DEPARTMENT OF MATHEMATICS
UNIVERSITY OF MALAKAND

Ref. No: UOM/Math/13/____ Dated: _____

To

The Deputy Registrar (Academics)

University of Malakand

Subject: **Approval/Renewal of Various Academics Programs**

Respected Sir,

The department of Mathematics in its 2nd meeting of the Board of Studies held on 16th February 2013, has recommended/renewed various academics programs, its scheme of studies and courses. Moreover, the same is recommended/ renewed by the board of faculty with slight modification in its meeting held on 1st April 2013. The document is now forwarded for approval/renewal to the Academic Council meeting University of Malakand.

Chairman

Department of Mathematics
University of Malakand

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DEPARTMENT OF MATHEMATICS

UNIVERSITY OF MALAKAND

ACADEMIC PROGRAMS

SUBMITTED TO:

ACADEMIC COUNCIL

UNIVERSITY OF MALAKAND

DEPARTMENT OF MATHEMATICS

UNIVERSITY OF MALAKAND

To

The Academic Council

University of Malakand

Subject: **Approval/ Renewal of Various Academics Programs**

The department of Mathematics is committed to achieve academic excellence by continuously revising its existing programs and courses to keep the students aware of the latest development taken place in Mathematics.

The Department of Mathematics made a detailed and exhaustive revision of the existing programs in its 2nd meeting of the Board of Studies held on 16th February 2013. The recommendation/ Renewal of the various programs have been given to strengthen the existing programs.

Moreover, the same is recommended/renewed by the Board of Faculty with slight modification in its meeting held on 1st April 2013.

The following programs are hereby submitted for approval to the meeting of Academic Council of University of Malakand:

Bachelor Program

BS-Mathematics (4 years Program)

Approval/Renewal of Scheme of Studies and Courses for BS-Mathematics Semester System

Master Programs

M.Sc Mathematics (2 years Program)

i) Approval/Renewal of Scheme of Studies and Courses for M.Sc Mathematics Annual System

ii) Approval/Renewal of Scheme of Studies and Courses for M.Sc Mathematics Semester System

MPhil/MPhil leading to PhD and PhD Programs

Approval of Scheme of Studies and Courses for MPhil/MPhil leading to PhD and PhD Mathematics

All the honorable members of the Academic Council are therefore requested to grant approval of the above mentioned programs and courses after their due consideration.

Date: 19-07-2013

Chairman

Department of Mathematics
University of Malakand

Minutes of the 2nd Meeting of the Board of Studies, Department of Mathematics University of Malakand

The 2nd meeting of the Board of Studies was held on 16th February, 2013 at 10:00 am in the committee room, University of Malakand. The meeting was chaired by Dr. Gul Zaman (Chairman, Department of Mathematics). The meeting was started with the recitation from the Holy Quran by Mr. Amanullah.

The following attended the meeting:

1. Dr. Gul Zaman, Associate Professor/Chairman Department of Mathematics University of Malakand
2. Prof. Dr. Inayat Ali Shah, Islamia College University, Peshawar
3. Dr. Siraj Ul Haq, Associate Professor, GIKI, Swabi
4. Mr. Zia Ul Haq, Associate Professor, GDC Timergara
5. Mr. Zamin Gul, Associate Professor, GDC Batkhela
6. Ms. Musarrat Begum, Assistant Professor GGDC Dargai
7. Dr. Imtiaz Ahmad, Assistant Professor, Department of Mathematics University of Malakand
8. Mr. Salman Zeb, Lecturer, Department of Mathematics University of Malakand

The Chairman welcomed all the members of the Board of Studies and expressed his gratitude over the members of sparing their precious time to attend the meeting.

The Chairman allowed the discussion on the agenda items one by one.

1. The 1st item of the agenda was the approval/renewal of BS-Mathematics Program. The Board was informed that the program has already been duly approved by the Board of studies (on 9th July, 2009) and subsequently by the Academic Council University of Malakand (on 3rd August, 2009). The Board was further informed that the program is running very successfully and so far six batches have been completed their course of studies. The department has made minor changes in the scheme of studies and revised the courses of BS-Mathematics Program. The Program, its scheme of studies and courses was discussed in details. The Board gave recommendation and approval to the said program, its scheme of studies and courses.
2. The 2nd item of the agenda was the approval and renewal of master programs. The Board was informed that the programs has already been duly approved by the Board of studies (on 9th July, 2009) and subsequently by the Academic Council University of Malakand (on 3rd August, 2009). The Board was further informed that the master program (annual system) is running very successfully and so far four batches have been completed their course of studies. The department has made minor changes in the existing master program (annual). The Board approved/renewed the program, its scheme of studies and courses.
3. The board was informed that the department is intended to switchover from annual to semester system in coming session. And all homework related to implementing the semester system has been done by the department. The Board gave recommendation and approval to the master program (semester system), its scheme of studies and courses with the minor change that Computing Tools can be offered in place of programming language C/C++ in 1st semester.

4. The 3rd item of the agenda was to approve the MPhil/MPhil leading to PhD and PhD programs. The Board was informed that the department has started MPhil/PhD program in the session 2006 under the supervision of HEC approved foreign faculty member. Subsequently the department also advertised MPhil admission in the session 2008. So for 9 research scholars have completed their MPhil degrees. Currently the department has seven full time PhD faculty members, and there are 57 MPhil and 15 PhD research scholars enrolled in the department. The Board thoroughly discussed the programs, its scheme of studies and courses, and gave approval to all existing, and previous programs.

