation	**MATH-661**	03(3-0)
17.	Electromagnetic Theory	**MATH-610**	03(3-0)
18.	Quantum Mechanics	**MATH-611**	03(3-0)
19.	Optimization Theory	**MATH-612**	03(3-0)
20.	Advanced Group Theory	**MATH-653**	03(3-0)
21.	Theory of Modules	**MATH-662**	03(3-0)
23.	Fluid Dynamics	**MATH-663**	03(3-0)
24.	Advanced Functional Analysis	**MATH-651**	03(3-0)
25.	Computational Mathematics	**MATH-655**	03(3-0)
26.	Mathematical Biology	**MATH-652**	03(3-0)
27.	Nonlinear Dynamics	**MATH-613**	03(3-0)
28.	*Stochastic Processes*	**MATH-614**	03(3-0)
29.	*Heat and Mass Transfer*	**MATH-664**	03(3-0)
30.	*Convex Analysis*	**MATH-615**	03(3-0)
31.	*History of Mathematics*	**MATH-616**	03(3-0)
32.	*Mathematical Physics*	**MATH-617**	03(3-0)
33.	*Galois Theory*	**MATH-665**	03(3-0)
34	*Lie Algebra*	**MATH-666**	03(3-0)
35.	Project	**MATH-69-**	03(3-0)

Scheme of Studies M. Sc Mathematics
(Two-Year Semester Program)
Semester-Wise Breakdown

First Year

First Semester

S. No.	Course Title		Course Code	Cr. Hrs
1.	Ordinary Differential Equations	MCC	MATH-501	03(3-0)
2.	General Topology	MCC	MATH-502	03(3-0)
3.	Mathematical Statistics	MCC	MATH-503	03(3-0)
4.	Real Analysis-I	MCC	MATH-504	03(3-0)
5.	Linear Algebra	MCC	MATH-505	03(3-0)
Total Credit Hours				**15**

Second Semester

S. No.	Course Title		Course Code	Cr. Hrs
1.	Software Packages	MCC	MATH-551	03(3-0)
2.	Vector and Tensor Analysis	MCC	MATH-552	03(3-0)
3.	Real Analysis-II	MCC	MATH-553	03(3-0)
4.	Mathematical Methods	MEC	MATH-554	03(3-0)
5.	Complex Analysis	MCC	MATH-555	03(3-0)
6.	Abstract Algebra	MCC	MATH-556	03(3-0)
Total Credit Hours				**18**

Second Year

Third Semester

S. No.	Course Title		Course Code	Cr. Hrs
1.	Mathematical Modeling	MEC	MATH-601	03(3-0)
2.	Measure Theory	MEC	MATH-602	03(3-0)
3.	Partial Differential Equations	MCC	MATH-603	03(3-0)
4.	Rings and Fields	MEC	MATH-604	03(3-0)
5.	Functional Analysis	MEC	MATH-605	03(3-0)
6.	Numerical Analysis	MCC	MATH-606	03(3-0)
Total Credit Hours				18

Fourth Semester

S. No.	Course Title		Course Code	Cr. Hrs
1.	Advanced Functional Analysis	MEC	MATH-651	03(3-0)
2.	Mathematical Biology	MEC	MATH-652	03(3-0)
3.	Advanced Group Theory	MEC	MATH-653	03(3-0)
4.	Differential Geometry	MEC	MATH-654	03(3-0)
5.	Computational Mathematics	MEC	MATH-655	03(3-0)
Total Credit Hours				15

Course Contents for M.Sc. Mathematics
Compulsory Subjects

GENERAL TOPOLOGY

Credit Hours: 03(3-0) **Course Code: MATH-502**

Prerequisite(s): Basic Topology.

Course Objectives:

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

Learning Outcomes: Upon successful completion of Set Theory, a student will be able to:

- Discuss the development of the axiomatic view of set theory in the early 20th century,
- Identify the axioms of a system of set theory, for example the Zermelo-Fraenkel axioms, including the Axiom of Choice,
- Define cardinality, discuss and prove Cantor's Theorem and discuss the status of the Continuum Hypothesis,
- Explain basic concepts and prove basic facts about ordinals and well-ordered sets,
- Use transfinite induction to prove a selection of theorems relating to ordinals and cardinals, and
- Define the set theoretic universe V and discuss its structure.

Recommended Book:

1. Munkres, J.R., Topology A First Course, Prentice - Hall, Inc. London, 2007.
2. Simon, G.F., Introduction to Topology and Modern Analysis McGraw-Hill, New York, 1963.
3. Pervin, W.J., Foundation of General Topology, Academic Press, London, 2nd, ed., 1965
4. Dr. Majeed, A., Element of Set Topology and Functional Analysis, Ilmi Kitab Khana Lahore, 1990.

Contents:

Week	Topics	Remarks
1.	Motivation and introduction to sets and their operations	
2.	Countable and uncountable sets, Topological spaces,	Assignment related to the topics
3.	Open and closed sets, interior, closure	
4.	Boundary of a set, neighborhoods and neighborhood systems	Quiz

5.	Isolated points, related theorems	Assignment related to the topics
6.	Limit points, the derived and perfect sets,	
7.	Dense sets and separable spaces, Bases and sub bases,	Quiz
8.	**Mid Term Exam**	
9.	Continuous maps, open and closed maps, Metric spaces, topology induced by a metric, equivalent topologies,	Quiz
10.	Formulation with closed sets, Cauchy sequence, complete metric spaces, characterization of completeness,	Assignment related to the topics
11.	Cantors intersection theorem, the completion of metric space, metrizable spaces. Continuous functions,	Quiz
12.	Various characterizations of continuous functions, homeomorphisms, open and closed continuous functions,	Assignment related to the topics
13.	Topological properties and homeomorphisms. Separation axioms, T1 and T2 spaces, regular and normal spaces,	Quiz
14.	Compact spaces their characterization and some theorems, construction of compact spaces, compactness in metric spaces,	Presentations
15.	Compactness and completeness, local compactness. Connected spaces	Assignment related to the topics
16.	Topological product of connected spaces, locally connected spaces	Presentations
17.	Continue…	Presentations
18.	**Final Term Exam**	

SOFTWARE PACKAGES

Credit Hour: 03(1-2) **Course Code: MATH-551**

Pre-requisite: Basic of Computer, Calculus, ODEs

Objectives: Students are expected to be able to apply techniques, routines and processes involving rational and real arithmetic, algebraic manipulation, equation solving, graph sketching, differentiation and integration with and without the use of technology, as applicable.

Learning Outcomes: On completion of this course, the students should be able to select and appropriately use a computer algebra system and other technology to develop mathematical ideas, produce results and carry out analysis in situations requiring problem-solving, modeling or investigative techniques or approaches.

Recommended Books:

1. Martha L. Abel, James P. Braselton, Mathematica by Examples, 3rd Edition, Elsevier Academic press, 2004.
2. Stephen Wolfram, Mathematica, 5th Edition, Wolfram Media, 2003.
3. Calculus with Maple V by John S. Devitt.
4. Rudra Partap, Getting started with MATLAB, Oxford University Press, 2006.

Contents:

Week	Topics	Remarks
1.	**Computer Algebra System (CAS):** Numerical Calculation	
2.	Exact and approximate results of linear and non-linear system,	Assignment related to the topics
3.	Complex Numbers, Algebraic Calculations,	
4.	Limits, Differentiation,	Quiz
5.	Integrations, Sum and Products,	Assignment related to the topics
6.	Solving Equation, Defining functions, Vector and Matrices, Two and Three dimensional graphics	
7.	Determinant, eigenvalues and eigenvectors, singular values, matrix factorization, solution of linear system	Quiz
8.	**Mid Term Exam**	
9.	Introduction to MATLAB windows, the use of command window, Power Series, Integral transforms	Quiz
10.	Numerical Solutions (Differentiation, Integrations, Sum and Products,)	Assignment related to the topics
11.	Numerical Solutions (Solving Equation, Solving ODEs and PDEs), Parametric and density plots, Polar plots.	Quiz
12.	**Programming in MATLAB:** Built in Functions, Arrays, Matrices, Script files,	Assignment related to the topics
13.	Plots, Functions and function file, Loops	Quiz
14.	Selection Statements, Polynomials, Curve fitting and interpolation.	Presentations
15.	Introduction to MAPLE	Assignment related to the topics
16.	Continue…	Presentations
17.	Introduction to MATHEMATICA.	Presentations
18.	**Final Term Exam**	

MATHEMATICAL STATISTICS

Credit Hours: 03(3-0) **Course Code: MATH-503**

Prerequisite(s): A Course of Mathematics in B.Sc level or Maths State at intermediate level.

Objectives: This course gives students a good chance to improve their abilities in the following skills:

- Data interpretation, inference, and prediction skills.
- Probabilistic analyzing skills.
- Random experiments analyzing skills.
- Probability distributions distinguishing skills.
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- Transformations methods of the discrete and continuous type's skills.

Learning Outcomes: Upon successful completion of the course:

- Students shall know how to organize, manage, and present data.
- Students shall be able to use and apply a wide variety of specific statistical methods.
- Students shall understand the mathematical basis and foundations of probability and statistics.

Recommended Books:

1. Mood, A.M. Graybill, F.A., and Boes, D.C., Introduction to the Theory of Statistics, 3rd Edition, McGraw-Hill Book Company New York, 1974.
2. Degroot, M. H., Probability and Statistics, 2nd Edition, Addison-Wesley Publishing Company, USA, 1986.
3. Mardia, K.V., Kent, J.T., and Bibby, J.M., Multivariate Analysis, Academic Press,New York, 1979.
4. Freund J-1962, Mathematical Statistics, Prentice Hall.Mathematical Statistics Schaum's outline series.
5. Murry R. Spiegel, John Schiller, Srinivasan, R.A., Probability and Statistics, 2nd Ed Schaum's outline series.
6. J.N. Kapur and H.C. Sexena S. Mathematical Statistics Chand and Company Ltd, New Delhe. (2005).

Contents:

Week	Topics	Remarks
1.	Frequency distributions, Measure of central tendency,	
2.	Measure of dispersion, Moments,	Assignment related to the topics
3.	Kurtosis, Probability, Conditional and Marginal Interpretations of Probability.	
4.	Bays formula and Bay's theorem of Probability,	Quiz
5.	Random variable,	Assignment related to the topics
6.	Discrete and continuous Random variable,	
7.	Mathematical expectation.	Quiz
8.	**Mid Term Exam**	
9.	Discrete distribution: Moment generating and cumulative distributions,	Quiz
10.	Discrete probability distribution,	Assignment related to the topics
11.	The Binomial distribution,	Quiz
12.	Hyper geometric distribution,	Assignment related to the topics
13.	Negative Binomial distribution, the Poisson distribution,	Quiz
14.	Geometric distribution, Uniform distribution.	Presentations
15.	Continuous distribution: Uniform distribution, the normal exponential distributions,	Assignment related to the topics
16.	Gamma and Beta distributions, Cauchy distribution,	Presentations
17.	Log-Normal distribution, Weibull distribution.	Presentations
18.	**Final Term Exam**	

REAL ANALYSIS-I

Credit Hour: 03(3-0) **Course Code: MATH-504**
Prerequisite(s): Math-A
Course Objectives:
This is the first course in analysis. It develops the fundamental ideas of analysis and is aimed at developing the students' ability in reading and writing mathematical proofs. Another objective is to provide sound understanding of the axiomatic foundations of the real number system, in particular the notions of completeness and compactness.

Learning Outcomes: Upon successful completion of Real Analysis I, students will be able to:

- Describe the real line as a complete, ordered field,
- Determine the basic topological properties of subsets of the real numbers,
- Use the definitions of convergence as they apply to sequences, series, and functions,
- Determine the continuity, differentiability, and integrability of functions defined on subsets of the real line,
- Apply the Mean Value Theorem and the Fundamental Theorem of Calculus to problems in the context of real analysis, and
- Produce rigorous proofs of results that arise in the context of real analysis.

Recommended Book:

1. Bartle, R.G. and Sherbert, D.R. Introduction to Real Analysis, John Wiley & Sons 1994.
2. Widder, D.V. Advanced Calculus, Prentice-Hall, 1982.
3. Rudin, W Principles of Real Analysis, McGraw-Hill, 1995.
4. S.C. Malik Mathematical Analysis, 1992.
5. Shaums Outlines calculus, 1999.

Contents:

Week	Topics	Remarks
1.	**The real numbers:** algebraic and order properties of R;	
2.	The completeness property;	Assignment related to the topics
3.	Cluster points; open and closed sets in R. Sequences,	
4.	The limit of a function,	Quiz
5.	Limit theorems. Continuous functions on intervals	Assignment related to the topics
6.	Boundedness theorem, maximum-minimum theorem	
7.	the intermediate value theorem; uniform continuity.	Quiz
8.	**Mid Term Exam**	
9.	**The derivative:** the mean value theorems	Quiz

10.	Taylor's theorem	Assignment related to the topics
11.	**Functions of several variables:** Limit and continuity of functions of two and three variables	Quiz
12.	Continue…	Assignment related to the topics
13.	Partial derivatives; differentiable functions	Quiz
14.	**Multiple Integrals:** regions in the x-y plane	Presentations
15.	Iterated integrals, double integrals	Assignment related to the topics
16.	Change in the order of integration,	Presentations
17.	Transformation of double integrals.	Presentations
18.	**Final Term Exam**	

LINEAR ALGEBRA

Credit Hours: 03(3-0) **Course Code: MATH-505**

Prerequisite(s): Basic Linear Algebra and Matrix Algebra.

Course Objectives:

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

Learning Outcomes: On successful completion of this course students will be able:

- To solve systems of linear equations by using Gaussian elimination to reduce the augmented matrix to row echelon form or to reduced row echelon form.
- To understand the basic ideas of vector algebra: linear dependence and independence and spanning;
- To apply the basic techniques of matrix algebra, including finding the inverse of an invertible matrix using Gauss-Jordan elimination;
- To know how to find the row space, column space and null space of a matrix, and be familiar with the concepts of dimension of a subspace and the rank and nullity of a matrix, and to understand the relationship of these concepts to associated systems of linear equations.
- To find the eigenvalues and eigenvectors of a square matrix using the characteristic polynomial and will know how to diagonalize a matrix when this is possible be able to recognize and invert orthogonal matrices be able to orthogonally diagonalize symmetric

matrices be able to find the change-of-basis matrix with respect to two bases of a vector space be familiar with the notion of a linear transformation and its matrix.

Recommended Book:

1. Shilov, G.E., Linear Algebra, Dover Publication, Inc., New York, 1997.
2. Zill, D.G. and Cullen M.R., Advanced Engineering Mathematics, PWS, publishing company, Boston, 1996.
3. Herstein, I., Topics in Algebra, John-Wiley, 1975.
4. Trooper, A.M., Linear Algebra, Thomas Nelson and Sons, 1969.

Contents:

Week	Topics	Remarks
1.	Review of matrices and determinants.	
2.	Linear spaces.	Assignment related to the topics
3.	Bases and dimensions.Subspaces.	
4.	Direct sums of subspaces.	Quiz
5.	Factor spaces.	Assignment related to the topics
6.	Linear forms. Linear operators.	
7.	Matrix representation	Quiz
8.	**Mid Term Exam**	
9.	Sums and products of linear operators.	Quiz
10.	The range and null space of linear operators.	Assignment related to the topics
11.	Invariant subspaces.	Quiz
12.	Eigen values and Eigen vectors of linear transformation and matrices,	Assignment related to the topics
13.	Continue…	Quiz
14.	Transformation of matrix linear operator,	Presentations
15.	Diagonalization,	Assignment related to the topics
16.	Inner direct product spaces and linear functional,	Presentations
17.	Minimal polynomial of linear transformations	Presentations
18.	**Final Term Exam**	

ABSTRACT ALGEBRA

Credit Hours: 03(3-0) **Course Code: MATH-556**

Prerequisite(s): Basic Algebra

Objectives: This course aims to provide an approach to the subject of algebra in general, which is one of the basic pillars of modern mathematics. By the end of the course students will learn certain algebraic structures called groups, rings, fields and some related structures and properties.

Furthermore, this course gives to student a good mathematical maturity and enables them to build mathematical thinking and skill.

Learning Outcomes:

- Assess properties implied by the definitions of a group and rings,
- Use various canonical types of groups (including cyclic groups and groups of permutations) and canonical types of rings (including polynomial rings and modular rings),
- Analyze and demonstrate examples of subgroups, normal subgroups and quotient groups,
- Analyze and demonstrate examples of ideals and quotient rings,
- Use the concepts of isomorphism and homomorphism for groups and rings, and
- Produce rigorous proofs of propositions arising in the context of abstract algebra.

Recommended Book:

1. Fraleigh, J.B., A First Course in Algebra, Addison-Wesley 1982.
2. Hamermesh, M., Group Theory, Addison-Wesley 1972.
3. Herstein, I.N., Topics in Algebra, John Wiley 1975.Bartle, R.G. and Sherbert, D.R., Introduction to Real Analysis, John Wile Sons 1994.

Contents:

Week	Topics	Remarks
1.	Introduction to Sets and Structures	
2.	Motivation for groups. Finite groups	Assignment related to the topics
3.	Product of Subgroups	
4.	Permutations	Quiz
5.	Cyclic groups	Assignment related to the topics
6.	Homomorphism of a group	
7.	kernel of Homomorphism	Quiz
8.	**Mid Term Exam**	
9.	Concept of an Isomorphism of a group	Quiz
10.	Isomorphism between Cyclic groups	Assignment related to the topics
11.	Cosets, Normal groups	Quiz
12.	Factor groups	Assignment related to the topics
13.	Simple groups	Quiz
14.	Concept of Normalizer	Presentations
15.	Centralizers	Assignment related to the topics
16.	Centre of a group	Presentations
17.	Series of groups	Presentations

18.	**Final Term Exam**	

REAL ANALYSIS-II

Credit Hours: 03(3-0) **Course Code: MATH-553**

Prerequisite(s): Advanced Calculus.

Course Objectives:

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.

Learning Outcomes: Upon successful completion of Real Analysis II, a student will be able to:

- Determine the Riemann integrability and the Riemann-Stieltjes integrability of a bounded function and prove a selection of theorems concerning integration,
- Recognize the difference between point-wise and uniform convergence of a sequence of functions,
- Illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability, and integrability, and
- Illustrate the convergence properties of power series.

Recommended Book:

1. Bartle, R.G. and Sherbert, D.R., Introduction to Real Analysis, John Wile Sons 1994.
2. Widder, D.V., Advanced Calculus, Prentice Hall 1982.
3. Rudin, W., Principles of Real Analysis, McGraw-Hill 1995.
4. Rabenstein, R.L., Elements of Ordinary Differential Equations, Academic Press, 1984.
5. S.C. Malik Mathematical Analysis, 1992.
6. Shaums Outlines calculus, 1999.

Contents:

Week	Topics	Remarks
1.	**The Riemann Integral:** Upper and lower sums, definition of a Riemann integral	
2.	Integrability criterion, classes of integrable functions, properties of the Riemann integral	Assignment related to the topics
3.	**Reimann Stieltjes Integrals:** upper and lower sums mean value theorems	
4.	relation between Reimann and Reimann Stieltjes integrals, related results	Quiz
5.	**Infinite Series:** Review of sequences, the geometric series, and tests for convergence, conditional and absolute convergence	Assignment related to the topics
6.	Regrouping and rearrangement of series. Power series, radius of convergence	

7.	Uniform Convergence: Uniform convergence of a sequence and a series, the M-test, properties of uniformly convergent series	Quiz
8.	**Mid Term Exam**	
9.	Weierstrass approximation theorem. **Improper Integrals:** Classification, tests for convergence	Quiz
10.	absolute and conditional convergence, convergence of $f(x)\sin xdx$ the gamma function	Assignment related to the topics
11.	Uniform convergence of integrals, the M-text, properties of uniformly convergent integrals	Quiz
12.	**Point-wise/ Uniform convergence:** Definitions of point-wise and uniform convergence	Assignment related to the topics
13.	Flaws in point-wise convergence	Quiz
14.	Properties of uniform convergence, related results	Presentations
15.	**Functions of several variables**: limit, continuity	Assignment related to the topics
16.	Partial derivatives, differentiations in R^2	Presentations
17.	Examples and related results	Presentations
18.	**Final Term Exam**	

NUMERICAL ANALYSIS

Credit Hours: 03(3-0) **Course Code: MATH-606**

Prerequisite(s): Basic Calculus

Course Objectives:

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.