5. The Board also duly approved all the scheme of studies and courses offered by the department of mathematics from time to time in its various programs.
6. The Board also unanimously approved that all the programs of the department of mathematics will be governed by the relevant By-laws of University of Malakand.

The meeting was adjourned with vote of thanks by the chair.

Chairman
Department of Mathematics
University of Malakand

WORKING PAPER FOR THE

MEETING OF THE BOARD OF FACULTY

DEPARTMENT OF MATHEMATICS

UNIVERSITY OF MALAKAND

WORKING PAPER FOR THE

2nd MEETING OF THE BOARD OF STUDIES

DEPARTMENT OF MATHEMATICS

UNIVERSITY OF MALAKAND

LIST OF CONTENTS

DETAILS AND JUSTIFICATION OF THE AGENDA ITEMS

S. No	Name of the program and its justification	Remarks
1	**Item One:** **Bachelor Program** **i)** Approval/Renewal of Scheme of Studies and Courses for BS-Mathematics Semester System for the session 2009-13 and onwards. **(Annexure A1)** The 1st meeting of the board of studies was held on 9th July 2009 in the committee room University of Malakand in which recommendation was accorded to scheme of studies and courses for the BS-Mathematics Semester System. The department is renewing the scheme of studies and courses for BS-Mathematics Semester System keeping in view the approved structure of the HEC for the said program. This step will help to keep the students intact with the latest developments taking place in the field of mathematics. Moreover, the same was recommended by the Board of Faculty in its meeting held on 1st April, 2013 with a slight modification.	
2	**Item Two:** **Master Program** **i.** Approval/Renewal of Scheme of Studies and Courses for M.Sc Mathematics Annual System for the session 2010-12 and onwards. **(Annexure B1)** The 1st meeting of the board of studies was held on 9th July 2009 in the committee room University of Malakand in which recommendation was accorded to scheme of studies and courses for the M.Sc Mathematics Annual System. The department is renewing the scheme of studies and courses of M.Sc Mathematics Annual System. Moreover, the same was recommended by the Board of Faculty in its meeting held on 1st April, 2013 with a slight modification. **ii.** Approval/Renewal of Scheme of Studies and Courses for M.Sc Mathematics Semester System for the session 2013-15 and onwards. **(Annexure B2)** The 1st meeting of the board of studies was held on 9th July 2009 in the committee room University of Malakand in which approval was accorded to scheme of studies and courses for the M.Sc Mathematics Semester System. The department is	

	renewing the scheme of studies and courses of M.Sc Mathematics Annual System. The department intends to switch over from the existing Annual System towards the Semester System in the coming session. Moreover, the same was recommended by the Board of Faculty in its meeting held on 1st April, 2013 with a slight modification.	
3	**Item Three:** **MPhil/MPhil leading to PhD and PhD Program** **i)** Approval of Scheme of Studies and Courses for MPhil/ MPhil leading to PhD and PhD Mathematics program for the session 2013 and onwards. **(Annexure C1)** The department has started MPhil/PhD program in the session 2006 under the supervision of HEC approved foreign faculty member. Subsequently the department also advertised MPhil admission in the session 2008. So for 9 research scholars have completed their MPhil degrees. Currently the department has seven full time PhD faculty members, and there are 57 MPhil and 15 PhD research scholars are enrolled in the department. The department is interested in approving the scheme of studies for MPhil/MPhil leading to PhD and PhD programs in order to strengthen the existing programs. This step will help to keep the research scholars intact with the latest research and development taking place in the field of Mathematics.	

Annexure A1

Item No: 01

Bachelor Program in Mathematics

Degree Awarded: BS-Mathematics

Entrance Requirements: HSC (Pre-Engineering Group) or equivalent with at least 45% marks

Duration of the Program: 4 years (8 Semesters)

Total Credit Hours: 136
Total Marks: 4500

Marks Breakdown for Courses

Item	Maximum Marks for Courses (without Laboratory)	Maximum Marks for Courses with Laboratory (2 + 1)
Mid-Term Examination	30%	15%
Internal Marks (Assignments, Quizzes, Presentations)	20%	20%
Laboratory	----	15%
Semester Examination	50%	50%
Total	100%	100%

The BS Scheme of Studies: Main Structure

S. No.	Categories	Number of Courses	Credit Hours
1	Compulsory Requirements	08	22
2	General Courses	10	30
3	Discipline-Specific-Foundation Courses	10	30
4	Major Courses	09	27
5	Electives Courses + Project	09	27
Total		**46**	**136**

The BS Scheme of studies: Layout/Framework

Compulsory Courses		**General Courses**	
Title	**Credit hours**	**Title**	**Credit hours**
1. Islamic Studies	**2**	**1.** Mechanics	**3**
2. Pakistan Studies	**2**	**2.** Waves & Oscillations	**3**
3. English Structure	**3**	**3.** Electromagnetic Theory	**3**
4. Communication Skills	**3**	**4.** Modern Physics	**3**
5. Technical Writing	**3**	**5.** Introduction to Economics	**3**
6. Introduction to computer	**3**	**6.** Econometrics	**3**
7. Programming Languages C/C++	**3**	**7.** Introduction to Accounting	**3**
8. Computing Tools	**3**	**8.** Business Mathematics	**3**
		9. Introduction to Psychology	**3**
		10. Introduction to Sociology	**3**
Total	**22**		**30**

Foundation Courses		**Major Courses**		**Electives Courses+ Project**	
Title	**Credit hours**	**Title**	**Credit hours**	**Title**	**Credit hours**
1. Calculus-I	**3**	**1.** Discrete Structures	**3**	**1.** Elective-I	**3**
2. Calculus-II	**3**	**2.** Number Theory	**3**	**2.** Elective-II	**3**
3. Calculus-III	**3**	**3.** Probability Theory	**3**	**3.** Elective-III	**3**
4. Algebra-I	**3**	**4.** Vector & Tensor Analysis	**3**	**4.** Elective-IV	**3**
5. Algebra-II	**3**	**5.** Classical Mechanics	**3**	**5.** Elective-V	**3**
6. Algebra-III	**3**	**6.** Basics Topology	**3**	**6.** Elective-VI	**3**
7. Complex Analysis	**3**	**7.** Mathematical Statistics	**3**	**7.** Elective-VII	**3**
8. Ordinary Differential Equations	**3**	**8.** Numerical Analysis	**3**	**8.** Elective-VIII	**3**
9. Real Analysis-I	**3**	**9.** Partial Differential Equations	**3**	**9.** Project/Elective-IX	**3**
10. Real Analysis-II	**3**				
Total	**30**		**27**		**27**

SECHEME OF STUDIES

(Semester-Wise Breakdown)

1st Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
1	MCC-201	Islamic Studies	50	2(2-0)
2	MCC-202	English Structure	100	3(3-0)
3	MGC-221	Mechanics	100	3(3-0)
4	MGC-222	Introduction to Economics	100	3(3-0)
5	MFC-231	Calculus-I	100	3(3-0)
6	MMC-251	Discrete Structure	100	3(3-0)
	Total		**550**	**17**

2nd Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
7	MCC-203	Pakistan Studies	50	2(2-0)
8	MCC-204	Introduction to Computer	100	3(2-1)
9	MGC-223	Waves and Oscillations	100	3(3-0)
10	MGC-224	Introduction to Accounting	100	3(3-0)
11	MFC-232	Calculus-II	100	3(3-0)
12	MMC-252	Number Theory	100	3(3-0)
	Total		**550**	**17**

3rd Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
13	MCC-205	Communications Skills	100	3(2-1)
14	MCC-206	Programming Languages C/C++	100	3(2-1)
15	MGC-225	Business Mathematics	100	3(3-0)
16	MGC-226	Introduction to Sociology	100	3(3-0)
17	MGC-227	Electromagnetic Theory	100	3(3-0)
18	MFC-233	Calculus-III	100	3(3-0)
	Total		**600**	**18**

4th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
19	MCC-207	Computing Tools	100	3(2-1)
20	MGC-228	Introduction to Psychology	100	3(3-0)
21	MGC-229	Modern Physics	100	3(3-0)
22	MFC-234	Algebra-I	100	3(3-0)
23	MMC-253	Probability Theory	100	3(3-0)
24	MMC-254	Basics Topology	100	3(3-0)
	Total		**600**	**18**

5th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
25	MFC-235	Algebra-II	100	3(3-0)
26	MFC-236	Real Analysis-I	100	3(3-0)
27	MFC-237	Ordinary Differential Equations	100	3(3-0)
28	MMC-255	Vector and Tensor Analysis	100	3(3-0)
29	MMC-256	Mathematical Statistics	100	3(3-0)
30	MMC-257	Numerical Analysis	100	3(3-0)
	Total		**600**	**18**

6th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
31	MFC-238	Algebra-III	100	3(3-0)
32	MFC-239	Real Analysis-II	100	3(3-0)
33	MFC-240	Complex Analysis	100	3(3-0)
34	MMC-258	Classical Mechanics	100	3(3-0)
35	MMC-259	Partial Differential Equations	100	3(3-0)
36	MGC-230	Econometrics	100	3(3-0)
	Total		**600**	**18**

7th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
37	MCC-208	Technical Writing	100	3(3-0)
38	----	Elective-I	100	3(3-0)
39	----	Elective-II	100	3(3-0)
40	----	Elective-III	100	3(3-0)
41	----	Elective-IV	100	3(3-0)
	Total		**500**	**15**

8th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
42	----	Elective-V	100	3(3-0)
43	----	Elective-VI	100	3(3-0)
44	----	Elective-VII	100	3(3-0)
45	----	Elective-VIII	100	3(3-0)
46	----	Project **OR** Elective-IX	100	3(3-0)
	Total		**500**	**15**

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

ELECTIVE COURSES

S. No	Course Code	Course Name	Credit hours
1	MEC-271	General Topology	03
2	MEC-272	Functional Analysis	03
3	MEC-273	Modeling and Simulations	03
4	MEC-274	Advanced Number Theory	03
5	MEC-275	Advanced Partial Differential Equations	03
6	MEC-276	Advanced Numerical Analysis	03
7	MEC-277	Advanced Functional Analysis	03
8	MEC-278	Differential Geometry	03
9	MEC-279	Optimization Theory	03
10	MEC-280	Measure Theory & Integrations	03
11	MEC-281	Fluid Mechanics	03
12	MEC-282	Stochastic Processes	03
13	MEC-283	Integral Equations	03
14	MEC-284	Relativity	03
15	MEC-285	Quantum Mechanics-I	03
16	MEC-286	Quantum Mechanics-II	03
17	MEC-287	Electrodynamics-I	03
18	MEC-288	Electrodynamics-II	03