Learning Outcomes: Upon successful completion of Numerical Analysis I, a student will be able to:

- Derive numerical methods for approximating the solution of problems of continuous mathematics,
- Analyze the error incumbent in any such numerical approximation,
- Implement a variety of numerical algorithms using appropriate technology, and

- Compare the viability of different approaches to the numerical solution of problems arising in roots of solution of non-linear equations, interpolation and approximation, numerical differentiation and integration, solution of linear systems.

Recommended Book:

1. McCracken, D.D., A guide to Fortran IV programme, Second Edition, John Wiley & Sons, Inc, New York, London, Sydney, Toronto, 1979.
2. Conte, S.D. and Boor, C., Elementary Numerical Analysis, McGraw-Hill 1980.
3. Ahmad, F. and Rana, M.A., Elements of Numerical Analysis, National Book Foundation, Islamabad, 1995.
4. Zurmuhl, R., Numerical Analysis for Engineers and Physicists, Springer-Verlag 1976.

Contents:

Week	Topics	Remarks
1.	**Number Systems and Errors:** Loss of significance and error propagation, condition and instability	
2.	Error estimation; floating point arithmetic; loss of significance and error propagation	Assignment related to the topics
3.	**Interpolation by Polynomials:** Existence and uniqueness of the interpolating polynomial	
4.	Lagrangian interpolation, the divided difference table. Error of the interpolating polynomial	Quiz
5.	Interpolation with equally spaced data, Newton's forward difference formulas	Assignment related to the topics
6.	Newton's backward difference formulas, Bessel's interpolation formula	
7.	**Solution of non-linear Equations:** Bisection method, iterative methods, secant and regula-falsi methods	Quiz
8.	**Mid Term Exam**	
9.	Fixed point iteration, convergence criterion for a fixed point iteration, Newton-Raphson method	Quiz
10.	Order of convergence of Newton-Raphson and secant methods. **System of Linear Equations:** Gauss elimination methods	Assignment related to the topics
11.	Triangular factorization, Crout method	Quiz
12.	**Iterative methods:** Jacobi method, Gauss-Seidel method	Assignment related to the topics
13.	SOR method, convergence of iterative methods	Quiz
14.	**Numerical Differentiation:** Numerical differentiation formulae based on interpolation polynomials, error estimates	Presentations
15.	**Numerical Integration:** Newton-Cotes formulae	Assignment related to the topics
16.	Trapezoidal rule, Simpsons formulas, composite rules	Presentations
17.	Error estimation of integration formulas	Presentations
18.	**Final Term Exam**	

ORDINARY DIFFERENTIAL EQUATIONS

Credit Hours: 03(3-0) **Course Code: MATH-501**
Prerequisite(s): Calculus
Course Objectives: To introduce students to the formulation, classification of differential equations and existence and uniqueness of solutions. To provide skill in solving initial value and boundary value problems. To develop understanding and skill in solving first and second order linear homogeneous and non-homogeneous differential equations and solving differential equations using power series methods.

Learning Outcomes: Upon successful completion of Theory of Ordinary Differential Equations, a student will be able to:

- Solve problems in ordinary differential equations, dynamical systems, stability theory, and a number of applications to scientific and engineering problems,
- Demonstrate their ability to write coherent mathematical proofs and scientific arguments needed to communicate the results obtained from differential equation models,
- Demonstrate their understanding of how physical phenomena are modeled by differential equations and dynamical systems,
- Implement solution methods using appropriate technology, and
- Investigate the qualitative behavior of solutions of systems of differential equations and interpret in the context of an underlying model.

Recommended Book:

1. Morris, M and Brown, O.E., Differential Equations, Englewood Cliffs, Prentice-Hall, 1964.
2. Spiegel, M.R., Applied Differential Equations, Prentice-Hall, 1967.
3. Chorlton, F., Ordinary Differential and Difference Groups, Van Nostrand, 1965.
4. Brand, L., Differential and Difference Equations, John-Wiley, 1966.
5. Zill, D.G and Cullen, M.R., Advanced Engineering Mathematics PWS, Publishing Co. 1992.
6. Rainville, E.D. and Bedient, P.E., Elementary Differential Equations, MaCmillian Company, New York, 1963

Contents:

Week	Topics	Remarks
1.	Definitions and occurrence of differential equations	
2.	Remarks on existence and uniqueness of solution	Assignment related to the topics

3.	First order and simple higher order differential equations	
4.	Special equations of 1st order	Quiz
5.	Elementary applications of 1st order differential equations	Assignment related to the topics
6.	Theory of linear differential equations	
7.	Linear equations with constant coefficients.	Quiz
8.	**Mid Term Exam**	
9.	Methods of undetermined coefficients and variation of parameter	Quiz
10.	Continue…	Assignment related to the topics
11.	SL boundary value problems	Quiz
12.	Self-adjoint operators	Assignment related to the topics
13.	Fourier series	Quiz
14.	Series solution of differential equations	Presentations
15.	The Bessel modified Bessel Legendre	Assignment related to the topics
16.	Hermit, Hyper geometric	Presentations
17.	Lauguere equations and their solutions. Orthogonal polynomials	Presentations
18.	**Final Term Exam**	

VECTOR AND TENSOR ANALYSIS

Credit Hours: 03(3-0) **Course Code: MATH-552**
Prerequisite(s): Math-A
Background and Goals: This course shall assume background in calculus. It covers basic principles of vector analysis, which are used in mechanics.
Learning Outcomes: Upon completion the course, students will be able to solve different problem in vector analysis. Students will also be familiar with tensor analysis as well. Students can easily use and successfully apply green's theorem, stock's theorem and Gauss divergence theorem to other science and engineering problems.
Recommended Books:

1. Bourne DE, Kendall PC, *Vector Analysis and Cartesian Tensors* (2nd edition), Thomas Nelson, 1992.
2. Shah NA, *Vector and Tensor Analysis*, A-One Publishers, Lahore, 2005.
3. Smith GD, *Vector Analysis*, Oxford University Press, Oxford
4. Spiegel MR, *Vector Analysis*, McGraw Hill, New York, 1974.
5. Murray Spiegel and Seymour Lipschutz, Schaum's Outline of Vector Analysis, 2nd edition, 2009.

Contents:

Week	Topics	Remarks
19.	3-D vectors, basic notions and definitions, dot and cross product, linear dependence and independence	
20.	vectors as quantities transforming under rotations with notation,	Assignment related to the topics
21.	scalar-and vector-triple products, scalar- and vector-point functions,	
22.	differentiation and integration of vectors	Quiz
23.	line integrals, path independence, surface integrals	Assignment related to the topics
24.	volume integrals, gradient	
25.	divergence and curl with physical significance and applications	Quiz
26.	**Mid Term Exam**	
27.	vector identities, Green's theorem in a plane	Quiz
28.	divergence theorem, Stokes' theorem	Assignment related to the topics
29.	coordinate systems and their bases, the spherical-polar- and the cylindrical-coordinate meshes,	Quiz
30.	summation convention, kronecker delta, Levi-Caveat symbol, alternating symbol, relation between alternating symbol and kronecker delta	Assignment related to the topics
31.	tensors of first, second and higher orders, algebra of tensors	Quiz
32.	contraction of tensor, quotient theorem, quotient theorem, symmetric and skew-symmetric tensors	Presentations
33.	invariance property, isotropic tensors, differentiation of tensors, application of tensors in modeling anisotropic systems	Assignment related to the topics
34.	study of physical tensors (moment of inertia, index of refraction, etc.),	Presentations
35.	diagnolization of inertia tensor as aligning coordinate frame with natural symmetries of the system	Presentations
36.	**Final Term Exam**	

PARTIAL DIFFERENTIAL EQUATIONS

Credit Hours: 03(3-0) **Course Code: MATH-603**

Prerequisite(s): Ordinary Differential Equation.

Course Objectives: 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.

Learning Outcomes: Upon successful completion of Partial Differential Equations, a student will:

- Be familiar with the modeling assumptions and derivations that lead to PDEs,
- Recognize the major classification of PDEs and the qualitative differences between the classes of equations, and
- Be competent in solving linear PDEs using classical solution methods.

Recommended Book:

1. Sneddon, I.N., Elements of Partial Differential Equations, McGraw-Hill Book Company, 1987.
2. ennemyer, R., Introduction to Partial Differential Equations and Boundary Value Problems, McGraw-Hill Book Company, 1968.
3. Humi, M and Miller, W.B., Boundary Value Problems and Partial Differential Equations, PWS-Kent Publishing Company, Boston, 1992.
4. Chester, C.R., Techniques in Partial Differential Equations, McGraw-Hill Book Company, 1971.
5. Haberman, R., Elementary Applied Partial Differential Equations, Prentice Hall, Inc. New Jersey, 1983.

Contents:

Week	Topics	Remarks
1.	Review of ordinary differential equation in more than one variables.	
2.	Partial differential equations (P.D.E) of the first order.	Assignment related to the topics
3.	Nonlinear P.D.E. of first order Applications of 1st order partial differential equations.	
4.	Partial differential equations of second order: Solution of heat equations.	Quiz
5.	Solution of Laplace equations.	Assignment related to the topics
6.	Solution of wave equations.	
7.	Classification of 2nd order P.D.E.	Quiz
8.	**Mid Term Exam**	
9.	Boundary and initial conditions.	Quiz
10.	Reduction to canonical form	Assignment related to the topics
11.	The solution of 2nd order P.D.E.	Quiz
12.	Technique of separation of variable for the solution of P.D.E with special emphasis on Heat, Laplace and wave equations. Laplace,	Assignment related to the topics
13.	Continue…	Quiz
14.	Continue…	Presentations
15.	Fourier transforms for the solution of P.D.E	Assignment related to the topics

16.	Continue…	Presentations
17.	Applicationof Fourier transforms to boundary value problems.	Presentations
18.	**Final Term Exam**	

COMPLEX ANALYSIS

Credit Hours: 03(3-0) **Course Code: MATH-555**
Prerequisite(s): Math-A
Course Objectives:
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 Advance Calculus), including the ability to write a simple proof in an analysis context.

Learning Outcomes: Upon successful completion of Complex Analysis, a student will be able to:

- Represent complex numbers algebraically and geometrically,
- Define and analyze limits and continuity for complex functions as well as consequences of continuity,
- Apply the concept and consequences of analyticity and the Cauchy-Riemann equations and of results on harmonic and entire functions including the fundamental theorem of algebra,
- Analyze sequences and series of analytic functions and types of convergence,
- Evaluate complex contour integrals directly and by the fundamental theorem, apply the Cauchy integral theorem in its various versions, and the Cauchy integral formula, and Represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.

Recommended Books:

1. Churchill, R.V. Verhey and Brown R., Complex Variables and Applications McGraw-Hill, 1996.
2. Marsden, J.E., Basic Complex Analysis, W.H.Freeman and Co, 1982.
3. Hille, E., Analytic Function Theory, Vols.I and II, Chelsea Publishing Co. New York, 1974.
4. Shaums Outlines Complex Variables.

Contents:

Week	Topics	Remarks
1.	Algebra of complex numbers	
2.	Analytic functions, C-R equations	Assignment related to the topics
3.	Harmonic functions	

4.	Elementary functions	Quiz
5.	Branches of log z, complex exponents	Assignment related to the topics
6.	Integrals: Contours	
7.	Cauchy-Goursat theorem, Cauchy integral formula	Quiz
8.	**Mid Term Exam**	
9.	Moreras theorem, Liouvilles theorem	Quiz
10.	Series: Convergence of sequences and series	Assignment related to the topics
11.	Taylor series, Laurent series	Quiz
12.	Zeros of analytic function.	Assignment related to the topics
13.	Residues and poles: the residue theorem, evaluation of improper integrals,	Quiz
14.	Integrals involving trigonometric functions	Presentations
15.	Integration around a branch point.	Assignment related to the topics
16.	Special Functions: Gamma, Beta,	Presentations
17.	Hyper geometric and Legendre polynomial.	Presentations
18.	**Final Term Exam**	

M.SC. ELECTIVE COURSES

MATHEMATICAL METHODS

Credit Hours: 03(3-0) **Course Code: MATH-554**
Prerequisites: ODE
Specific Objectives of course: The main objective of this course is to provide the students with a range of mathematical methods that are essential to the solution of advanced problems encountered in the fields of applied physics and engineering.
Learning Outcomes: This course will prepare the students with mathematical tools and techniques that are required in advanced courses offered in the applied physics and engineering programs.

Recommended Books:

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

Course Outline:

Week	Topics	Remarks
1.	**Fourier Methods:** The Fourier transforms.	
2.	Continue…	Assignment related to the topics
3.	Fourier analysis of the generalized functions.	
4.	Continue…	Quiz
5.	The Laplace transforms.	Assignment related to the topics
6.	Hankel transforms for the solution of PDEs and their application to boundary value problems.	
7.	Green's Functions and Transform Methods:	Quiz
8.	**Mid Term Exam**	
9.	Expansion for Green's functions.	Quiz

10.	Transform methods.	Assignment related to the topics
11.	Closed form Green's functions.	Quiz
12.	**Variational Methods:** Euler-Lagrange equations.	Assignment related to the topics
13.	Integrand involving one, two, three and n variables.Special cases of Euler-Lagrange's equations.	Quiz
14.	Necessary conditions for existence of an extremum of a functional.Constrained maxima and minima.	Presentations
15.	**Perturbation Techniques:** Perturbation methods for algebraic equations.	Assignment related to the topics
16.	Perturbation methods for differential equations.	Presentations
17.	Continue…	Presentations
18.	**Final Term Exam**	

MEASURE THEORY

Credit Hours: 03(3-0) **Course Code: MATH-602**
Prerequisite(s): Advanced Calculus.

Objectives: This course aims to

- Give a more rigorous introduction to the theory of measure.
- Develop the ideas of Lebesgue integration and its properties.

Learning Outcomes: Student s will be able to:

- Recall the concepts of probability theory and consider them from a measure theoretic point of view.
- Prove the Central Limit Theorem using these methods.

Recommended Books:

1. Natonson, Theory of Functions of Real Variables, 1960.
2. Burkill, Lebesgue Integral, 1951.
3. Titchmarsh, Theory of Functions, Oxford University Press, 1977.
4. Edmon Landou, Foundation of the Analysis.
5. Inder k. Rana. An Introduction to Measure and Integration 2nd Ed. Narosa.

Contents:

Week	Topics	Remarks
1.	Foundation of Analysis, A development of integral,	
2.	Real and complex number system from the Peano axioms,	Assignment related to the topics
3.	Denumerable and non Denumerable sets	
4.	Cardinal and ordinal number	Quiz

5.	Partial ordered sets and Totally ordered sets	Assignment related to the topics
6.	Well order sets, Transfinite induction	
7.	Axiom of choice and well ordering theorem	Quiz
8.	**Mid Term Exam**	
9.	Theory of set of points, covering theorems	Quiz
10.	Theory of Measure, Measurable functions,	Assignment related to the topics
11.	The Lebesgue integral convergence theorem	Quiz
12.	The fundamental theorem of the integral calculus	Assignment related to the topics
13.	Derivative, non differentiable functions	Quiz
14.	Function of bounded variation	Presentations
15.	The Lebesgue class L^p , strong convergence	Assignment related to the topics
16.	Simple treatment of Riemann- Stieltjes	Presentations
17.	Simple treatment Lebesgue- Stieltjes integral	Presentations
18.	**Final Term Exam**	

RINGS AND FIELDS

Credit Hours: 03(3-0) **Course Code: MATH-604**
Prerequisite(s): Group Theory.

Objectives: On completion of the module a student should be able to

- Determine a set is a group / ring with respect to given binary operations.
- Check a given group / ring for certain special conditions.
- Show that a subset of a group / ring is a subgroup / subring or factor group / an ideal.
- Apply reducibility criteria to polynomials.
- Decide if a mapping between groups / rings is a homomorphism and determine the associated subgroups / subrings.
- Perform algebraic calculations in field extensions.

Learning Outcomes: Demonstrate understanding of the idea of a ring, field and an integral domain, and be aware of examples of these structures in mathematics. Appreciate and be able to prove the basic results of ring theory and field extensions. Appreciate the significance of unique factorization in rings and integral domains. Apply the theory in the course to solve a variety of problems at an appropriate level of difficulty. Demonstrate skills in communicating mathematics orally and in writing.
Recommended Books:

1. Fraleigh, J.A., A First Course in Abstract Algebra, Addision Wesley Publishing Company, 1982.
2. Herstein, I.N., Topies in Algebra, John Wiley & Sons 1975.
3. Lang, S., Algebra, Addison Wesley, 1965.
4. Hartley, B., and Hawkes, T.O., Ring, Modules and Linear Algebra, Chapman and Hall, 1980.

Contents:

Week	Topics	Remarks
1.	Introduction to Ring theory and Field and their structure,	
2.	Continue…	Assignment related to the topics
3.	Quotient Rings,	
4.	Integral domain,	Quiz
5.	Homomorphism of a Ring,	Assignment related to the topics
6.	Continue…	
7.	Kernel of a Ring,	Quiz
8.	**Mid Term Exam**	
9.	Isomorphism of a Ring,	Quiz
10.	Maximal ideals,	Assignment related to the topics
11.	Prime ideals,	Quiz
12.	Euclidian rings, or Euclidian domain,	Assignment related to the topics
13.	Polynomial rings over a unique factorization domain,	Quiz
14.	the field of quotients of an integral domain,	Presentations
15.	Field structure, Ordered ring and field,	Assignment related to the topics
16.	introduction to extension field,	Presentations
17.	Algebraic extensions, Finite field.	Presentations
18.	**Final Term Exam**	

FUNCTIONAL ANALYSIS

Credit Hours: 03(3-0) **Course Code: MATH-605**

Prerequisite(s): Real Analysis

Course Objectives:

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.

Learning Outcomes: Upon completion of functional analysis, students will be able to discuss various problems in different space: vector space, inner product space and Hilbert Spaces.

Recommended Book:

1. Kreyszig, E., Introductory Functional Analysis with Applications, John Wiley, 1978.
2. Maddox, J., Elements of Functional Analysis, Cambridge, 1970.
3. Simmon, G.F., Introduction to Topology and Modern Analysis, McGraw-Hill, N.Y.1983.
4. Rudin, W., Functional Analysis, McGraw-Hill, N.Y., 1983.

Contents:

Week	Topics	Remarks
1.	Review of metric spaces,	
2.	**Normed spaces:** Definition and examples of Normed spaces, convergent sequences,	Assignment related to the topics
3.	Cauchy sequences, equivalent norm, quotient norm, and theorems on normed space.	
4.	**Banach Spaces:** Definition and examples of Banach spaces,	Quiz
5.	Characterization of Banach spaces. Bounded Linear Transformations: Bounded linear operators	Assignment related to the topics
6.	Functional and their examples,	
7.	Various characterizations of bounded (continuous) linear operators, The space of all bounded linear operators,	Quiz
8.	**Mid Term Exam**	
9.	The open mapping and closed graph theorems, The dual (conjugate) spaces, Reflexive spaces.	Quiz
10.	Hahn-Banach Theorem: Hahn-Banach theorem (without proof),	Assignment related to the topics
11.	Some important consequences of the Hahn-Banach theorem.	Quiz
12.	**Hilbert Spaces:** Inner product spaces and their examples	Assignment related to the topics
13.	Continue…	Quiz
14.	The Cauchy-Schwarz inequality,	Presentations
15.	Hilbert spaces	Assignment related to the topics
16.	Orthogonal complements, The projection theorem	Presentations
17.	The Riesz representation theorem	Presentations
18.	**Final Term Exam**	

MATHEMATICAL MODELING

Credit Hours: 03(3-0) **Course Code: MATH-601**

Prerequisite(s): ODEs

Course Objectives: The aim of this course is to: (1) Teach students how to mathematically model engineering/ real world problems and (2) Teach students how to use computer tools to

solve the resulting mathematical models. The computer tool used is MATLAB and Maple and the focus will be on developing and solving models of problems encountered in engineering/ real world phenomenon.

Learning Outcomes: After completing the course, students are expected to construct and solve both analytically and numerically mathematical models obtained from various real world phenomenons.

Recommended Books:

1. Giordano F.R. Weir M.D. Differential Equations, A modeling Approach, Addison-Weslly, Reading, Ma, USA, 1994.
2. Zill, D.G. Cullen, M.R. Differential Equation with boundary Value Problem.
3. Erwin Kreszig, Advanced Engineering Mathematics (John Willey and Sons).
4. Myint U.T. Debnath L, Partial Differential Equations for Scientist and Engineers 3rd Ed North Holland, Amsterdam. 1987.