COURSE CONTENTS

1st SEMESTER

MCC-201 ISLAMIC STUDIES
Prerequisite: None
Credit Hours: 2+0
Specific Objectives of the Course:
This course is aimed to provide basic information about Islamic studies, to enhance understanding of the students regarding Islamic civilization, to improve student skills to perform prayers and other worships, and to enhance the skill of the students for understanding of issues related to faith and religious life.
Course Outline:
Introduction to Quranic Studies; basics concepts of Quran, history of Quran, Uloom-ul Quran, Study of selected text of Holy Quran; verses of surah Al-Baqra related to faith (verse no: 284-286), verses of surah Al-Hujrat related to adab al-nabi (verse no:1-18), verses of surah Al-Muhammad related to characteristics of faithful (verse no:1-11), verses of surah Al-Baqra related to faith (verse no: 284-286), verses of surah Al- Furqan related to social ethics (verse no:63-77), verses of surah Al-Inam related to Ihkam (verse no:152-154), verses of surah Al-Ihzab related to adab al-nabi (verse no:6, 21, 40, 56, 57, 58), verses of surah Al-Hashar related to thinking, day of judgemnet (verse no:18,19,20), verses of surah Al-Saf related to tafakar, tadabar (verse no:1,14), Seerat of Holy Prophet; life of Muhammad in Makkah and Madina, (with focus on the major events), Introduction to Sunnah: basic concepts of Hadith, history of Hadith, Kinds of Hadith, Uloom-ul-Hadith, Sunnah and Hadith, legal position of Sunnah, selected study from text of Hadith, Introduction to Islamic law and Jurisprudence; Isalamic culture and Civilization, Islam and Science, Islamic Economic System, Political system of Islam, Islamic, Social system of Islam.
Recommended Books:

- Ahmad Hasan, *Principles of Islamic Jurisprudence*, Islamic Research Institute, International Islamic University, Islamabad, 1993
- Mir Waliullah, *Muslim Jurisprudence and the Quranic Law of Crimes*, Islamic Book Service, 1982
- H.S. Bhatia, *Studies in Islamic Law, Religion and Society*, Deep and Deep Publications New Delhi, 1989
- M. Zia-Ul-Haq, *Introduction to Al Sharia Al Islami*, Allama Iqbal Open University, Islamabad, 2001
- Muhammad Hammed Ullah, *Introduction to Islam*
- Prof. Khurshid Ahmad, *Islamli Nazriya Hayat*
- Dr. Hamid Ullah, *Khutbathe-e-Bhawapoor*
- Syed Amir Ali, *The Spirit of Islam*

MCC-202 ENGLISH STRUCTURE

Prerequisite(s): None

Credit Hours: 3 + 0

Specific Objectives of the Course:

The course aims at enhancing the language skills and developing critical thinking of the students.

Course Outline:

Basics of Grammar, parts of speech and use of articles, sentence structure, active and passive voice, direct and indirect narrations, practice in unified sentence, analysis of phrase, clause, and sentence structure, transitive and intransitive verbs, the use of punctuation marks on and spellings, Comprehension (answering questions on a given text), Discussion (about General and academic topics), Listening (To be improved by showing documentaries/films carefully selected by subject teachers, Translational skills (Urdu to English).

Recommended Books:

- A.J. Thomson and A.V. Martinet, *Practical English Grammar*, 3rd edition, Oxford University Press, 1997
- PC Wren and Martin, *English Grammar and Composition*
- M.C. Boutin, S.Brinand, F.Grellet, *Writing: Intermediate, Oxford Supplementary Skills*
- B.Tomlinson, R.Ellis, *Reading: Upper Intermediate, Oxford Supplementary Skills*

MGC-221 MECHANICS

Prerequisite(s): None

Credit Hours: 3 + 0

Specific Objectives of the Course:

The main objective of this course is to understand different motions of objects on a macroscopic scale and to develop simple mathematical formalisms to analyze such motions. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.

Course Outline:

Basic Concepts: Units and Dimensions, SI Units, Changing Units; Scalars and Vectors, Adding Vectors: Graphical as well as Component Method, Multiplying Vectors: Dot and Cross Products.
Motion in One, Two and Three Dimensions: Position & Displacement; Velocity and Acceleration; Motion under Constant Acceleration; Projectile Motion; Uniform Circular Motion; Relative Velocity and Acceleration in One and Two Dimensions; Inertial and Non-Inertial Reference Frames.
Newton's Laws: Newton's Laws of Motion and their Applications Involving some Particular Forces including Weight; Normal Force; Tension; Friction; and Centripetal Force; Newton's Law of Gravitation; Gravitational Potential Energy; Escape Velocity; Kepler's Laws; Satellite Orbits & Energy.
Work and Kinetic Energy: Work done by Constant and Variable Forces; Gravitational and Spring Forces; Power; Conservative and Non-conservative Forces; Work and Potential Energy; Isolated Systems and Conservation of Mechanical Energy; Work done by External Forces including Friction and Conservation of Energy.
System of Particles: Motion of a System of Particles and Extended Rigid Bodies; Center of Mass and Newton's Laws for a System of Particles; Linear Momentum; Impulse; Momentum & Kinetic Energy in One and Two Dimensional Elastic and Inelastic Collisions.

Rotational Motion: Rotation about a Fixed Axis; Angular Position; Angular Displacement; Angular Velocity and Angular Acceleration; Rotation under Constant Angular Acceleration; relationship between Linear and Angular Variables; Rotational Inertia; Parallel-axis Theorem; Torque and Newton's Law for Rotation; Work and Rotational Kinetic Energy; Power; Rolling Motion; Angular Momentum for a single Particle and a System of Particles; Conservation of Angular Momentum; Precession of a Gyroscope; Static Equilibrium involving Forces and Torques; Rotational inertia of various shapes i.e. for disc, bar and solid sphere; Elasticity; Stress; Strain and Properties of Materials.
Angular Momentum: Angular Velocity; Conservation of angular momentum; effects of Torque and its relation with angular momentum.
Simple Harmonic Motion (SHM): Amplitude; Phase; Angular Frequency; Velocity and Acceleration in SHM; Linear and Angular Simple Harmonic Oscillators; Energy in SHM; Simple Pendulum; Physical Pendulum; SHM and Uniform Circular Motion.
Fluid Mechanics: Static Fluids and Pressure; Archimedes' Principle; Fluid Dynamics; Equation of Continuity and Bernoulli's Principle.

Recommended Book:

- D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 9th ed., 2010.
- R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed., 2010.
- R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13th International ed., 2010.
- F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern, McGraw Hill, 2nd ed., 1992.
- D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4th ed., 2008.

MGC-222 INTRODUCTION TO ECONOMICS

Prerequisite(s): None
Credit Hours: 3 + 0
Specific Objectives of the Course:
The main purpose of this course is to familiarize the students with the main concepts used in the field of economics.
Course Outline:
Introduction: Definition, Nature, Scope and Importance (Micro and Macro Economics) Description, Analysis and Policy, Economic Methodology, Consumer Behavior: Definition and meaning, Marginal Utility, Law of Diminishing Marginal Utility Consumer's Surplus Indifference curve approach, Demand: Definition, Laws of Demand, Changes in Demand, Elasticity of Demand and its measurement, Supply: Supply, Changes in supply, Demand and Supply Relationship, Equilibrium Analysis, Production: Concept of Factor of Production, Land Labor, Capital &Entrepreneur, Laws of Returns and their application to Agriculture Sector, Costs: Costs over time period Fixed, Variable, Total, Average and Marginal, Market: Perfect and Imperfect Competition, Price and output determination under perfect and Imperfect competition, Market price and Normal price, Monopoly, Oligopoly, Duopoly and Price Control(Basic Concepts), Factor Pricing: Rent, Wages, Interest and Profit, 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, 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, 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, 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.

Recommended Books:

- Muhammad Irshad, *Economics*, Naveed Publications Lahore
- Sh Manzoor Ali, *Economics*, Ilmi Kutab Khana, Urdu Bazar, Lahore
- Lioyd G Reynolds Irwin, *Micro Economics-Analysis & Policy*, Irwin Homwood Illinois
- Nancy Smith Barrett, *The Theory of Macro Economics Policy*, Prentice Hall
- Edward Shapiro, *Macro Economic Analysis*, Harcourt Brace
- M.A.Saeed Nasir, *Textbook of Economics*, Ilmi Kutab Khana, Lahore
- Salman Rizavi, *Economics*
- P. A. Sameulson, *Economics*

MFC-231 CALCULUS-I

Prerequisite(s): Mathematics at intermediate level

Credit Hours: 3+0

Specific Objectives of the Course:

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

Course Outline:

Concept of Function, its different representation and examples, inverse functions, limit and continuity, Derivatives of different functions, applications of differentiation, anti-derivatives and integrals, definite integral, the fundamental theorems of calculus, and its application.

Recommended Books:

- J. Stewart, *Calculus* (5^{th} edition or latest edition), 2002, Brooks/Cole
- H. Anton, I. Bevens, S. Davis, *Calculus: A New Horizen* (8^{th} edition or latest), 2005, John Wiley, New York
- GB.Thomas, AR. Finney, *Calculus* (11^{th} edition or latest edition), 2005, Addison-Wesley, Reading, Ma, USA

MMC-251 DISCRETE STRUCTURE

Pre-requisite(s): Mathematics at intermediate level

Credit Hours: 3+0

Specific Objectives of the Course:

This course shall assume background in number theory. It lays a strong emphasis on understanding and utilizing various strategies for composing mathematical proof.

Course outline:

Mathematical Logic: Introduction, statements, negation, logical connectives, truth table, conjunction, disjunction, conditional and Bi-conditional statements, converse, inverse and contrapositive statements, exclusive or, NAND, NOR, Tautology and contradiction, Predicates and quantifiers, Set theory: sets and its types, operation on sets Binary relation and function: Binary relation, function and its type, Boolean algebra: Introduction, gates and its types, combinatorial circuit of graphs, Boolean expression, Boolean function and its representation. Graph theory: Graph its size, order and types. Matrix representation of a graph, Graph isomorphism, Tree: introduction, fundamental terminology.

Recommended Books:

- S. Epp. Susana, Discrete Mathematics with applications
- D.P. Acharjya, Sreckummar, Discrete Mathematics
- Kenneth H. Rossen, Discrete Mathematics and its applications
- Judith Gersting, Mathematical Structures for Computer Sciences