Contents:

Week	Topics	Remarks
1.	Concept of models, modeling and simulation functions,	
2.	Continue	Assignment related to the topics
3.	**ODE:** modeling with first order differential equations: Newton's law of cooling	
4.	Radioactive decay, Growth and decay problems	Quiz
5.	Half-life, motional in the gravitational field	Assignment related to the topics
6.	Modeling with 2nd order differential equation: Vibrations	
7.	Modeling with system of 1st order differential equations	Quiz
8.	**Mid Term Exam**	
9.	**PDE:** Methodology of Mathematical modeling	Quiz
10.	Objective, background, approximation and idealization	Assignment related to the topics
11.	Model validation, compounding	Quiz
12.	Modeling waves phenomenon (Wave equation)	Assignment related to the topics
13.	Modeling the heat equation	Quiz
14.	Modeling the potential equation (Laplace equation	Presentations
15.	Equation of continuity,	Assignment related to the topics
16.	Application in fluid Mechanics.	Presentations
17.	Continue	Presentations
18.	**Final Term Exam**	

ADVANCED FUNCTIONAL ANALYSIS

Credit Hours: 03(3-0) **Course Code: MATH-651**

Prerequisite(s): Functional Analysis

Course Objectives:

This course extends methods of linear algebra and analysis to spaces of functions, in more advanced fashion. The course will be mathematically sophisticated and will use ideas both from linear algebra and basis functional analysis.

Learning Outcomes: Upon completion of advanced functional analysis, students will be able to discuss various advanced problems in different space: vector space, inner product space and Hilbert Spaces.

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.

Contents:

Week	Topics	Remarks
1.	The Hahn-Banach theorem,	
2.	Principle of uniform boundedness,	Assignment related to the topics
3.	Continue	
4.	Open mapping theorem,	Quiz
5.	Continue	Assignment related to the topics
6.	Closed graph theorem	
7.	Continue	Quiz
8.	**Mid Term Exam**	
9.	Week topologies	Quiz
10.	The Banach-Alouglu theorem	Assignment related to the topics
11.	Extreme points and the Klein-Milman theorem	Quiz
12.	Continue	Assignment related to the topics
13.	The dual and bidual spaces	Quiz
14.	Continue	Presentations
15.	Reflexive spaces, compact operators	Assignment related to the topics
16.	Spectrum and eigenvalues of an operator	Presentations
17.	Elementary spectral theory	Presentations
18.	**Final Term Exam**	

ADVANCED GROUP THEORY

Credit Hours: 03(3-0) **Course Code: MATH-653**

Prerequisite(s): Group Theory

Objectives: This course aims to further polish the knowledge of the students in the field of Group Theory by introducing some new concepts. Several Theorems and results are discussed so that the students can apply those notions to other fields also.

Learning Outcomes: A student who completes this course successfully will be able to: Define the main concepts and theorems of group theory understand the fundamental results on group theory apply group theoretic reasoning to group actions, symmetry in space apply structural results for abelian, soluble and nilpotent groups prove results in group theory using abstract and rigorous reasoning present an advanced topic in group theory.

Recommended Books:

1. Rose, J.S., A course on group theory, Cambridge University Press, 1978.
2. Magnus, W., Karrass, A., and Solitar., Combinatorial group theory, Dover publication,1966.
3. Husain Taqdir., Introduction to topological groups, W.B. Saunder's Company-Philadelphia and London, 1966.

Contents:

Week	Topics	Remarks
1.	Isomorphism Theorems	
2.	Conjugacy Classes	Assignment related to the topics
3.	Generating Systems for finite Symmetric	
4.	Alternating groups,	Quiz
5.	Endomorphism and automorphism of a group	Assignment related to the topics
6.	Characteristic and Fully invariant subgroups	
7.	Direct product of a group	Quiz
8.	**Mid Term Exam**	
9.	Syllow theory and its applications	Quiz
10.	Continue	Assignment related to the topics
11.	Simple group, simplicity of A_n for 5	Quiz
12.	Zessanhaus lemma, Normal series	Assignment related to the topics
13.	Composition series	Quiz
14.	Jardon Holder theorem	Presentations
15.	Solvable groups	Assignment related to the topics
16.	The derived series of a group	Presentations

17.	The lower and upper central series of a group and Nilpotent groups, Free group.	Presentations
18.	**Final Term Exam**	

DIFFERENTIAL GEOMETRY

Credit Hours: 03(3-0) **Course Code: MATH-654**

Prerequisite(s): Calculus

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

Learning Outcomes: On satisfying the requirements of this course, students will have the knowledge and skills to:

- Explain the concepts and language of differential geometry and its role in modern mathematics
- Analyze and solve complex problems using appropriate techniques from differential geometry
- Apply problem-solving with differential geometry to diverse situations in physics, engineering or other mathematical contexts
- Apply differential geometry techniques to specific research problems in mathematics or other fields

Recommended Book:

1. Millman,R.S and Parker., G.D. Elements of Differential Geometry, Prentice-Hall Inc.,New Jersey, 1977.
2. Struik, D.J., Lectures on Classical Differential Geometry, Addison-Wesley, Publishing Company, Inc., Massachusetts, 1977.
3. Do Carmo, M.P., Differential Geometry of Curves and Surfaces, Prentice-Hall, Inc., Englewood, New Jersey, 1985.
4. Neil, B.O., Elementary Differential Geometry, Academic Press, 1966.
5. Goetz, A., Introduction to Differential Geometry, Addison-Wesley, 1970.
6. Charlton, F., Vector and Tensor Methods, Ellis Horwood, 1976.

Contents:

Week	Topics	Remarks
1.	Historical background; Motivation and applications. Circle and Sphere curves; Spherical contacts	
2.	Space curves, Arc length	Assignment related to the topics
3.	The moving trihedran Curvature; Principal normal	
4.	Binormal; Torsion; The osculating	Quiz
5.	The normal and the rectifying planes	Assignment related to the topics
6.	The Frenet-Serret Theorem	
7.	Spherical images; Osculating	Quiz
8.	**Mid Term Exam**	
9.	Fundamental theorem of space curves	Quiz

10.	Curves of constant slope and cylindrical helices	Assignment related to the topics
11.	The spherical indicaterices and their curvature and torsion	Quiz
12.	Concept of surface, the tangent and the normal planes	Assignment related to the topics
13.	Envelope and characteristic relating to one parameter family of surfaces	Quiz
14.	Involutes, edge of regression and evolutes	Presentations
15.	Parametric cuves; two fundamental form and the metric tensor;	Assignment related to the topics
16.	Principal direction and principal curvature,	Presentations
17.	Lines of curvatures, Euler's theorem	Presentations
18.	**Final Term Exam**	

MATHEMATICAL BIOLOGY

Credit hours: 03(3-0) **Course Code: MATH-652**

Specific Objective of the Course:

Mathematical biology is a fast-growing, well-recognized, albeit not clearly defined, subject and is, to my mind, the most exciting modern application of mathematics. The increasing use of mathematics in biology is inevitable as biology becomes more quantitative. The complexity of the biological sciences makes interdisciplinary involvement essential. For the mathematician, biology opens up new and exciting branches, while for the biologist, mathematical modeling offers another research tool commensurate with a new powerful laboratory technique but only if used appropriately and its limitations recognized. However, the use of esoteric mathematics arrogantly applied to biological problems by mathematicians who know little about the real biology, together with unsubstantiated claims as to how important such theories are, do little to promote the interdisciplinary involvement which is so essential. Mathematical biology research, to be useful and interesting, must be relevant biologically. The best models show how a process works and then predict what may follow. If these are not already obvious to the biologists and the predictions turn out to be right, then you will have the biologists' attention. Suggestions as to what the governing mechanisms are may evolve from this. Genuine interdisciplinary research and the use of models can produce exciting results, many of which are described in this study.

Corse Outlines:

Population Dynamics , Continuous and Discrete Population Models for Single Species, Models for Interacting Populations, Age-structured Populations, Stochastic Population Growth, Dynamics of Infectious Diseases, Historical Aside on Epidemics, Simple Epidemic Models and Practical Applications , Modeling Venereal Diseases , Multi-Group Model for Gonorrhea and Its Control, AIDS: Modeling the Transmission Dynamics of the Human Immunodeficiency Virus (HIV) , HIV: Modeling Combination Drug Therapy , Delay Model for HIV Infection with Drug Therapy , Modeling the Population Dynamics of Acquired Immunity to Parasite Infection , Age-Dependent Epidemic Model and Threshold Criterion.

Recommended Books:

- Mathematical Biology. An Introduction, Third Edition by J.D. Murray, FRS
- Dynamical Models in Biology by Miklos FarkasSchool of Mathematics, Budapest University of Technology Budapest, Hungary

COMPUTATIONAL MATHEMATICS

Credit Hours: 03(3-0) **Course Code: MATH-655**

Prerequisite(s): A Course of Mathematics in B.Sc level or Maths State at intermediate level.

Objectives: This is a survey course of the basic computational Mathematics which is used to solve practical computational problems. Important concepts such as accuracy, stability, and efficiency are discussed. The course provides an introduction to MATLAB, an interactive program for numerical linear algebra, and may provide practice in FORTRAN programming and the use of software library subroutines. Convergence theorems are discussed and applied, but the proofs are not emphasized.

Learning Outcomes: Upon successful completion of the course:

- Deal accurately with real world problems
- Students shall be able to use and apply a wide variety of computational methods.

Recommended Books:

1. William Ford,Numerical Linear Algebra with Applications: Using MATLAB.

Contents:

Week	Topics	Remarks
1.	Floating point arithmetic,	
2.	Gaussian elimination, polynomial interpolation,	Assignment related to the topics
3.	spline approximations,	
4.	numerical integration and differentiation,	Quiz
5.	Cont…	Assignment related to the topics
6.	solutions to non-linear equations	
7.	ordinary differential equations	Quiz
8.	**Mid Term Exam**	
9.	polynomial approximations	Quiz
10.	Other topics may include discrete Fourier transforms,	Assignment related to the topics
11.	two-point boundary-value problems	Quiz
12.	Matrix product and norm calculation	Assignment related to the topics
13.	LLS Problems and QR-Factorization	Quiz
14.	Gram-schmidt Orthogonalization	Presentations
15.	Householder reflection	Assignment related to the topics
16.	Givens Rotations	Presentations
17.	SVD and its applications	Presentations
18.	**Final Term Exam**	

FUZZY SET THEORY AND APPLICATIONS

Credit Hours: 03(3-0) **Course Code: MATH-607**

Aims and Objectives

The aim of the course is the introduction fuzzy set theory and their Mathematical properties. This is designed for graduate students and the graduate student will learn the basic properties of fuzzy set theory and they will able to apply fuzzy set theory to algebraic structures, Differential equations and partial differential equations.

Learning Outcomes: On successful completion of this course students will be able to

Gain the main subject of fuzzy sets learns crips and fuzzy set theory and to decide the difference between crips set and fuzzy set theory. Also to make calculation on fuzzy set theory and to gain the methods of fuzzy logic. Recognize fuzzy semigroups and fuzzy ideals using membership function. Further, to make applications on Fuzzy membership function and fuzzy set theory.

Recommended Books:

1. Kwang H. Lee , (2005). First Course on Fuzzy Theory and Applications, Springer Berlin Heidelberg NewYork.
2. J. N. Mordeson, D. S. Malik, N. Kuroki.(2003). Fuzzy Semigroups, Springer-Verlag Berlin Heidelberg.
3. H.-J. Zimmermann, *Fuzzy Set Theory and its Applieations*, 3rd edition, International Series in Management SciencesOperation Research (Kluwer-Nijhoff Publishing, Dordrecht, 1988).
4. J.M. Howie, *An Introduction to Semigroup Theory*, Academic Press, London, 1976.

Course Contents:

Week	Topics	Remarks
1.	**Set Theory review:** Sets, Operation of Sets, Characteristics of Crisp Set.	
2.	**Fuzzy Sets**: Brief History of Fuzzy set, Introduction of Fuzzy sets,	Assignment related to the topics
3.	Examples of fuzzy sets,	
4.	Properties of Fuzzy sets.	Quiz
5.	Applications of Fuzzy sets in other fields.	Assignment related to the topics
6.	**Standard Operation of Fuzzy Sets:** Fuzzy Complement, Fuzzy Union,	
7.	Fuzzy Intersection Other Operations in Fuzzy Set.	Quiz
8.	**Mid Term Exam**	
9.	**Fuzzy Relation and Composition:** Crisp Relation,	Quiz
10.	Properties of Relation on a Single Set,	Assignment related to the topics
11.	Fuzzy Relation and Extension of Fuzzy Set,	Quiz

12.	Properties of Fuzzy Relations,	Assignment related to the topics
13.	Fuzzy Equivalence Relations.	Quiz
14.	**Fuzzy Ideals of Semigroups :** Review of ideals of semigroups, Definitions of Fuzzy Left,	Presentations
15.	Fuzzy right and Fuzzy two sided ideals of semigroups,	Assignment related to the topics
16.	Fuzzy generalized bi-ideals,	Presentations
17.	Fuzzy bi-ideals, Fuzzy interior ideals and Fuzzy quasi-ideals.	Presentations
18.	**Final Term Exam**	

DYNAMICAL SYSTEMS

Credit Hours: 03(3-0) **Course Code: MATH-608**

Prerequisite(s): Ordinary Differential Equations, Real Analysis, Linear Algebra

Objectives:

In mathematics, a dynamical system is a system in which a function describes the time dependence of a point in a geometrical space. Examples include the mathematical models that describe the swinging of a clock pendulum, the flow of water in a pipe, and the number of fish each spring time in a lake. The aim of this course is to familiarize students with dynamical system. It uses notions from Real Analysis, Linear Algebra.

Learning Outcomes: Since this subject is widely used is many branches of Mathematics e.g. Fluid Mechanics, Mathematics Biology, Chemical Kinematics, Epidemiology, Physics etc. Therefore, upon successful completion students will be able to solve such dynamical system.

References:

1. Lawrence Perko, Differential Equations and Dynamical Systems, 1996, 1991 Springer-Verlag New York, Inc. 2nd 1996
2. J. P .Lassale, The Stability of Dynamical System, Brown University, Hamilton Press Berlin, New Jersey, USA
3. Hal. L . Smith, Horst R. Thieme, Dynamical System and Population Persistence, Graduate Study in Mathematics Vol: 118, American Mathematical Society, Providence Rhode Island.

Course outline:

Week	Topics	Remarks
1.	**Linear Systems**: Basic tools, Phase space, phase portrait, trajectories, Uncoupled Linear Systems,	
2.	Diagonalization, Exponentials of Operators, The Fundamental Theorem for Linear Systems,	Assignment related to the topics
3.	Complex Eigenvalues, Multiple Eigenvalues, Non-homogeneous Linear Systems,	
4.	**Nonlinear Systems:** Local Theory: Some Preliminary Concepts and Definitions,	Quiz

5.	The Fundamental Existence-Uniqueness Theorem, Dependence on Initial Conditions and Parameters, The Maximal Interval of Existence,	Assignment related to the topics
6.	The Flow Defined by a Differential Equation, Linearization, The Stable Manifold Theorem, The Hartman-Grobman Theorem,	
7.	Stability and Lyapunov Functions, Saddles, Nodes, Foci and Centers Non-hyperbolic Critical Points in R2, Center Manifold Theory.	Quiz
8.	**Mid Term Exam**	
9.	**Nonlinear Systems Global Theory**: Dynamical Systems and Global Existence Theorems,	Quiz
10.	Limit Sets and Attractors, Periodic Orbits, Limit Cycles and Separatrix Cycles,	Assignment related to the topics
11.	The Poincare Map, The Stable Manifold Theorem for Periodic Orbits,	Quiz
12.	Hamiltonian Systems with Two Degrees of Freedom ,	Assignment related to the topics
13.	The Poincare-Bendixson Theory in R2 , Lienard Systems, Bendixson's Criteria.	Quiz
14.	**Nonlinear Systems: Bifurcation Theory:** Structural Stability and Peixoto's Theorem, Bifurcations at Non-hyperbolic Equilibrium Points,	Presentations
15.	Hopf Bifurcations and Bifurcations of Limit Cycles from multiple focus	Assignment related to the topics
16.	Bifurcations at Non-hyperbolic Periodic Orbits	Presentations
17.	Homoclinic Bifurcations, Melnikov's Method, Global Bifurcations of Systems in R2	Presentations
18.	**Final Term Exam**	

FLUID MECHANICS

Credit Hours: 03(3-0) **Course Code: MATH-656**

Prerequisite(s): Mechanics.

Objectives: To know the fundamentals of Fluid Mechanics and its applications.

Learning Outcomes: Upon successful completion of the course, students will be able to use computational aspect for solving diffusion equation.

Recommended Books:

1. Chorlton, F., Textbook of fluid Dynamics, D. Van Nostrand Co. Ltd. 1967.
2. Thomson, M., Theoretical Hydrodynamics, Macmillan Press, 1979.
3. Jaunzemics, W., Continuum Mechanic, Machmillan Company, 1967.
4. Landau, L.D., and Lifshitz, E.M., Fluid Mehanics, Pergamon Press, 1966.

5. Batchelor, G.K., An Introduction to Fluid Dynamics, Cambridge University Press, 1969.

Contents:

Week	Topics	Remarks
1.	Introduction, Real fluids and ideal fluids,	
2.	Velocity of a fluid at a point,	Assignment related to the topics
3.	Streamlines and path lines,	
4.	Steady and unsteady flows	Quiz
5.	Velocity potential,	Assignment related to the topics
6.	Vorticity vector,	
7.	Local and particle rates of change,	Quiz
8.	**Mid Term Exam**	
9.	Equation of continuity.	Quiz
10.	Acceleration of a fluid,	Assignment related to the topics
11.	Conditions at a rigid boundary,	Quiz
12.	General analysis of fluid motion.	Assignment related to the topics
13.	Euler's equations of motion,	Quiz
14.	Bernoulli's equation steady motion under conservative body forces,	Presentations
15.	Some potential theorems,	Assignment related to the topics
16.	Impulsive motion.	Presentations
17.	Sources, sinks and doublets.	Presentations
18.	**Final Term Exam**	

ANALYTICAL MECHANICS

Credit Hours: 03(3-0) **Course Code: MATH-609**

Prerequisite(s): Calculus

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

Learning Outcomes: On successful completion of the course, students will be able to use the techniques of calculus of variation to find an optimal system from a given system. Apart this, students will be able to find Lagrangian and Hamiltonian for a given mechanical system.

Recommended Books:

1. Chorlton, F., Principles of Mechanics, McGraw Hill, N.Y 1983.
2. Symon, K.R., Mechanics, Addison Wesley, 1964.
3. Goldstein, H., Classical Mechanics, Addison Wesley, 2nd Edition, 1980.
4. Synge, J. I. and Griffith, B. A., Principles of Mechanics, McGraw-Hill, N.Y.1986.
5. Beer, F. P. and Johnston, E. R., Mechanics for Engineers, Vols.I&II, McGraw.

Contents:

Week	Topics	Remarks
1.	Review of basic principles	
2.	Kinematics of particle	Assignment related to the topics
3.	Rigid body in three dimension;	
4.	Work, Power, Energy,	Quiz
5.	Conservative field of force	Assignment related to the topics
6.	Impulsive forces,	
7.	Rectilinear particle motion,	Quiz
8.	**Mid Term Exam**	
9.	S.H.M, Damped and forced oscillation	Quiz
10.	Continue	Assignment related to the topics
11.	Moments and products of inertia,	Quiz
12.	Angular momentum, motion of a projectile	Assignment related to the topics
13.	Orbital motion, Keplar's laws,	Quiz
14.	Kinetic energy about a fixed point	Presentations
15.	Systems of particles, principal axes	Assignment related to the topics
16.	Motion replacing relative to the rotating earth,	Presentations
17.	D' Alembert's principal, Generalized coordinates.	Presentations
18.	**Final Term Exam**	

RESEARCH PROJECT

Credit Hour: 03(3-0) **Course Code: MATH-699**

With accompanying written report and presentation

NUMERICAL METHODS

Credit Hours: 03(3-0) **Course Code: MATH-667**
Prerequisite(s): Numerical Computing or Numerical Analysis.
Objectives:

- To gain knowledge on numerical and computational techniques used in solving common engineering problems.
- To understand the advantages and disadvantages of the different methods and to be able to choose adequate methods for different classes of problems.
- To be able to formulate a solution strategy for manual or computer implementation.

Learning Outcomes: Upon successful completion of Numerical Analysis II, a student will be able to:

- Derive numerical methods for approximating the solution of problems of continuous mathematics,
- Analyze the error incumbent in any such numerical approximation,
- Implement a variety of numerical algorithms using appropriate technology, and
- Compare the viability of different approaches to the numerical solution of problems arising in roots of solution of non-linear equations, interpolation and approximation, numerical differentiation and integration, solution of linear systems.