2nd SEMESTER

MCC-203 PAKISTAN STUDIES
Prerequisite: None
Credit Hours: 2+0
Specific Objectives of the Course:
To develop the vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan, and to study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.
Course Outline:
Pakistan Studies; An Introduction, Ideology of Pakistan; Meaning, Evolution and importance of the Ideology of Pakistan, Reformation Movements and Educational Institutions; Shah Wali Ullah and his Successors, Sir Syed Ahmad Khan and the Aligarh Movement, Dar-ul-Ulam of Deoband, Nadwat-Ul-Ulama, Lucknow, Islamia College Peshawar, Freedom/ Pakistan Movement; Partition of Bengal, Foundation of All India Muslim League (1906), Separate Electorates, Minto-Morley Reforms (1909), Lucknow Pact (1916), Government of India Act (1919), Delhi Proposals (1927), Simon Commission (1927), Nehru Report (1928), Jinnah's Fourteen Points, Allama Muhammad Iqbal and his Allahabad Address (1930), Round Table Conferences (1930-1932), Government of India Act (1935), The General Elections of 1937 and the Congress Ministries, The Lahore Resolution (1940), The Cripps Mission (1942), The General Elections of 1946 and the Transfer of Power, The Cabinet Mission Plan (1946), The Third June Plan and the establishment of Pakistan, Constitutional History of Pakistan; Early Constitution Making Problems, The Objective Resolution (1949), Initials Steps taken for the introduction of Shariah in Pakistan, Geography of Pakistan; Geographical locations of Pakistan; Its importance, Natural Resources of Pakistan, Pakistan and International Community; Foreign Policy of Pakistan, Pakistan and the Muslim World, Kashmir Problem.
Recommended Books:

- Shahid Javed Burki, *State and Society in Pakistan*, The Macmillan Press Ltd, 1980
- Akbar S. Zaidi, *Issue in Pakistan's Economy*, Oxford University Press, 2000
- Mehmood Safdar, *Pakistan Kayyun Toota*, Idara-e-Saqafat-e-Islamia, Club Road, Lahore
- Amin Tahir, *Ethno-National Movement in Pakistan*, Institute of Policy Studies, Islamabad
- Khalid Bin Sayeed, *The Political System of Pakistan*, Houghton Mifflin, Boston, 1967
- Lawrence Ziring, *Enigma of Political Development*, WmDawson and Sons Ltd, England, 1980
- Noor-Ul-Haq, *Making of Pakistan, The Military Perspective*, National Commission on Historical and Cultural Research, 1993
- S.M. Burke and Lawrence Ziring, *Pakistan Foerign Policy: An Historical analysis*, Oxford University Press, 1993

MCC-204 INTRODUCTION TO COMPUTER
Prerequisite(s): None
Credit Hours: 2 + 1
Specific Objectives of the Course:
This course focuses on a breadth-first coverage of computer science discipline, introducing computing environments, general applications, basic computing hardware and software,

operating systems, desktop publishing, Internet, software applications, tools and computer usage concepts. The main objective of this course is to enable the students to practically use computer for learning and apply their computing skills in the field of mathematics.

Course Outline:

Brief history of computers, major hardware components of a computer, software and its types, operating system, computer security threats and solutions, general applications of computers, network, Internet and its applications, search engines and effective searching, Office automation tools; Word processing, Graphic packages, Databases and Spreadsheets, Current trends, research and future prospects, Number Systems, Binary numbers, Boolean logic, Algorithms, programming, and software development cycle for non-technical users, Social and legal issues.

Recommended Books:

- Brian Williams and Stacey Sawyer, *Using Information Technology*
- Larry Long and Nancy Long, Computers: *Information Technology in Perspective*, 12/e:
- Sherer, Computer Science: *An Overview of Computer Science*
- Asya Sultan Ali, Amina Nudrat, *Fundamentals Concepts of Computer System*, Aays Desktop Publishing

MGC- 223 WAVES AND OSCILLATIONS

Pre-requisites: Mechanics

Credit Hours: 3+0

Specific Objectives of the Course:

To develop a unified mathematical theory of oscillations and waves in physical systems

Course Outline:

Simple and Damped Harmonic Oscillation: Mass-Spring System; Simple Harmonic Oscillator Equation; Complex Number Notation; LC Circuit; Simple Pendulum; Quality Factor; LCR Circuit.

Forced Damped Harmonic Oscillation: Steady-State Behavior; Driven LCR Circuit; Transient Oscillator Response; Resonance.

Coupled Oscillations: Two Spring-Coupled Masses; Two Coupled LC Circuits; Three Spring Coupled Masses; Normal Modes; Atomic and Lattice Vibrations.

Transverse Waves: Transverse Standing Waves; Normal Modes; General Time Evolution of a Uniform String; Phase Velocity; Group Velocity.

Longitudinal Waves: Spring Coupled Masses; Sound Waves in an Elastic Solid; Sound Waves in an Ideal Gas.

Travelling Waves: Standing Waves in a Finite Continuous Medium; Traveling Waves in an Infinite Continuous Medium; Energy Conservation; Transmission Lines; Reflection and Transmission at Boundaries.

Wave Pulses: Fourier Series and Fourier Transforms; Wave-Packets and Bandwidth.

Multi-Dimensional Waves: Plane Waves; Three-Dimensional Wave Equation; Electromagnetic waves; Laws of Geometric Optics; Waveguides; Cylindrical Waves.

Interference and Diffraction of Waves: Double-Slit Interference; Single-Slit and Double-slit Diffraction.

Recommended Books:

- J. Pain, "The Physics of Vibrations and Waves", John Wiley, 6th ed., 2005.
- A. P. French, "Vibrations and Waves", CBS Publishers, 2003.

- F. S. Crawford, Jr., "Waves and Oscillations", Berkeley Physics Course, Vol. 3, McGraw-Hill, 1968.
- A. Hirose, and K. E. Lonngren, "Introduction to Wave Phenomena", Krieger Publications, 2003.

MGC-224 INTRODUCTION TO ACCOUNTING

Prerequisite(s): None

Credit Hours:3+0

Specific Objectives of the Course:

The primary aim of this course is to provide students with an introduction to the process and function of financial reporting by the organizations. While a large proportion of the course is aimed at understanding accounting as a process, taking a preparers' perspective. We will also seek to develop an understanding of the importance of the role of accounting in today's society.