Recommended Books:

1. Conte, S.D., and De Boor., Elementary Numerical Analysis, McGraw-Hill 1972.
2. Gerald, C.F., Applied Numerical Analysis, Addison Wesely, 1984.
3. Froberg, C.E., Introduction to Numerical Analysis, Addison Wesely, 1972.
4. Gourlay, A.R. and Watson, G.A., Compitational Methods for Matrix Eigene Problems. John Wiley & Sons 1973.
5. Ahmad, F. and Rana, M.A., Elements of Numerical Analysis, National Book Foundation, Islamabad, 1995.
6. Zurmuhl, R., Numerical Analysis for Engineers and Physicists, Springer-Verlag 1976.

Contents:

Week	Topics	Remarks
1.	Differentiation and integration in multi-dimension.	
2.	Ordinary differential equations: Predictor methods,	Assignment related to the topics
3.	Modified Eulers method,	
4.	Truncation error and stability,	Quiz
5.	The Taylor series method,	Assignment related to the topics

6.	Runge-Kutta methods	
7.	Differential equations of higher order: System of differential equations;	Quiz
8.	**Mid Term Exam**	
9.	Shooting methods, finite difference methods.	Quiz
10.	Partial differential equations: Elliptic hyperbolic and parabolic equations;	Assignment related to the topics
11.	Continue	Quiz
12.	Explicit and implicit finite difference methods, stability, convergence and consistency analysis,	Assignment related to the topics
13.	The method of characteristic.	Quiz
14.	Eigen value problems; Estimation of eigenvalues and corresponding error bounds,	Presentations
15.	Gerschgorins theorem and its applications Schurs theorem,	Assignment related to the topics
16.	Power method, Shift of origin,	Presentations
17.	Deflation method for the subdominant eigenvalues.	Presentations
18.	**Final Term Exam**	

INTEGRAL EQUATIONS

Credit Hours: 03(3-0) **Course Code: MATH-619**

Prerequisite(s): Real Analysis, ODEs

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

Learning Outcomes: On completion of the module the learner will be able to:

- use Fourier transforms for solving a wide range of differential and integral equations
- formulate and solve initial and boundary value problems for the heat and wave equations in spherical and cylindrical coordinates
- solve linear Volterra and Fredholm integral equations using appropriate methods
- understand the relationship between integral and differential equations and transform one type into another.

Recommended Books:

1. Lovitt, W.V., Linear integral equations, Dover Publications 1950.
2. Smith, F., Integral equations, Cambridge University Press.
3. Tricomi, F.G., Integral equations, Interscience, 1957.
4. B. Noble., Methods based on the Wiener-Hopf technique, Pergamon Press, 1958.

5. Abdul J. Jerri., Introduction to integral equations with applications, Marcel Dekker Inc. New York, 1985.

Contents:

Week	Topics	Remarks
1.	Linear integral equations of the first kind,	
2.	Linear integral equations of the second kind	Assignment related to the topics
3.	Relationship between differential equation and Volterra integral equation	
4.	Neumann series.	Quiz
5.	Fredholm Integral equation of the second kind with separable Kernels	Assignment related to the topics
6.	Eigenvalues and eigenvectors	
7.	Iterated functions.	Quiz
8.	**Mid Term Exam**	
9.	Quadrature methods.	Quiz
10.	Least square methods.	Assignment related to the topics
11.	Homogeneous integral equations of the second kind	Quiz
12.	Fredholm integral equations of the first kind	Assignment related to the topics
13.	Fredholm integral equations of the second kind	Quiz
14.	Abel's integral equations	Presentations
15.	Hilbert Schmidt theory of integral equations with symmetric Kernels.	Assignment related to the topics
16.	Continue…	Presentations
17.	Regularization and filtering techniques.	Presentations
18.	**Final Term Exam**	

ANALYTICAL DYNAMICS

Credit Hours: 03(3-0) **Course Code: MATH-660**

Prerequisite(s): Analytical Mechanics.

COURSE OBJECTIVES: The objective of this course is to provide a thorough and systematic introduction to the subject of dynamics of particles and rigid bodies using a Newton-Euler approach. All development is done in a coordinate-free manner and will be applied to several examples.

Learning Outcomes: Upon successful completion of this course, the student will be able to: *(Knowledge based)*

- derive equation of motions of rigid bodies,
- derive and apply the Lagrange's equation;*(Skills)*

- demonstrate good knowledge of the use of the Lagrange's equation for deriving equation of motions; and
- apply the knowledge in Dynamics at higher levels.

Recommended Books:

1. Chorlton, F., Textbook of dynamics, Van Nostrand, 1963.
2. Chester, W., Mechanics, George Allen and Unwin Ltd., London 1979.
3. Goldstein, H., Classical Mechanics, Cambridge, Mass Addison-Wesley, 1980. (latest edition).
4. G. Meirovitch. L., Methods of Analytical Dynamics, McGraw-Hill, 1970.

Contents:

Week	Topics	Remarks
1.	Introduction, Constraints,	
2.	generalized co-ordinates, generalized forces,	Assignment related to the topics
3.	general equation of dynamics,	
4.	Lagrange's equations,	Quiz
5.	conservation laws, ignorable co-ordinates,	Assignment related to the topics
6.	Explicit form of Lagranges equation in terms of tensors	
7.	Hamiltons principle, principle of least action	Quiz
8.	**Mid Term Exam**	
9.	Hamiltons equations of motion	Quiz
10.	Hamilton-Jacobi Method.	Assignment related to the topics
11.	Poisson Brackets (P.Bs); Poissons theorem;	Quiz
12.	Solution of mechanical problems by algebraic technique based on (P.Bs).	Assignment related to the topics
13.	Small oscilations and normal modes,	Quiz
14.	vibrations of strings, transverse vibrations,	Presentations
15.	normal modes, forced vibrations and damping,	Assignment related to the topics
16.	reflection and transmission at a discontinuity,	Presentations
17.	Iongitudinal vibrations, Rayleighs principle.	Presentations
18.	**Final Term Exam**	

THEORY OF MODULES

Credit Hours: 03(3-0) **Course Code: MATH-662**

Prerequisite(s): Group Theory.

Objectives: This course aims to introduce some new notions in pure Mathematics. Modules play an important role in Mathematics. After completion of the course, students will be able to solve several problems of Homological Algebra.

Learning Outcomes: A student who completes this course successfully will be able to: The structure of module, sub module, quotient, cyclic modules etc. He will be able to apply these concepts in the homological algebra. A student will also know noetherian rings, semi-simple rings and basic theorems of modules. He will also be able to construct examples using these notions.

Recommended Books:

1. Adamson, J., Rings and modules. Blyth, T.S., Module theory, Oxford University Press, 1977.
2. Hartley, B. and Hawkes, T.O., Rings, Modules and Linear algebra, Chapman and Hall, 1980.
3. Herstein, I.N., Topics in Algebra, John Wiley and Sons, 1975.

Contents:

Week	Topics	Remarks
1.	Elementary notions and examples,	
2.	Continue…	Assignment related to the topics
3.	Continue…	
4.	Modules	Quiz
5.	Sub-modules	Assignment related to the topics
6.	Continue…	
7.	quotient modules,	Quiz
8.	**Mid Term Exam**	
9.	finitely generated and cyclic modules	Quiz
10.	Continue…	Assignment related to the topics
11.	Continue…	Quiz
12.	exact sequences	Assignment related to the topics
13.	elementary notions of homological algebra	Quiz
14.	Continue…	Presentations
15.	Noetherian and Artinian rings and modules	Assignment related to the topics
16.	Radicals	Presentations
17.	semi-simple rings and modules	Presentations
18.	**Final Term Exam**	

ADVANCED COMPLEX ANALYSIS

Credit Hours: 03(3-0) **Course Code: MATH-618**

Prerequisite(s): Complex Analysis.

Course Objectives:

This is an advanced course in complex analysis, giving advanced level theory of complex analysis along with applications, with an emphasis on applications of complex analysis and especially conformal mappings.

Learning Outcomes: Upon successful completion of this course, the student will be able to:

- Manipulate complex numbers in various representations, define fundamental topological concepts in the context of the complex plane, and define and calculate limits and derivatives of functions of a complex variable.
- State and prove fundamental results, including: Cauchy's Theorem and Cauchy's Integral Formula, the Fundamental Theorem of Algebra, Morera's Theorem and Liouville's Theorem. Use them to prove related results.
- Represent analytic functions as power series on their domains and verify that they are well-defined. Define a branch of the complex logarithm. Classify singularities and find Laurent series for meromorphic functions.

Recommended Books:

1. Churchill, R.V. Verhey and Brown R., Complex Variables and Applications McGraw-Hill, 1996.
2. Marsden, J.E., Basic Complex Analysis, W.H.Freeman and Co, 1982.
3. Hille, E., Analytic Function Theory, Vols.I and II, Chelsea Publishing Co. New York, 1974.
4. Shaums Outlines Complex Variables.

Contents:

Week	Topics	Remarks
1.	Conformal mapping	
2.	Preservation of mapping,	Assignment related to the topics
3.	Scale Factors	
4.	Local inverses	Quiz
5.	Harmonic Conjugates,	Assignment related to the topics
6.	Transformation of Harmonic functions	
7.	Transformation of boundary conditions	Quiz
8.	**Mid Term Exam**	
9.	Application of conformal mapping	Quiz
10.	The Schwarz-Christoffel transformation	Assignment related to the topics
11.	Integral formula	Quiz

12.	the Poisson type, Dirichlet problem for a disk	Assignment related to the topics
13.	Schwarz integral formula	Quiz
14.	Neumann problems	Presentations
15.	mapping by elementary functions,	Assignment related to the topics
16.	linear frictional transformation, linear functional, the function $\frac{1}{Z}$	Presentations
17.	the transformation $w = \exp(z)$ and $w = \sin z$ Analytic continuation	Presentations
18.	**Final Term Exam**	

QUANTUM MECHANICS

Credit Hours: 03(3-0) **Course Code: MATH-611**

Prerequisite(s): Analytical Mechanics, Modern Physics.

Objectives:

This course will help in understanding the behavior of quantum mechanical particle and development of Schrodinger equation in one and three dimensions. Also the course aims to introduce the quantum mechanical operators and to determinate the angular momentum of a quantum mechanical particle.

Learning Outcomes: Students who have completed this course should

- Have a deep understanding of the mathematical foundations of quantum mechanics,
- Be able to solve the Schrodinger equation for simple configurations,
- Understand the effect of symmetries in quantum mechanics.

Recommended Books:

1. Richard L. Liboff Introductory Quantum Mechanics 4th Ed.
2. David J. Griffith. Introduction to Quantum Mechanics 2nd Ed.
3. Quantum Mechanics Schaum out line series.

Contents:

Week	Topics	Remarks
1.	Wave-Particle	
2.	Plan-Einstein relation,	Assignment related to the topics
3.	Debroglie relations	
4.	Schrodinger equation, Normalization of wave function	Quiz
5.	Waves-Pocket,	Assignment related to the topics
6.	Heisenberg indeterminacy or UIXCER Taint principal	
7.	Phase velocity	Quiz
8.	**Mid Term Exam**	

9.	Group velocity, Stationary states, Properties of a waves function	Quiz
10.	Linear operators, Orthogonal basis in waves equation, Closure relation,	Assignment related to the topics
11.	Parseval relation, Orthonormalization relation, Delta functions, Ketand Bro vectors,	Quiz
12.	The adjoint operators,Eigen value equations and observables	Assignment related to the topics
13.	Projection operation, Basic postulates of Quantum theory	Quiz
14.	Implementations of the Schrödinger Equations, Conservative system,	Presentations
15.	Angular momentum, Time-Energy Uncertainty	Assignment related to the topics
16.	Raising operators, Spin Observable, Hormonic oscillator,	Presentations
17.	Hydrogenic atoms, Pavli Exclusion Principal.	Presentations
18.	**Final Term Exam**	

ELECTROMAGNETISM

Credit Hours: 03(3-0) **Course Code: MATH-610**

Prerequisite(s): Analytical Mechanics.

Objectives:

The main objective of this course is to understand the Physics of Electromagnetism and to develop simple mathematical formalisms to analyzethe electromagnetic fields and interactions. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.

Learning Outcomes: Students who completed this course should

- Have a deep understanding of the theoretical foundations of electromagnetic phenomena,
- Be able to solve the Maxwell equations for simple configurations,
- Have a working knowledge of special relativity.

Recommended Books:

1. Ferroro, Electromagnetism Theory.
2. Ramsy, A.S. Electricity and Magnetism.

Contents:

Week	Topics	Remarks
1.	The electromagnetic law of force, Potential and field for several charges,	
2.	Equipotential and lines of force,	Assignment related to the topics
3.	Gauss's flux theorem, electronics potential energy of a system of charges,	

4.	energy of a system of conductors,	Quiz
5.	dielectrics, the magneto static law of forces,	Assignment related to the topics
6.	magnetic doublets, magnetic shells,	
7.	forces on magnetic doublets,	Quiz
8.	**Mid Term Exam**	
9.	magnetic induction,	Quiz
10.	electric current, conductivity,	Assignment related to the topics
11.	resistance, Kirchhoff's laws,	Quiz
12.	maximum energy theorem,	Assignment related to the topics
13.	magnetic field and energy law of electromagnetic induction, Current of A.C.	Quiz
14.	Maxwell's equations in free space and in material,	Presentations
15.	media and their solution in simple cases,	Assignment related to the topics
16.	Continue…	Presentations
17.	Electromagnetic waves, reflection, refraction and polarization.	Presentations
18.	**Final Term Exam**	

ADVANCED NUMBER THEORY

Credit Hours: 03(3-0) **Course Code: MATH-668**
Prerequisite(s): Number Theory
Course Objectives:
The focus of the course is to study more advance properties of integers and develops ability to prove advance level theorems.

Learning Outcomes: Upon successful completion of Math 319 - Number Theory, a student will be able to:

- Define and interpret the concepts of divisibility, congruence, greatest common divisor, prime, and prime-factorization,
- Apply the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues,
- Formulate and prove conjectures about numeric patterns, and

- Produce rigorous arguments (proofs) centered on the material of number theory, most notably in the use of Mathematical Induction and/or the Well Ordering Principal in the proof of theorems.

Recommended Books:

1. The Theory of Algebraic Numbers, John Wiley.
2. Hardy and Wright, Number Theory, Clarendon presses.
3. Grass Wald E. Topics from the theory of Numbers, the Mc. Millen Company, New York.
4. Leveque W.J. Topics in Number Theory Vol: I and II, (Addison-Wesley Publisher Company)

Contents:

Week	Topics	Remarks
1.	Review of Basic Algorithm, Congruence,	
2.	Residue classes and Euler's ϕ function,	Assignment related to the topics
3.	Linear Congruence and Congruence of higher degree,	
4.	the theorem of Fermat's,	Quiz
5.	Euler and Wilson's. Primitive roots and indices,	Assignment related to the topics
6.	Integers belonging to a given exponent, composite module,	
7.	Indices, Quadratic Residues, Composite module, Legendre Symbols,	Quiz
8.	**Mid Term Exam**	
9.	laws of Quadratic reciprocity, the Jacobi symbol,	Quiz
10.	Number theoretic functions, Mobius functions,	Assignment related to the topics
11.	Diophantine equation and Fermat's conjecture,	Quiz
12.	for $N = 2,\ N = 4$, Algebraic number and integers, Units and primes R(V) Ideals,	Assignment related to the topics
13.	Arithmetic of Ideals, the norm of prime Ideals, Unit of Algebraic number field.	Quiz
14.	Applications to Rational Number Theory,	Presentations
15.	Equivalence and Class number Cyclotomic field K. Fermat's equations,	Assignment related to the topics
16.	Kummer's Theorem, Pure Cubic field,	Presentations
17.	Distribution of primes and Riemes and Riemann function, the prime number theorem.	Presentations
18.	**Final Term Exam**	

ITEM NO: THREE

Annexure C

Master of Philosophy in Mathematics

Degree Awarded: Master of Philosophy in Mathematics (M. Phil in Mathematics)

Entrance Requirements: M. Sc Mathematics or BS Mathematics (with at least 50% marks In annual system or with at least 2.5 CGPA) and 50% score in the entrance test as per requirement of the university

Total Credit Hours: **30 (**24 Credit Hour for Course Work and 06 Credit Hour for the Thesis)

Marks Breakdown for Courses

Item	Maximum Marks for Courses (3 - 0)
Mid-Term Examination	30%
Internal Marks (Assignments, Quizzes, Presentations)	20%
Final-Term Examination	50%
Total	100

SCHEME OF STUDIES

(Semester-Wise Breakdown)

1TH SEMESTER

S. No.	Course Code	Course Title	Marks	Credit Hours
1	MATH-	Elective -I	100	3(3-0)
2	MATH-	Elective –II	100	3(3-0)
3	MATH-	Elective –III	100	3(3-0)
4	MATH-	Elective-IV	100	3(3-0)
Total			**400**	**12**

2th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
5	MATH-	Elective-V	100	3(3-0)
6	MATH-	Elective-VI	100	3(3-0)
7	MATH-	Elective-VII	100	3(3-0)
8	MATH-	Elective-VIII	100	3(3-0)
Total			**400**	**12**

M. Phil COURSES

S. No	Course Code	Course Name	Credit hours
1	MATH-701	Advanced Real Analysis	03(3-0)
2	MATH-702	ODEs and Computational Linear Algebra	03(3-0)
3	MATH-703	Mathematical Techniques	03(3-0)
4	MATH-704	Partial Differential Equations	03(3-0)
5	MATH-705	Integral Equations	03(3-0)
6	MATH-706	Higher Algebra	03(3-0)
7	MATH-707	Banach Algebra	03(3-0)
8	MATH-708	Numerical Methods	03(3-0)
9	MATH-709	Riemannian Geometry	03(3-0)
10	MATH-710	Mathematical Physics	03(3-0)
11	MATH-711	LA-semi groups	03(3-0)
12	MATH-712	Lebesgue Spaces with Variable Exponent	03(3-0)
13	MATH-713	Ring Theory and Applications	03(3-0)
14	MATH-714	Measure Theory	03(3-0)
15	MATH-715	Semi group Theory	03(3-0)
16	MATH-716	Fuzzy Group Theory	03(3-0)
17	MATH-717	Approximation Theory	03(3-0)
18	MATH-718	Impulsive Differential Equations	03(3-0)
19	MATH-719	Finite Element Methods	03(3-0)
20	MATH-720	Fourier Analysis	03(3-0)
21	MATH-721	Fixed Point Theory in Modular Function Spaces	03(3-0)
22	MATH-722	Numerical Methods for Partial Differential Equations	03(3-0)

23	MATH-723	Fluid Mechanics	03(3-0)
24	MATH-724	Introduction To Computational Software and Research Methodology	03(3-0)
25	MATH-725	Mathematical Inequalities And Applications	03(3-0)
26	MATH-751	Graph Theory	03(3-0)
27	MATH-752	Applied Dimension Analysis and Modeling	03(3-0)
28	MATH-753	Numerical Solution of Differential Equations	03(3-0)
29	MATH-754	Fixed Point Theory	03(3-0)
30	MATH-755	Dynamical Systems and Ergodic Theory	03(3-0)
31	MATH-756	Mathematical Modeling in Physical Sciences	03(3-0)
32	MATH-757	Methods of Mathematical Physics	03(3-0)
33	MATH-758	Dynamical Systems and Control Theory	03(3-0)
34	MATH-759	Fuzzy Sets and their Applications	03(3-0)
35	MATH-760	Fractional Differential Equations	03(3-0)
36	MATH-761	Applications of Fixed Point Theory in Generalized Spaces	03(3-0)
37	MATH-762	Advance Mathematical Methods	03(3-0)
38	MATH-763	Mathematical Methods For Arbitrary order Differential Equations	03(3-0)
39	MATH-764	Theory of Majorization	03(3-0)
40	MATH-765	Fuzzy Algebra	03(3-0)
41	MATH-766	Nonlinear Analysis and its Applications	03(3-0)
42	MATH-767	Near Rings	03(3-0)
43	MATH-768	Topological Algebra	03(3-0)
44	MATH-769	Nilpotent And Soluble Groups	03(3-0)
45	MATH-770	Nonlinear Dynamics and Nonlinear Waves Phenomena	03(3-0)
46	MATH-771	Optimization Theory	03(3-0)
47	MATH-772	Dynamical System Theory	03(3-0)
48	MATH-773	Biomechanics	03(3-0)
49	MATH-774	Applied Numerical Analysis	03(3-0)

50	MATH-775	Mathematical Biology	03(3-0)
51	MATH-776	Computational Fluid Dynamics	03(3-0)
52	MATH-798	M. Phil Dissertation	06

Course Contents

ADVANCED REAL ANALYSIS

Credit hours: 03(3-0) **Course Code: MATH-701**

Specific Objective of the Course: This course will appeal to the students in pure and applied mathematics as well as research in statistics, education, engineering and economics. This course addresses functions spaces and provides familiar applications, such as the Weierstrass and Stone-Weierstrass approximation theorems, functions of bounded variation, Riemann-Stieltjes integration etc. This course is an enormous field with application to many areas of mathematics. Roughly speaking, it has applications to any setting where one integrates functions, ranging from harmonic analysis on Euclidean space to partial differential equations on manifolds, from representation theory to number theory, from probability theory to integral geometry, from ergodic theory to quantum mechanics.

Course Outlines: Infinite Dimensional Spaces, Sequence Spaces, Completions, Metric Spaces, Quasi Metric Space, Normed Vector Spaces, Limits in Metric Spaces, More Inequalities, Continuous Functions, Homeomorphisms, The Space of Continuous Functions, Connected Sets, Compactness, Continuous Functions on a Compact Interval, Compact Metric Spaces, Sequences of Functions, Point wise and Uniform Convergence ,Interchanging Limits, The Space of Bounded Functions, Functions of Bounded Variation, Separable Spaces, Power Series, Radius of Convergence, Riemann-Stieltjes Integral ,The Space of Integrable Functions.

Recommended Books:

- N. L. Carothers, Bowling Green State University, Real Analysis, Cambridge University Press.
- Mukherjea and K.Pothoven, University of South Florida Tampa, Real and Functional Analysis, Plenum Press. New York and London.
- Arthur Mattuck, Massachusetts Institute of Technology, Introduction to Analysis, Prentice Hall Upper Saddle River, New Jersey 07458.
- Anthony W. Knapp, Basic Real Analysis, Birkhauser Bosten. Basel.Berlin.

ODE'S AND COMPUTATIONAL LINEAR ALGEBRA

Credit hours: 03(3-0) **Course Code: MATH-702**

Specific Objective of Course:

Many physical laws are most simply and naturally formulated as differential equations. For this reason, differential equations have been studied by the greatest mathematicians and mathematical physicists since the time of Newton. Differential equations are mostly used in dynamical systems and electrical networks. They are much easier to treat than partial differential equations, whose unknown functions depend on two or more than two independent variables.

Course Outlines:

Review of Ordinary Differential Equations including First, Second and high Order Linear differential Equations with Constant and variable Coefficients. Modeling with first and higher order differential Equations. Modeling with first and higher order nonlinear differential equations. Power Series Solutions about Ordinary, Regular and Singular Points, Plane Autonomous Systems, Existence and Uniqueness Theorems, Strum-Lowville Systems, Expansions in Eigen Functions. Eigen values and Eigen vectors and their applications to systems of ODEs. Orthogonal functions and Fourier series analysis.

Recommended Books:

- Ordinary Differential Equations Fourth Edition By Garrett Birkhoff Harvard University
- Differential Equations Computing and Modeling Fourth Edition C. Henry Edwards and David E. Penny University of Georgia

MATHEMATICAL TECHNIQUES

Credit hours: **03**(3-0) **Course Code: MATH-703**

Course objectives: The main objective of this course is to familiarize students with a range of mathematical terminology that are essential for solving advanced problems in applied sciences.

Course contents: Introduction to complex algebra; complex functions; De Moivre formula; Cauchy-Riemann conditions; line integral; Cauchy's integral theorem; Cauchy's integral formula; Cauchy's integral and derivative of the functions; Taylor expansion; analytic extension; poles of the function; determination of residues; Laurent development; mapping; cut line, branch point and multi-valued functions; conformal mapping; singularities; Residue Theorem; Cauchy principal value. Complex vector spaces, Hermitian inner products, The eigenvalue problems and application, Eigenvectors and eigenvalues, Diagonalisability,

Spectral theorem for hermitian transformations,: quadratic forms Application: normal modes , Application: near equilibrium dynamics . Analytic functions, Differentiability and analyticity, Complex powers and line integrals, Laurent series and Contour integrals, residues and contour integrals, Integrals on the Real Axis. Special functions, Gamma, Beta and Mittage Leffler functions, the zeta functions. Conformal mapping and conformal derivative and integrals.Sequences and Series, Fourier series and its consequences. The Fourier series of periodic functions,Application: steady-state response.

Recommended Books:

- J. Figueroa-O'Farrill**,** Mathematical Techniques III, Second Version of December 5, 2004.
- D. Jordan, ,Mathematical techniques, 1994
- D. Jordan , Mathematical Techniques: An Introduction for the Engineering, Physical, and Mathematical Sciences 4th Edition, ISBN-13: 978-0199282012.

PARTIAL DIFFERENTIAL EQUATIONS

Credit hours: 03(3-0) **Course Code: MATH-704**

Aims and Objectives: Mathematical models involving evolutionary partial differential equations (PDEs) as well as ordinary differential equations (ODEs) arise in many diverse applications, such as fluid flow, image processing and computer vision, physics-based animation, mechanical systems, relativity, earth sciences, and mathematical finance.

Contents:

Introduction to PDEs, classifications of PDEs and review of separation of variable method. Introduction to the heat equation, Wave equations, The Heat and Wave Equations in 2D and 3D Quasi Linear PDEs. Introduction to the fundamental solution, uniqueness of the solutions. Fundamental solution and the global Cauchy problem of heat and wave equations. Laplace's and

Poisson's equations, Fundamental solution and Green functions. Introduction to Schrödinger's equation, Transport equations and Burger's equation. The Maxwell equations of electrodynamics.

Infinite Domain Problems and the Fourier Transform.

Recommended Books:

- N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill Book Company
- R. Ennemyer, Introduction to Partial Differential Equations and Boundary Value Problems, McGraw-Hill Book Company
- M. Humi, and W. B. Miller, Boundary Value Problems and Partial Differential Equations, PWS-Kent Publishing Company, Boston
- C. R. Chester, Techniques in Partial Differential Equations
- R. Haberman, Elementary Applied Partial Differential Equations
- Salsa, Sandro. *Partial Differential Equations in Action: From Modelling to Theory*. Springer, 2010.

INTEGRAL EQUATIONS

Credit hours: 03(3-0) **Course Code: MATH-705**

Aims and objectives: Integral equations are the important tools to model many real world problems related to physics, biology, dynamics etc. The existence theory for the said equations is important to investigate physical behavior of the phenomenon's and process.

Course contents: Preliminary concept of the integral equation, Historical background of the integral equations.Classification of integral equations: Volterra integral equations, Fredholm integral equations, Singular integral equations, Integro-differential equations. Converting Volterra equation to ODE, Converting IVP to Volterra equations, Converting BVP to Fredholm integral equations, Types of solution techniques. The method of successive approximations. Existence theorem of Picard's method. Abel's problem. The Weekly-singular Volterra equation.

Recommended Books:

- *Integral Equations* and *their Applications*. WITeLibrary. Home of the Transactions of the Wessex Institute, the WIT electronic-library 2001.
- Solutions of Nonlinear *Integral Equations* and *Their Application* to Singular Perturbation Problems. Thesis by. Douglas Warren vlillett. 1963.
- Related Articles.

HIGHER ALGEBRA

Credit hours: 03(3-0) **Course Code: MATH-706**

Course Outline:

Introduction to Sylow theory and its Applications, Simple groups, Simplicity of An for 5, Zassenhaus lemma, Normal series, Composition series, Jordan Holder theorem, Solvable groups, The derived series of a group, The lower and upper Central series of a group and Nilpotent groups and applications. Growth of nilpotent and polycyclic groups, Polynomial growth of nilpotent groups, Wolf 's Theorem for semi-direct products Z^n x Z. Distortion of a subgroup in a group. Solvable groups: Definition and basic properties, Milnor's theorem.

Recommended Books:

- John. B Fraleigh, A first Course in Abstract Algebra, Addison-Wesley Pub Co. London
- M. Hall, Theory of groups, The MacMillan Company N. Y. (1959)

- Lan D McDonald, The theory of groups, Oxford University Press (1975)
- T. Rose, A Course of group theory, Cambridge University Press (1978)
- Majeed, Theory of groups, IImi Kitab Khana, Lahore (1994)
- T. Inui, Y. Tanabe, Y. Onodera, Application of Group Theory in Physics, Springer Verlage, 1990

BANACH ALGEBRA

Credit hours: 03(3-0) **Course Code: MATH-707**

Aims and objectives: To construct existence theory and stability analysis and best numerical techniques required fundamental knowledge of functional analysis. Functional analysis is the backbone in the existence theory, stability analysis and numerical approximations of applied problems arising in science, engineering and technology.

Course contents: Introduction to normed, Banach and Inner product spaces, Hilbert spaces. Bounded linear operators in Hilbert spaces and their various characterizations. Self adjoint, normal, unitary and projection operators.Compact and contraction operators, elementary spectral theory. Introduction to Banach Fixed point theorem and its applications. Iterative methods. Reflexive spaces, Hahn-Banach Theorem for real and complex version. Week and strong topologies and the Banach-Alouglu theorem. The Main theorem of iterative methods for linear operator equations. Reiz representation theorems and Reiz potentials and its applications.

Recommended Books:

- Functional Analysis by Alexander C. R. Belton, Cambridge University Press, Cambridge, 2004 and 2006.
- E. Kreyszig, Introductory functional analysis with applications, John Wiley &Sons, Inc., New York, 1978.
- P. Lax, Functional analysis, John Wiley & Sons, Inc., New York, 2002.
- G. Pisier, Introduction to Operator Space Theory, London Mathematical SocietyLecture Noes Series 294, Cambridge University Press, Cambridge, 2003.
- W. Rudin, Functional analysis, second edition, McGraw-Hill, Inc., New York.
- G. F. Simmons, Introduction to topology and modern analysis, McGraw-Hill, Inc.,NewYork, 1963.
- J. Weir, Lebesgue integration and measure, Cambridge University Press, Cambridge, 1973.
- E. Kreyszig, Introductory functional analysis with applications, John Wiley & Sons, Inc., New York, 1978.

NUMERICAL METHODS

Credit hours: 03(3-0) **Course Code: MATH-708**

Specific Objective of the Course:

Problems in linear algebra arise in a wide variety of scientific and engineering applications including the design of structures, the analysis of electrical networks, and the modeling of chemical processes. This course will cover the analysis and implementation of algorithms used to solve linear algebra problems in practice. We will study algorithms for linear systems solution, linear least-squares problems, and eigenvalue and singular value problems. We will develop numerical algorithms for these four main-stream problems. The quality of a numerical algorithm is often judged based on two criteria namely efficiency (vaguely speaking number of arithmetic operations required) and accuracy. We will analyze the accuracy and efficiency of the numerical algorithms developed. We will also examine issues of problem sensitivity and algorithmic stability and ways to improve efficiency by taking advantage of special matrix structures. In each case, we will also study the computational tools underlying the algorithm (generally, techniques for matrix factorization and for introducing zeros into a matrix). Emphasis will be on dense linear algebra although we will introduce sparse linear algebra as class interest and time permit.

Course Outline: This is a general outline of the material we will cover (not necessarily in this order). It is subject to change according to time and class interests.

1. Fundamentals of Numerical Computation
    a. Matrix-Vector operations
    b. Counting of floating point operations
    c. IEEE floating point arithmetic
    d. Vector and matrix norms
    e. Sensitivity analysis and condition numbers
    f. Forward and backward errors and their analysis
2. Numerical Solution of Linear Systems
    a. Properties of linear systems
    b. Solving triangular systems
    c. The Basic Linear Algebra Subprograms
    d. Gaussian elimination
    e. LU decomposition
    f. Cholesky factorization
    g. The sensitivity of linear systems
3. Round-off error, stability, and conditioning
4. Linear Least Squares Problems (Over determined Systems)

a. Projectors and QR factorization
b. Gram-Schmidt Orthogonalization
c. Givens rotations
d. Householder transformations
e. The least squares problem defined
f. Algorithms for the least squares problem

5. Numerical Computation of Eigenvalues and Eigenvectors
    a. Properties of the eigenvalue decomposition
    b. The QR algorithm
    c. Rayleigh quotient iteration
    d. Schur factorization
    e. Sensitivity of eigenvalues and eigenvectors
6. The Singular Value Decomposition and its Computation
    a. Properties of the singular value decomposition
    b. Methods for the singular value decomposition.

Recommended Books:

- Lloyd N. Trefethen and David Bau, "Numerical Linear Algebra", SIAM 1997.
- G. H. Golub and C. F. Van Loan, "Matrix Computations", Johns Hopkins University
- J. W. Demmel, "Applied Numerical Linear Algebra", SIAM 1997.
- D. S. Watkins, "Fundamentals of Matrix Computations", Wiley-Inter-science, 2nd Ed
- Biswa Datta, "Numerical Linear Algebra and Applications", 2nd Edition, SIAM, 2010

RIEMANNIAN GEOMETRY

Credit hours: 03(3-0) **Course Code: MATH-709**

Importance of the course: Basis ideas of Riemannian geometry such as Riemannian metric, covariant differentiation, geodesics and curvature belong to the core of mathematical knowledge and are widely used in applications that range from general relativity in physics to mechanics and engineering. Besides that, this subject is one of the most beautiful in mathematics, containing such gems as Gauss's Theorem Egregious and the Gauss-Bonnet Theorem providing a link with the topology of surfaces. The course introduces these ideas. Riemannian geometry is used in almost all areas of mathematics and its applications, including physics and engineering.

Course Outlines: Introduction of a covariant derivative. Expression in local coordinates. Manifolds, sub manifolds, mappings, vector fields, Lie derivative, Tensors Riemannian connection, covariant derivatives, Riemannian curvature. Isometric immersions, Riemannian submersions, conformal metrics. Exponential map, Jacobi fields, conjugate points. Complete manifolds, Hadamard

manifolds. Spaces of constant curvature: hyperbolic space. Symmetric spaces, homogeneous spaces. Cut locus, closed geodesics, Preissman's Theorem. Complete manifolds of nonnegative curvature. Flat manifolds, Bieberbach's theorem, almost-flat manifolds.

Recommended Books:

- I. Chavel: Riemannian Geometry, a modern introduction
- F. Warner, Foundations of Differentiable Manifolds and Lie groups
- S. Kobayashi, K. Nomizu, Foundations of Differential Geometry
- M Hirsch, Differential Topology
- M. do Carmo, Riemannian Geometry
- J. Cheeger, D. Ebin, Comparison Theorems in Riemannian Geometry
- J. Milnor, Morse Theory

MATHEMATICAL PHYSICS

Credit hours: 03(3-0) **Course Code: MATH-710**

Importance: In this course we will discuss mathematical techniques used to solve physical problems. The goal of this course is to help the research students to make connections between some of their preparatory math work and their current and future physics courses.

Course Outlines: Introduction to Vector spaces, inner product and Hilbert spaces, Rotations, transformations, and linear operators. Eigenvalues, Diagonalization, and Special Matrices. Spectral properties of linear operator's spectrum and resolvent set. Radius of convergence of matrices.Normal modes. Curvilinear coordinates and parallel transport.Differential operators in curvilinear coordinates. Green's functions; self-adjoint differential equations; hermitian operators, Gram-Schmidt orthogonalization process; orthogonal polynomials; completeness of the Eigen functions; Bessel's inequality; Schwarz inequality; expansion of Green's functions; Green's functions in one dimension; Dirac delta function; gamma function; Bessel functions of the first kind; Legendre polynomials; associated Legendre polynomials; Spherical function; Hermite polynomials; Laguerre polynomials; associated Laguerre polynomials; calculus of variations; Rayleigh-Ritz variational technique.Differential equations and series solutions.The Sturm-Liouville problem. Representation and a little on Lie groups analysis.

Recommended Books:

- Butkov, *Mathematical Physics* Addison Wesley
- Courant & Hilbert, *Methods of Mathematical Physics*
- Arfken & Weber, *Mathematical Methods for Physicists* 6th ed. Elsevier.
- Lea, *Mathematics for Physicists* Thompson Brooks Cole.

LA-SEMI GROUPS

Credit hours: 03(3-0) **Course Code: MATH-711**

Course outlines:

LA-semigroups and basic results, Connection with other algebraic structures, Medial and exponential properteis, LA-semigroups defined by commutative inverse semigroups, Homomorphism theorems for LA-semigroups, Abelian groups defined by LA-semigroups, Embedding theorem for LA-semigroups, Structural properties of LA-semigroups, LA-semigroups as a semilattice of LA-subsemigroups, Locally associative LA-semigroups, Relations on locally associative LA-semigroups, Maximal separative homomorphic images of locally associative LA-semigroups, Decomposition of locally associative LA-semigroups.

Recommended Books:

- Fundamentals of Semigroup Theory John M. Howie
- Amer. Math. Soc. Surveys, 7, Providence, R.I.
- Contemporary Abstract Algebra, by J. A. Gallian
- The Algebraic Theory of Semigroups, by A. H. Clifford, Volume I & II

LEBESGUE SPACES WITH VARIABLE EXPONENT

Credit hours: 03(3-0) **Course Code: MATH-712**

Specific Objective of the Course:

Lebesgue Spaces with variable exponent is the generalized Lebesgue space, it generalize the classical Lebesge space where the exponent is constant. This course familiarize the students with the basics properties of variable exponent spaces, in this course the students learn the boundedness of the "Maximal and Potential Operators" in Lebesgue spaces & weighted Lebesgue Spaces with variable exponent.

Course Outlines:

Classical Lebesgue spaces, Lebesgue Space with variable exponent, Space of Homogenous type, History of variable exponent spaces, Elementary properties, Maximal Function, One-sided Maximal Function, Logrithmic Holder continuity, point wise estimates, the boundedness of the Maximal operators, the boundedness of Potential operators, Hardy-type Transforms, Week type estimates, Necessary Conditions for the boundedness, Weighted Lebesgue Space, One-sided Potentials.

Recommended Books:

- Lars Diening, Petteri Harjulehto, Peter Hästö and Michael Růžička, Lesbesgue and Sobolev Spaces with variable exponents, Springer International Edition
- Ioseb Genebashvili, Amiran Gogatishvili, Vakhtang Kokilashvil and Miroslav Krbec, Weight Theory of Integral Transforms on Spaces of Homogenous Type, (Pitman Monographs& Surveys in Pure and Applied Mathematics)
- Alexender Meskhi, Measure of Non-copactness for Integral Operators in Weighted Lebesgue Spaces, Nova Science Publishers, Inc
- David E. Edmund, Vakhtang Kokilashvili and Alexender Meskhi, Bounded & Compact Integral Operators, Kulwer Academic Publishers

Ring Theory and its Applications

Credit hours: 03(3-0) **Course Code: MATH-713**

Specific Objective of the Course:

Ring theory is important as a foundation for algebraic geometry and complex analytic geometry. The idea of a ring is so fundamental that it is also vital in many applications of Mathematics. Indeed it is so fundamental that many other vital tools of Applied Mathematics are built from it. For example, the crucial notion of linearity, and linear algebra, which is a practical necessity in Physics, Chemistry, Biology, Finance, Economics, Engineering and so on, is built on the notion of a vector space, which is a special kind of ring module.

Course Outlines:

Rings and Fields, Type of Rings, Subring and characteristic of a ring Integral Domain, Fermat' s and Euler Theorem, Ring of Polynomials, Ring Homomorphism , Factorization of Polynomials over a Field, Eisenstein Criterion, Non-commutative Examples, Ring of Endomorphism, Ordered Rings and Fields, Ideals and Factor Rings, Prime and Maximal Ideals, Sum and Direct Sum of Ideals, Nilpotent and Nil Ideals, Fundamental Homomorphism Theorem, Ideal Structure in F[x], Introduction to Extension Fields, Algebraic and Transcendental Elements, Unique factorization domains and Euclidean domains.

Recommended Books:

- P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Cambridge University Press.
- D. S. Dummit and Richard M. Foote, Abstract Algebra, John Wiley & Sons, Inc.
- J. B. Fraleigh, A First Course in Abstract Algebra, Pearson.
- H. Matsumura, Commutative ring theory, Cambridge University Press

ADVANCED MEASURE THEORY

Credit hours: 03(3-0) **Course Code: MATH-714**

Specific Objective of the Course:

It generalizes the concept of the integral. Typically, the integral is introduced as the area under a given curve. Area is just a single specific example of a 'measure' -- there are many others. This course familiarize the student with the concept of, Riemann Integrals for continuous functions, Lebesgue Integral, Lebesgue measure etc. This course in general is roughly making sense of "Integration" for function more general than just the continuous one.