After studying this course the student will be able to understand: The language of accounting and financial reporting; Complete Accounting Cycle, Preparation and the role of Journal, Ledger and subsidiary books, and Preparation of balance sheet, profit and loss account and statement of cash flows.

Course Outline:

Accounting and its role, Accounting Defined, Why study Accounting , Financial statements, Major fields of Accounting, Accounting as a Career, Basic Accounting Concepts, The Entity Concept, The Reliability (or Objectivity) principle, The cost Principle, The Going-Concern Assumptions, The Stable Currency Assumptions, Ethics-the-Most Fundamental Principle of Accounting, The recording process, Debit Credit Rules, The Classification Issue, The Recording Process, Analysis of Transaction, The Journal, The Ledger, Balancing the Accounts Preparation of Financial Statements, Preparing Trial Balance, Locating and correcting errors in recording process, Preparing Profit and Loss Account and Balance Sheet The adjusting and closing entries, Need for Adjusting Entries, Recording adjusting entries, Preparing adjusted trial balance, Recording closing entries, Preparing post-closing trial balance, Preparing work-sheet, Preparation of Financial Statements, Accounting for trading organization, Accounting for Purchases and Sales, Return and allowances, Cash and trade Discounts, Periodic System, Perpetual Stock System, Accounting Systems, Subsidiary ledgers, Cash Book, Petty cash book, Control Accounts, Cash and temporary investment, Nature and Composition of Cash, Cash Management and Control, Maintaining Bank Account, Bank Reconciliation, Short term investments, Accounting for debtors and stock, Accounting Treatment of Bad Debts, Direct write-Off Method, Aging Schedule, Percentage of Sales Method, Recoveries of Bad debts Stock, Accounting for property, plant and equipment, Property, Plant and Equipment, Depreciation methods, Revaluation, Review of Useful life, Intangible Assets and Amortization, Wasting Assets and Depletion.

Recommended Books:

- Williams, Haka, Bettner: Financial & Managerial Accounting, Latest Edition, Prentice Hall
- Professor Muhammad Amanullah Khan: Financial Accounting, Latest Edition
- Meigs and Meigs, Accounting for Business Decision, 9th Edition/Latest edition

MFC-232 CALCULUS-II

Prerequisite(s): Calculus-I

Credit Hours: 3+0

Specific Objectives of the Course:

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

Course Outline:

Continuation of Calculus I: Techniques of integration, further applications of integration, parametric equations and polar coordinates, sequences and series, power series representation of functions.

Recommended Books:

- J. Stewart, *Calculus* (5^{th} edition or latest edition), 2002, Brooks/Cole
- H. Anton, I. Bevens, S. Davis, *Calculus: A New Horizen* (8^{th} edition or latest), 2005, John Wiley, New York
- GB Thomas, AR Finney, *Calculus* (11^{th} edition or latest), 2005, Addison-Wesley, Reading, Ma, USA

MMC-252 NUMBER THEORY

Prerequisite(s): Mathematics at intermediate level

Credit Hours: 3+0

Specific Objective of the Course:

This course covers those topics of number theory which are the essential ingredients for a beginner. In this course the students leans the basics concepts of number theory, as the theory of number has always occupied a unique position in the world of mathematics. Because of the basic nature of its problem, number theory has a fascinating appeal for the leading mathematicians as well as for thousands of armatures. This course also familiarizes the students with the applications of some theorems.

Course Outline:

Divisibility, Divisibility tests, Euclidean Algorithm, GCD and LCM of integers, Prime number, Properties of prime numbers, Fundamental theorem of arithmetic's (UFT), The Tau and sigma functions. Congruence relation, Solutions of system of linear congruencies, Congruence of higher degree, Chinese reminder theorem and its applications, Euler's phi-function and its applications, Fermat s little theorem and its applications, Wilson theorem and its applications, Fibonacci and Lucas Numbers, Fermat Numbers, perfect number and Mersenne primes, Fermat number, Linear Diophantine equation, Reduced residue system, Complete residue system.

Recommended Books:

- M. Mushtaq Suhail, *Elementary Theory of Number*, Jadeed book depot, Urdu bazaar Lahore
- K.C. Chowdhury, *A First Course in Number Theory*, Asian Book Private Limited
- Thomas Koshy, *Elementary Number Theory with Applications*, Academic Press is an imprint of Elsevier
- Kenneth H.Rosen, *Elementary Number Theory and its Applications*, Addison-wesley, Publishing Company

3rd SEMESTER

MCC-205 COMMUNICATION SKILLS
Prerequisite(s): English Structure
Credit Hours: 3 + 0
Specific Objectives of the Course:
The course aims at enabling the students to meet their real life communication needs.
Course Outline:
Paragraph writing (practice in writing a good, unified and coherent paragraph), Introduction to Essay Writing, Study Skills (skimming and scanning, intensive and extensive, and speed reading, summary and precise writing, and comprehension), Academic Skills (Letter/memo writing, minutes of meetings, use of library and internet) Presentation Skills (Personality development with emphasis on content, style and pronunciation).
Recommended Books:

- A. J. Thomson and A. V. Martinet, *Practical English Grammar*, 3rd edition, Oxford University Press, 1997
- PC Wren and Martin, *English Grammar and Composition*
- M. C. Boutin, S.Brinand, F.Grellet, *Writing: Intermediate, Oxford Supplementary Skills*
- R. Nolasco, Writing: *Upper Intermediate, Oxford Supplementary Skills*
- B. Tomlinson, R.Ellis, *Reading: Advanced, Oxford Supplementary Skills*
- J. Langan, *Reading and Study Skills*
- R. Yorky, *Study Skills*