Course Outlines:

Measure, Measurable Sets, Non-Measurable Set, Measurable Functions, Elementary properties of Measurable Functions, Lebesgue Measure on Euclidean Spaces, Two Properties of the Lebesgue Measure, Measurable and Lebesgue Integrable Functions on Euclidean Spaces, The Convergence Theorem, Comparison of the Lebesgue Integral with the Riemann Integrals, The Lebesgue Dominated Convergence Theorem, Convergence in Measure, The space L1 of integrable functions, The Hardy-Littlewood maximal function, The Lebesgue differentiation theorem, Littlewood's three principles, Fubini's theorem and its Applications.

Recommended Books:

- Karen Saxe, Beginning Functional Analysis, Springer International Edition
- Elias M. Stein & Rami Shakarchi, Real Analysis Measure Theory, Integration and Hilbert Spaces, Princeton University Press Princeton and Oxford
- Richard L. Wheeden & Antoni Zygmund, Measure and Integral, An Introduction to Real Analysis
- Gerald B. Folland,Real Analysis Modern Techniques and Their Applications, A wiley-Intersciences Series of Text, Monograph, and Tracts

SEMI GROUP THEORY

Credit hours: 03(3-0) **Course Code: MATH-715**

Course outlines: Introductory ideas; Basic definitions, Monogenic semigroups, Ordered sets, semilattices and lattices, Binary relations; equivalences, Congruence, Free semigroups and monoids; presentations, Ideals and Rees congruencies, Lattices of equivalences and congruences, Green's equivalences; regular semigroups, Green's equivalences, The structure of D-classes, L.R.H.J and D; Regular semigroups, regular D-classes, Regular semigroups, Ordinary and Partial Transformations; Basic Definitions, Graph of a (Partial) transformation, Linear Notation for Partial Transformations, the Semigroups T_n and PT_n, Composition of

Transformations, Identity Elements, Zero Elements, Isomorphism of Semigroups, Regular and Inverse Elements, Idempotents, Nilpotent Elements. Semigroups of shift operators; Semigrgoup of multi-tiles, illustration of the semigroup, semigroup of one-tile, generators, presentation and caley table of semigroups, semigroup of various shaped boards.

Recommended Books:

- Fundamentals of Semigroup Theory John M. Howie
- Classical Transformation Semigroups by Olexandr Ganyushkin
- Techniques of Semigroup Theory , by Peter M. Higgins
- The Algebraic Theory of Semigroups, by A. H. Clifford, Volume I.

FUZZY GROUP THEORY

Credit hours:03(3-0) **Course Code: MATH-716**

Specific Objective of the Course: The course motivates and develops results and applications of fuzzy group theory. To introduce notation of a fuzzy subgroup of a group: develop some concepts about fuzzy subgroups.

Course Outlines: Fuzzy subsets and fuzzy subgroups, fuzzy Caley's theorem and fuzzy Lagrange's theorem, nilpotent, commutators, and solvable fuzzy subgroups, characterization of certain groups and fuzzy subgroups, fuzzy subgroup of abelian groups, direct products of fuzzy subgroups and fuzzy cyclic subgroups, equivalence of fuzzy subgroups of finite abelian groups, lattices of fuzzy subgroups.

Recommended Books:

- J. N. Mordeson, R. B. Kiran and A. Rosenfeld, Fuzzy Group Theory.
- J. George, Fuzzy sets and Fuzzy Logic.
- H. L. Kwang, first Course on Fuzzy Theory and Applications

APPROXIMATION THEORY

Credit hours: 03(3-0) **Course Code: MATH-717**

Aims and objectives: In applied analysis most of the problems have not exact solutions. Therefore a strong motivation is found for developing numerical procedure to find out best approximate solutions to the concerned problems. The aims and objectives of this course is to train the research students to use various polynomial either orthogonal or non-orthogonal to develop numerical schemes for the approximate solutions of the problems arising in engineering, and other disciplines of applied sciences.

Course contents: Introduction to Legendre, Bernstein, Jacobi, Lagurre and Chybshive, Bernoulli polynomials and their properties and recurrence relations. The Shifted Jacobi and The Shifted Legendre polynomials, the Hermit polynomials. Approximations of functions in terms of the above polynomials. The convergence analysis of the approximation of the above polynomials.The iterative technique and contraction mapping.Applications of above polynomials to the approximate solutions of differential and integral equations.

Recommended Books:

- E. Aparicio, Three theorems on approximation in the space L_p by means of polynomials with integral coeeficients , Collect. Math, 28(1977) , Spanish.
- G.G. Lorentz, Bernstein polynomials, University of Toronto Press, 1953.
- Henryk G. and Jose' L. P,On the Approximation Properties of Bernstein polynomials via Probabilistic tools, Boletin de la Asociacion Matematica Venezolana., (2003) .

De Villiers, J. M, Mathematics of approximation, Atlantic Press, Amsterdam 2012.

IMPULSIVE DIFFERENTIAL EQUATIONS

Credit hours: 03(3-0) **Course Code: MATH-718**

Aims and objectives: In daily life we are facing to numerous physical and biological phenomenon that are subject to abrupt changes in their sate. Such process and phenomenon include earth quake, fluctuation of economy in financial mathematics, storm and disease dynamics, etc. The impulsive differential equations are increasingly use to model such like process. To make such differential equations applicable different aspects have been investigated for the aforesaid equations including qualitative theory, stability analysis etc.

The aims and objectives of this course is to train graduate students to establish the qualitative theory and derive sufficient conditions for the existence of solutions of impulsive differential equations of classical as well as fractional order.

Course contents: Introduction to impulsive differential equations. Investigation of initial and boundary value problems of impulsive differential equations, their existence theory and stability analysis. Study of nonlocal boundary value problems of impulsive differential equations. Investigation of implicit type impulsive differential equations and their applications.Iterative techniques for impulsive differential equations.

Recommended Books:

- V Lakshmikantham , D D , P S Simeonov, Theory of Impulsive Differential Equations,Series in Modern Applied Mathematics: Volume 6, 1989.
- Mykola Perestyuk, Impulsive differential equations, Institute of Mathematics, Academy of Sciences of the Czech Republic, 2011.

- Yong Zhou , Basic theory of fractional differential equations , World Scientifc Publishing Co. Pte. Ltd **,**2014.
- A. M. Samoilenko, N. A. Perestyuk, Impulsive differential equations, World Scientific, Singapore, 1995.
- N. A. Perestyuk, V. A. Plotnikov, A. M. Samoilenko, N. V. Skripnik, Differential equations with impulse effects: Multivalued right-hand sides with discontinuities, DeGruyter Studies in Mathematics 40, Walter de Gruyter Co, Berlin, 2011.

FINITE ELEMENT METHODS

Credit hours: 03(3-0) **Course Code: MATH-719**

Aims and Objectives: The finite element method (**FEM**) is a numerical method for solving problems of engineering and mathematical physics. It is also referred to as finite element analysis (**FEA**). Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The analytical solution of these problems generally require the solution to boundary value problems for partial differential equations. The finite element method formulation of the problem results in a system of algebraic equations. The method yields approximate values of the unknowns at discrete number of points over the domain. To solve the problem, it subdivides a large problem into smaller, simpler parts that are called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem.Accurate representation of complex geometry**,** Inclusion of dissimilar material properties**,** Easy representation of the total solution**,** Capture of local effects.

Course Contents: History and of the methods, the structure of finite element methods Applications. Solutions of some illustrative problems of PDEs and fluid problems by the FEM. Various types of finite element methods like generalization of the finite element method, conforming and non-conforming element method, Smoothed Finite Element Methods, Spectral element methods, Meshfree methods, Discontinuous Galerkin method, Finite element limit analysis, Stretched grid method.

Recommended Books and Articles:

- Daryl L. Logan (2011). A first course in the finite element method. Cengage Learning.
- P. Solin, K. Segeth, I. Dolezel: Higher-Order Finite Element Methods, Chapman & Hall/CRC ,Press, 2003.
- Hastings, J. K., Juds, M. A., Brauer, J. R., *Accuracy and Economy of Finite Element Magnetic , Analysis*, 33rd Annual National Relay Conference, April 1985.

FOURIER ANALYSIS

Credit hours: 03(3-0) **Course Code: MATH-720**

Course Outlines. Coin Tossing, Law of Large Numbers, Rademacher Functions, Measure Theory, Random Models, Measurable Functions, Lebesgue Integral, Measurable Functions,Lebesgue Integral, Lebesgue Spaces, Inner Products, Hilbert Space, Fourier Series and their Convergence, Applications of Fourier Series, Fourier Integrals, Fourier Integrals of Measures, Central Limit Theorem, Brownian Motion.

Recommended Books

- Adams, Malcolm Ritchie, and Victor Guillemin. *Measure Theory and Probability*. Birkhäuse, 1996.
- Fourier Analysis - Theory and Applications (Spring 2004)

FIXED POINT THEORY IN MODULAR FUNCTION SPACES

Credit hours: 03(3-0) **Course Code: MATH-721**

Course Contents:

Lebesgue spaces, Modular function spaces, examples of Modular function spaces, Space E_p, convergence theorem, Vitali Property, Uniform Convexity in Modular Function Spaces, Parallelogram Inequality and Minimizing Sequence Property, Uniform Non-compact Convexity in Modular Function Spaces,Contractions in Modular Function Spaces, Nonexpansive and Pointwise Asymptotic Non-expansive Mappings, KKM and Ky Fan Theorems in Modular Function Spaces, Fixed Point Construction Processes, Modular Metric Spaces, Banach Contraction Principle in Modular Metric Spaces, Non-expansive Mappings in Modular Metric Spaces.

Recommended Books:

- 1.Fixed Point Theory in Modular Function Spaces, Mohamed A. Khamsi and Wojciech M. Kozlowski, 2008.

NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS

Credit hours: 03(3-0) **Course Code: MATH-722**

Course Contents:

Fundamental concepts and examples, Well-posedness and Fourier methods for linear initial value problems, Numerical solutions of Laplace and Poisson equation, Heat equation, transport equation, wave equation, General finite difference approach and Poisson equation, Elliptic equations and errors, stability, Lax equivalence theorem, Spectral methods, Elliptic equations and linear systems, Conservation laws: Numerical methods, Conservation laws: High resolution methods.

Recommended Books:

- 1.Numerical Methods for Partial Differential Equations Spring 2009.
- David Francis Mayers and Keith William Morton, Numerical Solution of Partial Differential Equations, Cambridge University Press New York, NY, USA ,2005.

FLUID MECHANICS

Credit hours: 03(3-0) **Course Code: MATH-723**

Specific Objectives: To introduce the basic principles of fluid mechanics and to understand the basic concepts in fluid static and fluid dynamics.

Course Outline: Fluid Properties: Ideal and real fluids, viscosity and compressibility of fluids, fluid pressure, absolute, gauge and vacuum pressures, difference between static and dynamic pressure, flow velocity and flow rate. Fluid statics: Measurement of static pressure, stagnation pressure, pressure in a fluid under the action of gravity, homogeneous fluid, constant-velocity rotation of a liquid around-fixed axis, hydraulic circuits, force on container wall, force on flat surfaces, force on curved surfaces, buoyancy of fluid at rest, stability of a floating body, surface tension and capillary tubes. Fluid dynamics: One dimensional inviscid flow (flow filament theory), equation of continuity, Euler's equations of motion, Bernoulli's equation, impulse and momentum, one dimensional viscous flow, generalized Bernoulli's equation, flow in conduits.

Dimensional analysis, similitude and its applications: Buckingham- Pi theorem, Reynolds' law of similitude.

Recommended Books:

- Fundamentals of Fluid Mechanics, By Munson, Young and Okiishi, John Wiley & Sons.
- Fluid Mechanics, By Frank M. White McGraw-Hill.
- Fluid Mechanics by Shames McGraw-Hill. McGraw-Hill Science/Engineering/Math.

- Engineering Fluid Mechanics, By Clayton T. Crowe, Donald F. Elger, John A. Roberson, John Wiley & Sons.

INTRODUCTION TO COMPUTATIONAL SOFTWARE AND RESEARCH METHODOLOGY

Credit hours: 03(3-0) **Course Code: MATH-724**

Aims and Objectives: Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. Computational software are the demanding task of modern research. Applied research without computational software may not possible.

Couse out lines: There are no formal prerequisites for this course. It is intended to assist graduates in learning the basics of programming in general and programming in computational softwares. Only the very basics of programming in Matlab, Maple, Mathematica will be covered, with the goal of having students become comfortable enough to continue learning these softwares. To train the graduates how why we do research, what are the methodologies. How to make the research fruit full and marketable.

Recommended Books and Articles:

- S. Rajasekar, et.al., Research Methodology, 2013.
- Howell, K. E. Introduction to the Philosophy of Methodology. London, (2013)

MATHEMATICAL INEQUALITIES AND APPLICATIONS

Credit hours: 03(3-0) **Course Code: MATH-725**

Aims and Objectives: Inequalities are one of the most important instruments in many branches of mathematics such as functional analysis, theory of differential and integral equations, interpolation theory, harmonic analysis, probability theory, etc. They are also useful in mechanics, physics and other sciences. The usefulness of Mathematical inequalities is felt from the very beginning and is now widely acknowledged as one of the major driving forces behind the development of modern real analysis

Course outlines:

Jensen's and Jensen-Steffensen's inequalities, Hermite-Hadamard's, Slater's and some companion inequalities to the Jensen inequality, deduction of the Hölder, Cauchy Schwartz, AM-GM inequalities from Jensen's inequality, Young's, Chebyshev's and Gruss inequalities, some determintal and matrix inequalities, refinements, reverses, generalizations, multi-dimensional version and applications of the above mentioned inequalities.

Recommended Books:

- E. F. Beckenbach and R. Bellman, Inequalities, Springerverlag, Berlin, 1961.

- G. H. Hardy, J. E. Littlewood and G. Polya, Inequalities, 2nd Ed., Cambridge University Press, Cambridge 1952.
- D. S. Mitrinović, Analytic Inequalities, Springer-Verlag, Berlin, 1970.
- J. Pečarić, F. Proschan and Y. L. Tong, Convex functions, Partial Orderings and Statistical Applications, Academic Press, New York, 1992.
- D. S. Mitrinović, J. Pečarić and A. M. Fink, Classical and new inequalities in analysis, Kluwer Academic Publishers, The Netherlands, 1993.
- E. Hewitt and K. Stromberg, Real and Abstract Analysis, Springer-Verlag, 1965.

GRAPH THEORY

Credit hours: 03(3-0) **Course Code: MATH-751**

Course Outlines:

Introduction, Basic definitions and examples, subgraphs, adjacency matrix of a graph, graph isomorphism, connectivity, paths and cycles, Eulerian graphs, Hamiltonian graphs, trees and spanning trees, labeling of trees, minimum spanning trees, Kruskal's and prim'salgorithm for finding minimum spanning trees, bipartite graphs and multipartite graphs, planar graphs, line graphs, Euler's formula, Dual graphs, product of graphs, coloring of graphs, graphs labeling, bandwidth labeling of graphs.

Recommended Books:

- Theory and Problems of Graph theory, by V.K. Balakrishnan, Schaum's Oulines Series
- Graph theory III by Reinhard Diestel, Electronic Edition 2005
- Introduction to Graph Theory by R.J Wilson, Fourth edition
- Graph theory with applications by J. A. Bondy and U. S. R. Murty 1982

APPLIED DIMENSIONAL ANALYSIS AND MODELING

Credit hours: 03(3-0) **Course Code: MATH-752**

Specific Objectives of the Course:

The student being introduced to dimensional analysis for the first time is always amazed by the demonstration, without recourse to full physical analysis, that the period of oscillation of a simple pendulum must be proportional to the square root of the pendulum length and independent of its mass. The rationale for this relationship is, of course, based on the simple argument that each term of a "properly" constructed physical equation needs to be dimensionally homogeneous with the others. Likewise, the student is also impressed by the application of such results to predicting full-scale behavior from measurements using a scale model. From this simple example, dimensional arguments can be taken

to increasing levels of complexity, and can be applied to a wide range of situations in science and engineering.

Course Outlines:

Mathematical Preliminaries, Formats and Classification**,** Dimensional Systems**,** Transformation of Dimensions, Arithmetic of Dimensions, Dimensional Homogeneity, Structure of Physical Relations, Systematic Determination of Complete Set of Products of Variables, Transformations, Number of Sets of Dimensionless Products of Variables, Dimensional Modeling.

Recommended Books:

- Applied Dimensional Analysis and Modeling by Thomas SzirtesToronto, Ontario, Canada

NUMERICAL SOLUTIONS OF DIFFERENTIAL EQUATIONS

Credit hours: 03(3-0) **Course Code: MATH-753**

Aims and objectives: Most of the mathematical models of nonlinear phenomenon of applied sciences and engineering has not exact solution. Therefore, it is necessary to seek the solutions to these problem approximately. For the best approximation, strong numerical techniques are required to find best approximate solutions to both ordinary and partial differential equations. The aims and objectives of this course is to train the researches of applied mathematics to develop numerical procedure for ordinary and partial differential equations.

Course contents: Introduction to Euler, modified Euler method, Taylor polynomials, Range-Kutta methods and its applications. Predictor-Corrector methods and its applications to fined numerical solutions of differential equations. Introduction to integral transforms like Hinkle, Sumudu, Natural and Fourier transforms and their applications to solve differential equations.

Recommended Books:

- Ordinary differential equations and Dynamical Systems**,** Gerald Teschl, 2004
- Elementary differential equations and boundary value problems / William E. Boyce Richard C. DiPrima – 7th ed , John Wiley & Sons, Inc., 605 Third Avenue, New York
- Cheney, W. and Kincaid, D., "Numerical Mathematics and Computing," Third Edition, Brooks/Cole Publishing Company, 1994.
- Buchanan, J.L. and Turner, P.R., "Numerical Methods and Analysis," McGraw-Hill, 1992.
- Numerical Analysis 9th-ed, Richard L. Burden and J. Douglas Faires, 2006, Brooks/Cole 20 Channel Center Street Boston, MA02210 USA.
- Ascher, U. M., R. M. M. Mattheij, and R. D. Russell, *Numerical solution of boundary value problems for ordinary differential equations*, Prentice-Hall, Englewood Cliffs, NJ, 1988, 595 pp. QA379.A 83 *712*.

- Botha, J. F. and G. F. Pinder, *Fundamental concepts in the numerical solution of differential equations*, Wiley-Interscience, New York, 1983, 202 pp. QA374.B74 *356*.

FIXED POINT THEORY

Credit hours: 03(3-0) **Course Code: MATH-754**

Course Contents:

Metric Spaces, Normed Spaces, Banach Spaces, Fixed point Space, Banach Contraction Principle(BCP) and its applications, The Converse problem, Extension and generalization of Banach Contraction principle , Caristi, s fixed theorem , Boyd–Wong Theorem**,** Set valued contractions, generalized contractions(Kannan contraction, Cheterge contraction , Week contraction, rational type contraction etc.) , Multivalued versions of BCP, Hausdorff metric, Nadler' fixed point theorem, Some extensions of BCP under generalized distances, Fixed point for non-expensive mappings, Ultra Metric Spaces and its Properties.

Recommended Books:

- Fixed Point Theory and Applications, R. Agarwal, M. Meehan and D. O Regan , Cambrige University Press
- Topics in Fixed Point Theory by Saleh_Almezel, Qamrul Hasan_Ansari Mohamed Amine_Khamsi Springer International Publishing Switzerland 2014.
- E. Kreyszic , Introductory functional Analysis and Applications
- Handbook of Metric Fixed Point Theory by William A. Kirk and Brailey Sims published by Kluwer Academic Publishers
- Fixed Point Theory by Andrzej Granas and James Dugundji, Springer Publisher.

DYNAMICAL SYSTEMS AND ERGODIC THEORY

Credit hours: 03(3-0) **Course Code: MATH-755**

Specific Objective of the Course:

The course will provide an introduction to subject of dynamical systems, from a pure-mathematical point of view. The first part of the course will be driven by examples so that students will become familiar with various basic models of dynamical systems. We will then develop the mathematical background and the main concepts in topological dynamics, symbolic dynamics and ergodic theory. Dynamical systems are an exciting and very active field in pure and applied mathematics, which involves tools and techniques from many areas such as analyses, geometry and number theory. A dynamical system can be obtained by iterating a function or letting evolve in time the solution of equation. Even if the rule of evolution is deterministic, the long term behavior of the system is often chaotic. Different branches of dynamical systems, in particular ergodic theory, provide tools to quantify this chaotic behaviour and predict it in

average. At the beginning of this lecture course we will give a strong emphasis on presenting many fundamental examples of dynamical systems, such as circle rotations, the baker map on the square and the continued fraction map. Driven by the examples, we will introduce some of the phenomena and main concepts which one is interested in studying. In the second part of the course, we will formalize these concepts and cover the basic definitions and some fundamental theorems and results in topological dynamics, in symbolic dynamics and in particular in ergodic theory. We will give full proofs of some of the main theorems. During the course we will also mention some applications both to other areas of mathematics, such as number theory, and to very concrete problems as data storage and Internet search engines.

Course Outlines: Basic notions: dynamical system, orbits, fixed points and fundamental questions; Basic examples of dynamical systems: circle rotations; expanding maps of the circle and the shift map; the Baker's map; the CAT map and toralautomorphisms; the Gauss transformation and Continued Fractions. Topological Dynamics: basic metric spaces notions, transitivity, minimality; topological conjugacy; topological mixing; topological entropy. Symbolic Dynamics: Shift and Subshifts spaces, topological dynamical properties of shift spaces, symbolic coding, coding of the CAT map. Ergodic Theory: basic measure theory notions; invariant measures, Poincare recurrence, ergodicity using Fourier series, mixing, ergodic theorems (Birkhoff Ergodic Theorem, ergodic theorem for Markov chains); applications to Internet Search

Recommended Books:

- An Introduction to Dynamical System by M. Brin and G. Stuck (Chapter 1 to 4) (The first three chapters contains the topics will be presented (in expanded and simplifyed exposition) during the course.)
- "A first course in Dynamics by B. Hasselblatt and A. Katok (This is the most accessible of the three. Most of the topics which we will cover from this book appear in Chapter 8 and 9.)
- "Dynamical Systems and Ergodic Theory" by M. Pollicott and M. Yuri

MATHEMATICAL MODELING IN PHYSICAL SCIENCES

Credit hours: 03(3-0) **Course Code: MATH-756**

Specific Objectives of the Course:

Mathematical modeling is the process of creating mathematical representation of some phenomenon in order to gain a better understanding of that phenomenon. The main goal of this course is to learn how to make a creative use of some mathematical tools, such as difference equations, ordinary and partial differential equations and numerical analysis, to build a mathematical description of some physical

problems. During the course the students will be required to work on papers written by scientists from several fields of science, such as biology and physics, and they will practice on some specific modeling problems. The final exam will consist in the completion of a self-consistent modeling project.

Course Outlines:

Introduction to Modeling: modeling process, overview of different kinds of models, Qualitative Modeling with Functions, Modeling with Dimensional Analysis, Modeling with Difference Equations:(a) Overview of basic concepts concerning matrices, eigenvalues and eigenvectors;
(b) Fixed points, stability and iterative processes;(c) Applications to population growth.
Modeling with Ordinary Differential Equations:(a) Overview of basic concepts in ODE and stability of solutions: existence and uniqueness for 1st order IVPs, Picard iteration, numerical methods, higher order IVPs; (b) Linear operators, coupled linear systems, phase plane, stability analysis;(c) Some applications: growth of cells, market growth, enzyme reactions, examples in mechanics and electric circuits, Empirical Modeling with Data Fitting:(a) Error function, least squares method;(b) Fitting data with polynomials and splines, Modeling with Partial Differential Equations:(a) Overview of the key properties of some particular kinds of PDEs: advection, diffusion, advection-diffusion;(b) Separation of variables, equilibrium solutions, stability and linear stability;(c) Travelling waves, spatially periodic solutions (patterns);(d) Some applications: stripes on the skin of the Marine Angelfish, analysis of temperature from the Greenland Ice Sheet.

Recommended Books:

- A First Course in Mathematical Modeling, by F. R. Giordano, M.D. Weir and W.P. Fox
- Modeling and Quantitative Methods in Fisheries By Malcolm Haddon A CRC

METHODS OF MATHEMATICAL PHYSICS

Credit hours: 03(3-0) **Course Code: MATH-757**

Specific Objective of the Course:

This is a calculus based Mathematical Methods course for mathematicians and students of the physical sciences

Course Outlines:

Functions of many variables, partial differentiation with applications. Most of the Mathematical equations of physics and chemistry involve partial differentiation and this section is a basic introduction to this calculus. Optimization; maximum and minimum values, with and without constraints.Lagrange Multipliers. Curve fitting. The theory of optimization is of importance in diverse applications in the physical and social/economic sciences. Introduction to Fourier series, with applications in the solution of partial differential equations. The theory of Fourier series is of fundamental importance in all the physical sciences. Multiple integrals and Green's Theorem.

Recommended Books:

- Mathematical Techniques by Jordan and Smith (Oxford).

- R. Courant and D. Hilbert, Methods of Mathematical Physics, Wiley, 2008
- H. Jeffreys and B. Jeffreys, Methods of Mathematical Physics, Cambridge University

DYNAMIC SYSTEMS AND CONTROL THEORY

Credit hours: 03(3-0) **Course Code: MATH-758**

Specific Objective of the Course:

To provide comprehensive understanding of complex behaviour of nonlinear physical systems, with an emphasis on chaos and the general theory of control of nonlinear dynamical systems.

Course Outlines:

Characterization of chaos in different systems, bifurcations, Rossler system, mappings, Poincaré section, p-cycles, folding and stretching, Lyapunov exponents, Henon map, saddle manifolds, homoclinic tangles, and basin of attraction, fractals and fractal dimensions. Linear dynamical systems, basics, state space solutions and realizations, stability, controllability&observability, state feedback and state estimation. Optimiation problems of dynamic Systems, optimization problems with path constaints, optimal feedback control, linear systems with quadratic criteria, optimal feedback control in the presence of uncertainity, Bellman's equation & dynamical programming: (a) calculus of variations, (b) computational aspects. Nonlinear system analysis: phase plane analysis, Lyapunov theory, advanced stability theory. Nonlinear Control Systems Design: Feedback linearization, sliding mode control, adaptive control, control of multi-input physical systems,schochastic and adaptive control.

Recommended Books:

- T. Kailath, A.H. Sayed, and B. Hassibi, Linear Estimation, Prentice Hall
- H.K. Khalil, Nonlinear Systems, Prentice Hall
- R. Bellman, Adaptive Control Process, Princeton University Press
- A.E. Bryson and Y.C. Ho, Applied Optimal Control, Hemisphere Publishing
- C.T.Chen, Linear System Theory & Design, Oxford University Press
- Robert F. Stengel, Optimal Control & Estimation, Dower Publications

FUZZY SETS AND THEIR APPLICATIONS

Credit hours: 03(3-0) **Course Code: MATH-759**

Specific Objective of the Course:

At the end of the course the readers will be able to know about Classical Sets via Fuzzy Sets, Types of Fuzzy Sets, Operations on Fuzzy Sets, Zadeh's Extension Principle, Fuzzy Relations, and Possibility Theory.

Course Outlines:

Fuzzy Sets

Classical sets via Fuzzy Sets, Need for fuzzy sets, Definition and Mathematical representations, Level Sets, Fuzzy functions, Zadeh's, Extension Principle.

Operations on [0,1], Fuzzy negation, triangular norms, t-norms, fuzzy implications, Aggregation Operations, Fuzzy Functional Equations.

Fuzzy Binary and n-ary relations, composition of fuzzy relations, Fuzzy Equivalence Relations, Fuzzy Compatibility Relations, Fuzzy Relational Equations.

Fuzzy Measures, Evidence Theory, Necessity and Belief Measures, Probability Measures via Possibility Measures.

Fuzzy Decision Making, Fuzzy Relational Inference, Compositional Rule of Inference, Efficiency of Inference, Hierarchical.

Fuzzy If-Then Rule Base, Inference Engine, Takagi-Sugeno Fuzzy Systems, Function Approximation.

Recommended Books:

- George J Klir and Bo Yuan, *Fuzzy Sets and Fuzzy Logic: Theory and Applications*, Prentice Hall NJ,1995.
- H.J. Zimmermann, *Fuzzy Set Theory and its Applications*, Allied Publishers, New Delhi, 1991.
- Kevin M Passino and Stephen Yurkovich, *Fuzzy Control*, Addison Wesley Longman, 1998.
- Michal Baczynski and Balasubramaniam Jayaram, *Fuzzy Implications*, Springer Verlag, Heidelberg, 2008.

FRACTIONAL DIFFERENTIAL EQUATIONS

Credit hours: 03(3-0) **Course Code: MATH-760**

Specific Objective of the Course:

Fractional derivatives provide an excellent instrument for the description of memory and hereditary properties of various materials and processes. This is the main advantage of fractional derivatives in comparison with classical integer-order models, in which such effect are in fact neglected. The advantages of fractional derivatives become apparent in modeling mechanical and electrical properties of real materials, as well as in the description of rheological properties of rocks, and in many other fields.

The other large field which requires the use of derivatives of non-integer order is the recently elaborated theory of fractals. Fractional calculus also appears in the theory of control of dynamical systems.

Course Outlines:

Historical origins of fractional calculus. Introduction to fractional order derivatives and integrals.Riemann, Liouville-Caputo fractional derivative-Riesz-Feller fractional derivative-Grunwal-Letnikov, Hadamard fractional derivative. The Riemann-Liouville, the Caputo's, types derivatives and their properties and relationship. Fractional Integrals, introduction to some fixed point theorems including Banach, Schauder and Schaefer etc for obtaining the Existence and Uniqueness Theorems, formation of Green's Function,

Other Methods for the Solution of Fractional-order Equations, existence theory for one, two and more solutions of Fractional-order equations and their Systems. and Controllers, Survey of Applications of the Fractional Calculus.

Recommended Books:

- An Introduction to Fractional Derivatives, Fractional Differential Equations, by Igor PodlubnyTechnical University of Kosiee, Slovak Republic.
- An Introduction to Fractional Calculus and Fractional Differential Equations by Kenneth Miller Mathematical Consultant Formally Professor Of Mathematics New York University and Bertram RossUniversity of New Haven.

APPLICATIONS OF FIXED POINT THEORY IN GENERALIZE SPACES

Credit hours: 03(3-0) **Course Code: MATH-761**

Course Contents:

Banach Spaces, Hilbert spaces, Fixed point results in generalized spaces (metric spaces, b-metric spaces, complex valued metric spaces, G-metric spaces etc.), Applications of fixed point results to Functional equations, matrix equations, differential and integral equations, Variational inequality and variational inclusion mapping.

Recommended Books:

- Fixed Point Theory by Andrzej Granas And James Dugundji, Springer Publisher.
- Fixed Point Theory in Ordered Sets and Applications, Siegfried Carl and Seppo Heikkilä
- Fixed Point Theory for Lipschitzian-type Mappings with Applications, by Ravi P. Agarwal Donal O'Regan and D.R. Sahu, Springer.
- Fixed Point Theory and Applications, R. Agarwal, M. Meehan and D. O Regan , Cambrige University Press

ADVANCED MATHEMATICAL METHODS

Credit hours: 03(3-0) **Course Code: MATH-762**

Aims and objectives: At graduate level the research scholars of physics, mathematics and computational sides need some best numerical methods for treating the nonlinear differential equations numerically. Some already known methods are not adequate for treating most of the nonlinear problems of differential ad integral equations. Therefore some iterative methods have been developed to find best approximate solutions to nonlinear problems of applied sciences.

Course contents: Euler, Tyler methods, Heun;s methods and applications**.** Introduction to Adomian polynomial and Adomian decomposition method and its applications to differential and integral equations. Introduction to homotopy analysis (HAM), Variation iteration method (VIM), homotopy perturbation method (HPM), Laplace homotopy decompositions method (LHDM), differential transform methods and its generalizations and the applications of these methods in nonlinear differential equations. Introduction to operational matrices and numerical solutions by using operational matrices methods.

Recommended Books and Articles

- Alfio Quarteroni, Riccardo Sacco, Fausto Saleri Numerical Mathematics, ISBN 0-387-98959-5nSpringer-VerlagnNew YorknBerlinnHeidelbergMSPIN 10747955. (2000).
- .H. He, Variational iteration method for autonomous ordinary differential systems, Applied Mathematics and Computation 114 (2–3) (2000) 115–123.
- J.H. He, Some asymptotic methods for strongly nonlinear equations, International Journal of Modern Physics B 20 (10) (2006) 1141–1199.
- M.A. Abdou, A.A. Soliman, Variational-iteration method for solving Burger's and coupled Burger's equations, Journal of Computational and Applied Mathematics 181 (2) (2005) 245–251.
- S. Momani, S. Abuasad, Application of He's variational-iteration method to Helmholtz equation, Chaos, Solitons & Fractals 27 (5) (2006) 1119–1123.
- B.A. Finlayson, The Method of Weighted Residuals and Variational Principles, Academic press, New York, 1972.
- S.J. Liao, Beyond Perturbation: *Introduction to the Homotopy Analysis Method*, *Chapman Hall/CRC Press*, *Boca Raton*., 2003.
- A. H. M. Abdilraze, *Admoian Decomposition method: convergence analysis and numerical approximations*, *M.sc. Dissertation*, *McMaster University Hamilton*., Canada, 2008.
- Z. Odibat, Differential transform method for solving Volterra integral equation with separable kernels, Math. Comput. Model., 48(2008) 1144 - 1146.

MATHEMATICAL METHODS FOR ARBITRARY ORDER DIFFERENTIAL EQUATIONS

Credit hours: 03(3-0) **Course Code: MATH-763**

Aims and objectives: Investigations of numerical solutions of non-integer order differential equations is an attractive area of research in recent times. Since as compared to classical differential and integral operators, fractional differential and integral operator are global operators. Therefore to find exact solutions to fractional differential equations is a challenging job. Therefore strong motivation has been

found to develop numerical procedure for the approximate solutions of fractional differential/integral equations.

Course Contents: Introductions to homotopy analysis and perturbations methods for treating fractional differential/ integral equations. Approximate solutions of fractional differential/ integral equations by using differential transform methods and Adomian decomposition methods. Applications of Laplace-Adomian decompositions methods to fractional differential/ integral equations.Introduction of variation iteration method and its applications to find numerical solutions of fractional differential/ integral equations.

Recommended Books:

- J.K. Zhou, Differential transform and its Applications for Electrical Circuits, Huazhong University Press, Wuhan, China, 1986.
- A. H. M. Abdilraze, Admoian Decomposition method: convergence analysis and numerical approximations, M.sc.
- Dissertation, McMaster University Hamilton , Canada 2008.
- K. Deimling, Nonlinear Functional Analysis, Springer-Verlag, New York, 1985.
- E. Zeidler, Nonlinear Functional Analysis an Its Applications. I: Fixed Point Theorems. Springer, New York (1986).

THEORY OF MAJORIZATION

Credit hours:03(3-0) **Course Code: MATH-764**

Course Contents:

Majorization theory is a key tool that allows us to transform complicated non-convex constrained optimization problems that involve matrix-valued variables into simple problems with scalar variables that can be easily solved. The additive majorization relation plays an important role in the design of linear MIMO transceivers, whereas the multiplicative majorization relation is the basis for nonlinear decision-feedback MIMO transceivers.

Course outlines:

Basic theory of convex functions, weighted and unweighted majorization theorems, applications of majorization theorem, Fuch's, Dragomir's, Shoshana- Pečarić's, Niezgoda's majorization results and relations between their results, generalization of majorization theorem for the class of n-convex functions by using Taylor's formula and Green function as well as Abel-Gontscharoff Polynomial, n-exponential convexity, n-exponential convexity for the functional obtained from the generalized majorization inequalities, some examples for exponential convexity results, Favard's and Berwald's inequalities and their generalizations.

Recommended Books:

- P. J. Davis, Interpolation and Approximation, Blaisdell Boston, 1961.

- J. Pečarić, F. Proschan and Y. L. Tong, Convex functions, Partial Orderings and Statistical Applications, Academic Press, New York, 1992.
- A. W. Marshall, I. Olkin and B. C. Arnold, Inequalities: Theory of Majorization and Its Applications (Second Edition), Springer Series in Statistics, New York 2011.
- R. P. Agarwal and P. J. Y. Wong, Error Inequalities in Polynomial Interpolation and their Applicationns, Kluwer Academic Publishers, Dordrecht, 1993.
- D. V. Widder: The Laplace Transform, Princeton Univ. Press, New Jersey, 1941.
- R. Bhatia, Matrix Analysis, New York: Springer-Verlage, 1997.

FUZZY ALGEBRA

Credit hours: 03(3-0) **Course Code: MATH-765**

Specific Objective of the Course:

At the end of the course the readers will be able to know about fuzzy subsemigroups, Fuzzy Rings, and fuzzy ideals of a semigroup and rings: can provide examples related to the course content as well.

Course Outlines:

Introduction

The concept of Fuzziness with examples, Operations of fuzzy sets, Fuzziness as uncertainty.

Algebra of Fuzzy Sets: Equivalence relations and partitions, Composing mappings, Alpha-cuts, Images of alpha-level sets, Operations on fuzzy sets.

Fuzzy Relations: Definitions and Examples, Binary Fuzzy Relations, Operations on Fuzzy relations, Fuzzy Partitions.

Fuzzy Semigroups: Fuzzy ideals of semigroups, Fuzzy quasi-ideals, Fuzzy bi-ideals of Semigroups, Characterization of different classes of semigroups by the properties of their fuzzy ideals fuzzy quasi-ideals and fuzzy bi-ideals.

Fuzzy Rings: Fuzzy ideals of rings, Prime, semiprime fuzzy ideals, Characterization of rings using the properties of fuzzy ideals

Recommended Books and Materials:

- J. N. Mordeson, Fuzzy Semigroups, Springer-Verlage, 2003. D.S. Malik andNobuki Kuroki
- H. T. Nguyen and A First course in Fuzzy Logic, Chapman and Hall/CRC Elbert A. Walker 199
- D. Dubois and H. Prade, Fuzzy Sets and Systems: Theory and Applications
- J. N. Mordeson and Fuzzy Commutative algebra, World Scientific, 1998.D.S. Malik
- M. Ganesh, Introduction to Fuzzy Sets and Fuzzy Logic, Prentice-Hall of India, 2006

NONLINEAR ANALYSIS AND ITS APPLICATIONS

Credit hours: 03(3-0) **Course Code: MATH-766**

Prerequisite: General Topology and Functional Analysis

Aims and objectives: This course will enable research students how to deal nonlinear problems for their respective solutions. They will be enabled to know how the techniques works in different situations and how the problems solutions are obtain by using the technique of nonlinear analysis.

Course contents:.Banach and Hilbert spaces, contraction operators.Introduction to homotopy and its applications. Monotone iterative techniques of contraction operators, Fixed point theorem of Banach, Schaudar, Schaefer, Brower's and applications in nonlinear differential and integral equations. Degree theory and its applications, the Brouwer degree theory, the Schauder degree theory and topological degree theory.The Picard-Lindelop theorem and its applications.

Recommended Books

- Martin Schechter, An Introduction to Nonlinear Analysis, University of California, Irvine**,** Cambridge University Press 2004.
- Akhiezer, N. I.The Calculus of Variations.New York, Blaisdell, 1962.
- Berger, M. S.Nonlinearity and Functional Analysis. New York, Academic , Press, 1977.
- Pavel Dr ´ abek, Jaroslav Milota, Lectures on Nonlinear Analysis, Czech Republic, Plzen-Prah,2004.
- Collin Adams and R. Franzosa, Introduction to topology pure and applied , second edition 2012.

NEAR RINGS

Credit hours:03(3-0) **Course Code: MATH-767**

Course Outlines:

Near Rings, Ideals of Near-rings, Isomorphism Theorems, Near Rings on finite groups, Near-ring modules. Isomorphism theorem for R-modules, R-series of modules, Jorden-Holder- Schrier Theorem, Type of Representations, Primitive near-rings R-centralizers, Density theorem, Radicals of near-rings.

Recommended Books:

- G. Pilz, (1982), "Near-Rings: What They Are and What They Are Good For" in Contemp. Math., 9, pp. 97–119. Amer. Math. Soc., Providence, R.I., 1981.
- G. Pilz, "Near-rings, the Theory and its Applications", North-Holland, Amsterdam, 2nd edition, (1983).
- J. Clay, "Nearrings: Geneses and applications", Oxford, (1992).

TOPOLOGICAL ALGEBRA

Credit hours:03(3-0) **Course Code: MATH-768**

Course Outlines:

Definition of a Topological algebra and its Examples. Adjunction of Unity, Locally Convex Algebras, Idempotent and m-convex sets, Locally Multiplicatively convex (l.m.c) algebras, Q-algebras, Frechet algebras, Spectrum of an element, Spectral radius, Basic theorems on Spectrum, Gelfand-Mazur Theorem. Maximal ideals, Quotient algebras, Multiplicative linear functionals and their continuity, Gelfand transformations, Radical of an algebra, Semi-simple algebras, Involutive algebras, Gelfand-Naimark theorem l.m.c. algebras.

Recommended Books:

- E. Beckenstein, L. Narici and C. Suffel, Topological Algebras, North-Holland Company, 1977.
- A. Mallios, Topological Algebras, Selected Topics, North-Holland Compnay, 1986. T. Husain, Multiplicative Functions on Topological Algebras, Pitman Advanced Publishing Program, 1983.
- E. Michael, Locally Multiplicatively-convex Topological Algebras, Memoirs Amer. Math. Soc. No.11, 1951.

NILPOTENT AND SOLUBLE GROUPS

Credit hours: 03(3-0) **Course Code: MATH-769**

Course Outlines:

Normal and Subnormal Series, Abelian and Central Series, Direct Products, Finitely Generated Abelian Groups, Splitting Theorems, Soluble and Nilpotent Groups, Commutators Subgroup, Derived Series, The Lower and Upper Central Series, Characterization of Finite Nilpotent Groups, Fitting Subgroup, Frattini Subgroup, Dedekind Groups, Supersoluble Groups, Soluble 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:

- D.J.S. Robinson,A Course in the Theory of Groups, Graduate Textes in Mathematics 80, Springer, New York, 1982.
- K. Doerk, T. Hawkes, Finite Soluble Groups, De Gruyter Expositions in Mathematics 4, Walter De Gruyter, Berlin, 1992.

NONLINEAR DYNAMICS AND NONLINEAR WAVES PHENOMENA

Credit hours: 03(3-0) **Course Code: MATH-770**

Specific Objective of the Course:

Nonlinear Dynamics and Nonlinear wave phenomena are of great importance in the physical world, and have been for a long time a challenging topic of research for both pure and applied mathematicians. This course focuses on analytical and physical aspects of nonlinear dynamics and nonlinear wave phenomena. This important area of research has traditionally interesting aspects of the theory of nonlinear waves, especially as described by one and two space-dimensional integrable PDEs, and inverse problems relating to this area. All of these topics have seen significant advances in recent years, and research is very active. The present course focuses more specifically on nonlinear waves and recent related techniques, presenting nonlinear wave propagation models and specific properties. The course will also include the classical inverse scattering transforms and some recent advances in this field. It aims to describe various different aspects of the relevant theory to an audience of postgraduate students and young postdoctoral researchers in applied mathematics.

Course Outlines:

Review of phase plane analysis, limit cycles. Perturbation techniques for Weekly nonlinear systems. Nonlinear forced vibrations, jump phenomena, synchronization, super harmonic and sub harmonic resonance. The classical water wave problem and derivation of model equations Derivation of canonical equations of mathematical physics from the water wave problem, with focus on Weekly nonlinear dispersive waves. Introduction to multiple scale analysis, the nonlinear Schroedinger equation as an envelope equation. Mean field generation. Multiple scale formalism with a few examples.Derivation of the Davey-Stewartson system. The nonlinear Schroedinger equation: Basic dynamical effects, Solutions in one space dimension; Solution Instability for tranverse perturbation. Structural properties of the NLS equation: Lagrangian and Hamiltonian structure, Noether theorem, invariances and conservation laws. The initial value problem: Existence theory, Long-time behavior; finite-time blowup. Analysis of the blow-up: self-similarity, modulation analysis, rate of blow-up.

References:

- W. Strauss: Nonlinear Wave Equations, CBMS, Volume 73, American M. Society
- C. Sulem and P.-L. Sulem: The Nonlinear Schroedinger Equation: Self-focusing and Wave Collapse, Appl. Math. Sciences, Volume 139, 1999, Springer
- Thierry Cazenave :Semilinear Schroedinger Equations, AMS, Lecture Notes of the Courant Institute, vol 10, 2003
- Jean Bourgain: Global solutions of Nonlinear Schroedinger equation, AMS, C. Series

OPTIMIZATION THEORY

Credit hours: 03(3-0) **Course Code: MATH-771**

Specific Objective of the Course:

Optimization is central to any problem involving decision making, whether in engineering or in economics. The task of making entails choosing between various alternatives. This choice is governed by our desire to make the best decision. The measure of goodness of the alternatives is described by an objective function or performance index. Optimization theory and methods deal with selecting the best alternative in the sense of the objective function. The area of optimization has received enormous attention in recent years, primarily because of rapid progress in computer technology, including the development and availability of user friendly software, high speed and parallel processors, and artificial neural networks.

Course Outlines:

Vector Spaces and Matrices, Rank of matrix, Linear Equations, Transformations, Eigenvalues and Eigenvectors, Matrix norms, Line segment, Convex sets, Elements Of Calculus, Sequence and Limits, Differentiability, The Derivative Matrix, Level Sets, Taylor Series, Un-constrained Optimization, Basics of Set-Constrained and Unconstrained Optimization, One Dimensional search Methods, Linear Programing,

References:

- An Introduction to Optimization Second Edition by Edwin K. P. Chong and H. Z. Stanislaw
- Optimization Theory with Applications by Donald A. Pierre Department of Electrical Engineering University of Bozeman, Montana

DYNAMICAL SYSTEM THEORY

Credit Hours: 03(3-0) **Course Code: MATH-772**

Specific Objective of the Course:

Establishing the theoretical basis of linear and non-linear dynamical systems in both continuous and discrete time.Learning how to anticipate the qualitative behaviour of the time-evolution of linear, Weekly nonlinear and strongly nonlinear dynamical systems.Applying this to models from various fields.

Course Outlines: Time domain solution, Stability: Definition, Exponential of a diagonalizable matrix, Stability of a linear system with a diagonalizable state matrix, Existence and uniqueness of the solutions, Asymptotic behaviour, Jordan normal form, General form of the free solution of linear systems, Stability of linear systems (general case), Asymptotic Behaviour, Solution of linear

autonomous systems, Classification of the flows of 2-d autonomous continuous-time systems, Stability of linear systems, Classification of equilibria and sketching of phase portraits, Phase portraits of 3-dim autonomous systems, Stability of linear discrete-time systems, Link with Frequency Domain Analysis, Nonlinear systems: Introduction to nonlinear systems,Iterations of the logistic map, Van der Pol oscillator,Stability of nonlinear systems:Large-scale notions of (in) stability, Boundedness and asymptotic uniform boundedness of solutions, Lyapunov functions for proving boundedness and asymptotic uniform boundedness of the solutions, Large-scale notions of (in)stability, Special class of systems: Hamiltonian systems, Small-scale notions of (in)stability, Stability of a solution, Criterion for stability of a fixed/equilibrium point, Stable and unstable manifold of a fixed/equilibrium point, Sketching the flow in the vicinity of a fixed/equilibrium point in 2 dimensions, Lyapunov functions for estimating the basin of attraction of an asymptotically stable equilibrium/fixed point and for proving global asymptotic stability of an equilibrium/fixed point, Special class of systems: Gradient systems, Stability of periodic solutions of discrete-time systems, Stability of periodic solutions of continuous-time systems, Bifurcations:Implicit Function Theorem, 1-parameter bifurcations of equilibrium and fixed points: necessary conditions for the eigenvalues of the Jacobian matrix, Existence of periodic solutions, Stability of periodic solutions, Fold bifurcation in one-dimension, Pitchfork bifurcation inone-dimension, Andronov-Hopf bifurcation in one-dimension

Recommended Books:

- C. J, Harris, J.E. Mills, Stability of linear systems: some aspects of kinematic similarity, Elsevier Science
- P.G. Drazin, Nonlinear Systems, Cambridge University Press
- S. Wiggins, Introduction to Applied Nonlinear Dynamical Systems and Chaos
- T. Dougherty, Systems and Control: An Introduction to Linear, Sampled and Non-Linear Systems, World Scientific
- S.N. Chow, and J.K. Hale, , Methods of bifurcation theory, Springer-Verlag
- D. Luo, Bifurcation Theory and Methods of Dynamical Systems, World Scientific

BIO-MECHANICS

Credit hours: 03(3-0) **Course Code: MATH-773**

Specific Objective of the Course:

Biomechanics is mechanics applied to biology. Biomechanics seeks to understand the mechanics of living systems. It is the modern subject with ancient roots and covers a very wide territory. The research in this area comes from the realization that biology can no more understood without biomechanics than an

airplane can without aerodynamics. For an airplane, mechanics enables us to design its structure and predict its performance.

Course Outlines:

Introduction: A Sketch of the History and Scope of the Field, Stress, Strain, Strain Rate, The meaning of the Constitutive Equation, The Non-viscous Fluid, The Flow Properties of Blood,
Newtonian Fluid, Non Newtonian Fluids, Navier Stokes Equations.

Recommended Books:

- Biomechanics Mechanical Properties of Living Tissues Second Edition By Y. C. Fung Department of Bioengineering University of California USA.

APPLIED NUMERICAL ANALYSIS

Credit hours:03(3-0) **Course Code: MATH-774**

Specific Objective of the Course:

The purpose of numerical analysis is two-fold: To find acceptable approximate solutions when exact solutions are either impossible or so arduous and time-consuming as to be impractical, and To devise alternate methods of solution better suited to the capabilities of computers.

This course will cover the general issues arising in numerical computing and implementation of algorithms used to solve numerical problems in practice. We will develop numerical algorithms for the main-stream problems. The quality of a numerical algorithm is often judged based on two criteria namely efficiency (vaguely speaking number of arithmetic operations required) and accuracy. We will analyze the accuracy and efficiency of the numerical algorithms developed.

We will also examine issues of problem sensitivity and algorithmic stability and ways to improve efficiency.

Course Outline: This is a general outline of the material we will cover (not necessarily in this order). It is subject to change according to time and class interests.

1. Mathematical Preliminaries and Error Analysis
    a. Round-off Errors and Computer Arithmetic
    b. Algorithms and Convergence
2. Solutions of Equations in One Variable
    a. The Bisection Method
    b. Fixed-Point Iteration
    c. Newton's Method and Its Extensions
    d. Error Analysis for Iterative Methods
    e. Accelerating Convergence
3. Interpolation and Polynomial Approximation
    a. Interpolation and the Lagrange Polynomial
    b. Divided Differences
    c. Hermite Interpolation

d. Cubic Spline Interpolation

4. Numerical Differentiation and Integration
   a. Numerical Differentiation
   b. Richardson's Extrapolation
   c. Elements of Numerical Integration
   d. Composite Numerical Integration
   e. Romberg Integration
   f. Adaptive Quadrature Methods
   g. Gaussian Quadrature

5. Approximation theory
   a. Discrete Least Squares Approximation
   b. Continuous Least Squares Approximation
   c. Chebyshev polynomials
   d. Rational Function Approximation
   e. Trigonometric polynomial Approximation
   f. Fast Fourier transforms

6. Initial-Value Problems for Ordinary Differential Equations
   a. The Elementary Theory of Initial-Value Problems
   b. Euler's Method
   c. Higher-Order Taylor Methods
   d. Runge-Kutta Methods
   e. Multistep Methods
   f. Variable Step-Size Multistep Methods

7. Boundary-Value Problems for Ordinary Differential Equations
   a. Shooting methods.
      i. The method of bisection
      ii. The Newton–Raphson method
   b. Matrix methods
      i. Linear boundary value problem.
      ii. Nonlinear boundary value problem
   c. Collocation method

8. Numerical Methods for Partial Differential Equations

   a. Hyperbolic Partial Differential Equations
   b. Parabolic Partial Differential Equations
   c. Elliptic Partial Differential Equations

9. Other topics of interest to you.

Recommended Books:

- Brian Bradie, A Friendly Introduction to Numerical Analysis, 2006, Prentice Hall
- Burden and Faires, Numerical Analysis, 10th edition 2010, Brooks Cole

- J Kendall Atkinson, Elementary Numerical Analysis, 3rd edition 2004, Wiley
- J. H. Mathews, and K. D. Fink, Numerical Methods Using Matlab (4th ed.)

MATHEMATICAL BIOLOGY

Credit hours: 03(3-0) **Course Code: MATH-775**

Specific Objective of the Course:

Mathematical biology is a fast-growing, well-recognized, albeit not clearly defined, subject and is, to my mind, the most exciting modern application of mathematics. The increasing use of mathematics in biology is inevitable as biology becomes more quantitative. The complexity of the biological sciences makes interdisciplinary involvement essential. For the mathematician, biology opens up new and exciting branches, while for the biologist, mathematical modeling offers another research tool commensurate with a new powerful laboratory technique but only if used appropriately and its limitations recognized. However, the use of esoteric mathematics arrogantly applied to biological problems by mathematicians who know little about the real biology, together with unsubstantiated claims as to how important such theories are, do little to promote the interdisciplinary involvement which is so essential. Mathematical biology research, to be useful and interesting, must be relevant biologically. The best models show how a process works and then predict what may follow. If these are not already obvious to the biologists and the predictions turn out to be right, then you will have the biologists' attention. Suggestions as to what the governing mechanisms are may evolve from this. Genuine interdisciplinary research and the use of models can produce exciting results, many of which are described in this study.

Corse Outlines:

Population Dynamics , Continuous and Discrete Population Models for Single Species, Models for Interacting Populations, Age-structured Populations, Stochastic Population Growth, Dynamics of Infectious Diseases, Historical Asideon Epidemics, Simple Epidemic Models and Practical Applications , Modeling Venereal Diseases , Multi-Group Model for Gonorrhea and Its Control, AIDS: Modeling the Transmission Dynamics of the Human Immunodeficiency Virus (HIV) , HIV: Modeling Combination Drug Therapy , Delay Model for HIV Infection with Drug Therapy , Modeling the Population Dynamics of Acquired Immunity to Parasite Infection , Age-Dependent Epidemic Model and Threshold Criterion.

Recommended Books:

- Mathematical Biology. An Introduction, Third Edition by J.D. Murray**,** FRS
- Dynamical Models in Biology by Miklos FarkasSchool of Mathematics, Budapest University of Technology Budapest, Hungary

COMPUTATIONAL FLUID DYNAMICS

Credit hours: 03(3-0) **Course Code: MATH-776**

Specific Objective of the Course:

The field of computational fluid dynamics has a broad range of applicability. The first step involves the specification of the problem, including the geometry, flowconditions, and the requirements of the simulation. The geometry may result from measurements of an existing configuration or may be associated with a design study. Alternatively, in a design context, no geometry need be supplied. Instead, a set of objectives and constraints must be specified. Flow conditions might include, for example, the Reynolds number and Mach number for the flow over an airfoil. The requirements of the simulation include issues such as the level of accuracy needed, the turnaround time required, and the solution parameters of interest. It is generally accepted that the phenomena of importance to the field of continuum fluid dynamics are governed by the conservation of mass, momentum, and energy.

Course Outlines:

The Basic Equations of Fluid Dynamics, Governing Equations, The Flow and its Mathematical Description, Principles of Solution of the Governing Equations, Partial Differential equations: Analytic aspects, Finite Volume and Finite Difference Discretization on Non-uniform grids, Inviscid Flow, Boundary Layer Flow, Flow Governed by reduced Navier-Stokes Equations, Incompressible Viscous Flow, Compressible Viscous Flow.

Recommended Books:

- Computational Fluid Dynamics: Principles and Applications By J. BlazekAlstomPower Ltd.,Baden-Daettwil, Switzerland.
- Principles of Computational Fluid Dynamics By Pieter Wesseling Faculty of Information Technology and Systems Delft University of Technology Netherlands.

ITEM NO: FOUR
ANNEXURE D

Marks break down and papers pattern for Software Packages

Marks break down of Software Packages Course (1+2)

The distribution of marks for the course software packages is as under:

Evaluation	Marks	% of total
Mid Term Exam	20	20%
Final Term Exam	40	40%
Quizzes / Assignments	10	10%
Practical / Viva	30	30%
Total	100	100%

Papers pattern of Software Packages Course

The Mid Term and Final Term papers may be as under:

Mid Term:

Total Marks 20 Total time 1.30 Hour

Section A of 10 marks comprises of three MCQs, Four fill in the blanks and three true/false.

Section B of 10 marks comprises of three questions out of which two may be attended of 5 marks each.

Final Term:

Total Marks 40 Total time 2.00 Hour

Section A of 10 marks comprises of three MCQs, Four fill in the blanks and three true/false.

Section B of 6 marks comprises of four questions out of which three may be attended of 2 marks each.

Section C of 24 marks comprises of four questions out of which three may be attended of 8 marks each.

There will be a Practical/Viva of 30 marks conducted by an external and internal examiner. Further distribution of these 30 marks will be as under

Practical	20 marks
Viva Voce	10 marks

Practical will includes writing and implementation of codes and program for the problems given by the examiner.

Ten (10) marks are reserved for quizzes, assignments and presentation.

Sample Papers

University of Swat
Department of Mathematics & Statistics
Mid Term Examination,
Proposed Paper Pattern (Software Packages)

tal Time: 1:30 Hours Total Marks: 20

Student Name---------- **Roll. No----------**
Degree program---------- **Answer sheet No----------**
Semester---------- **Student signature----------**
Examiner signature_____

Section – A (10 Marks) **Time allowed: 15 minutes** **(Overwriting is not allowed)**

Q: 1 **(A) Choose the correct option.** **(3)**

i.
ii.
iii.

(B) Fill in the blanks. **(4)**

i.
ii.
iii.
iv.

(C) Write T for True and F for False. **(3)**

i.
ii.
iii.

University of Swat

Department of Mathematics & Statistics

Mid Term Examination,

Proposed Paper Pattern (Software Packages)

Time: 1:30 Hours Total Marks: 20

Section-B (10 Marks)

Attempt any two questions of the following. All questions carry equal marks.

Q No.2 (May or may not contain parts, depending on the nature of the question) **(05 Marks)**

Q No.3 (May or may not contain parts, depending on the nature of the question) **(05 Marks)**

Q No.4 (May or may not contain parts, depending on the nature of the question) **(05 Marks)**

Good Luck!

University of Swat

Department of Mathematics & Statistics

Final Term Examination,

Proposed Paper Pattern (Software Packages)

Time: 2:00 Hours Total Marks: 40

Student Name---------- **Roll. No----------**
Degree program---------- **Answer sheet No----------**
Semester---------- **Student signature----------**
Examiner signature_____

Section – A (10 Marks) **Time allowed: 15 minutes** **(Overwriting is not allowed)**

Q: 1 **(A)Choose the correct option.** **(3)**

iv.

v.

vi.

(B) Fill in the blanks. **(4)**

v.

vi.

vii.

viii.

(C) Write T for True and F for False. **(3)**

iv.

v.

vi.

University of Swat

Department of Mathematics & Statistics
Final Term Examination,
Proposed Paper Pattern (Software Packages)

ime: 2:00 Hours Total Marks: 40

Section-B **(06 Marks)**

Attempt any three questions of the following. All questions carry equal marks.

I. **(02 Marks)**
II. **(02 Marks)**
III. **(02 Marks)**
IV. **(02 Marks)**

Section-C **(24 Marks)**

Attempt any three questions of the following. All questions carry equal marks.

Q No.1 (may or may not contain parts, depending on the nature of question) **(08 Marks)**
Q No.2 (may or may not contain parts, depending on the nature of question) **(08 Marks)**
Q No.3 (may or may not contain parts, depending on the nature of question) **(08 Marks)**
Q No.4 (may or may not contain parts, depending on the nature of question) **(08 Marks)**

Good Luck!

University of Swat

DEPARTMENT OF MATHEMATICS AND STISTICS

Program Name:_____

Award List

Fresh ☐ **Repeat** ☐ **SCE** ☐ **Makeup** ☐ **IOG** ☐

Examination
Fall ☐
Spring ☐
Year ☐
Session ☐

Semester: I ☐ II ☐ III ☐ IV ☐ V ☐ VI ☐ VII ☐ VIII ☐ IX ☐ X ☐

Course Title: Software Packages

Teacher Name: _____ Credit Hours: 03 (1-2)

Roll No.	Name of Student	Marks Obtained						
		MT (20)	FT (40)	Practical (20)	Viva Voce (10)	Assig. (05)	Pres. (05)	Total 100

*MT: Mid Term, FT: Final Term, Assig: Assignments, Pres: Presentations,

Name of Examiner/Prof: _____

Signature with date: _____ Countersigned by HoD _____