MCC-206 PROGRAMMING LANGUAGES C/C++
Prerequisite(s): Introduction to Computer
Credit Hours: 2 + 1
Specific Objectives of the Course:
The purpose of this course is to introduce students to operating systems and environments.
Course Outline:
Introduction to programming, applications of programming in mathematics, program structure, flow chart, C/C++ language, building blocks, variables, data types, input/output, repetition (FOR, WHILE, DO), selection (IF, IF ELSE, ELSE IF) construct switch statement, conditional statement, function that returns a value using argument to pass data to another function, external variable, arrays and strings, pointers, structure, file processing and introduction to object-oriented programming.
Recommended Books:

- Dietel & Dietel, *C++ How to program*, 7th Edition, Prentice Hall
- H. Schildt, C/C++ The Complete Reference, 4th Edition, McGraw Hill Osborne media
- J. L. Hein, *Theory of Computations*: *An Introduction*, Jones and Bartlett, Boston
- R. Laffore, *Introduction to Object Programming*, McGraw Hill, New York

MGC-225 BUSINESS MATHEMATICS

Prerequisite(s): Calculus-I, basic arithmetic and algebra skills

Credit Hours: 3+0

Specific Objectives of the Course:

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

Define the different ways in which interest on money can be calculated

Explain the meaning of simple interest, compound interest, equivalent rates of interest, promissory and demand notes, annuities

Undertake the computations for problems of interest, annuities

Use the results of mathematical calculations to help evaluate various options in reaching financial decisions, whether personal or business-related

Evaluate and select financial arrangements which are best for you as a consumer

Course Outline:

Equations and functions, system of linear equations, mathematical functions, linear functions, quadratic and polynomial functions, exponential and logarithmic functions, finite mathematics (simple interest, compound interest, simple annuities, general annuities, debt reduction, sinking funds), matrix algebra, linear programming, differential calculus and its application in finance, integral calculus and its application in finance.

Recommended Books:

- Frank S. Budnik, *Applied Mathematics for Business, Economics and the Social Sciences*
- Teresa Bradley, Paul Patton, *Essential Mathematics for Economics and Business*
- S. A. Hummel brunner, K. S. Coombs, *Contemporary Business Mathematics with Canadian Applications,* 7th edition, Scarborough, Ontario: Prentice-Hall Canada Inc., 2005
- S. A. Hummel brunner, K. S. Coombs, *Student's Solutions Manual for Contemporary Business*
- *Mathematics with Applications*, 7th edition Scarborough, Ontario: Prentice-Hall Canada Inc., 2005
- Mirza Muhammad Hassan, Muhammad Ali Mirza, *Business Mathematics*

MGC-226 INTRODUCTION TO SOCIOLOGY

Pre-requisite(s): None

Credit Hours: 3+0

Specific Objectives of the Course:

The purpose of the subject is to introduce sociological knowledge and their applications among the students of mathematics. Further, this will help students in understanding of different concepts and their use in practical social life.

Course Outline:

Science, natural science, social sciences, introduction to sociology, relationship with other social sciences e.g. economics, political science, anthropology and history, various perspectives in sociology, introduction to society, elements, characteristics and types of society, introduction to community, essentials and types of community, difference between society and community, introduction to culture, elements, characteristics and types of culture, culture and related concepts, introduction to socialization, agencies of socialization, sociological theories, August Comte, Herbert Spencer, Emile Durkheim, Max Weber, Introduction to social institutions,

family, education, religion, economic, political, introduction to social problems, poverty, unemployment, drug addiction, urbanization, illiteracy, gender disparity.

Recommended Books:

- Paul B. Horton and Hunt, *Introduction to Sociology* 1990, Singapore: McGraw Hill Company
- Anwar Alam, *Principles of Sociology* 2002, Saif Printing Press Peshawar
- Abdul Hameed Tagga, *An Introduction to Sociology* 2009, Alfazal Market Urdu Bazzar, Lahore

MGC-227 ELECTROMAGNETIC THEORY

Prerequisite(s): None

Credit Hours: 3 + 0

Course Outline:

Electric charge &Electric Field: Charge, properties of charges, Coulombs Law, Field due to a point charge: due to several point charges, Electric dipole, Electric field of continuous charge distribution e.g Ring of charge, Disc of charge, infinite line of charge. 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, Charge on isolated conductors, conductor with a cavity, field near a charged conducting sheet, Field of infinite line of charge, field of infinite sheet of charge, field of spherical shell and field of spherical charge distribution, Electric Potential: Potential due to point charge, potential due to collection of point charges, potential due to dipole, Electric 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, Capacitors and dielectrics: Capacitance, calculating the electric field in a capacitor, Capacitors of various shapes, cylindrical, spherical etc. and calculation of their capacitance, Energy stored in an electric field, Energy per unit volume, Capacitor with dielectric, Electric field of dielectric, An atomic view, Application of Gauss's law to capacitor with dielectric, 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, 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, Ampere's law, integral and differential forms, applications to solenoids and toroid's, (integral form), Inductance: Faraday's Law of electromagnetic induction, review of emf, Faraday law and Lenz's Law, induced electric fields, calculation and application using differential and integral form, inductance, Basic definitions, Inductance of a solenoid, Toroid.

Recommended Books:

- Halliday, D. Resnick, Krane, *Physics*, Vol. I & II, John Wiley, 5th edition, 1999
- Halliday, D. Resnick and Walker, *Fundamental of Physics*, Extended ed. John Wiley, 5th edition
- Ritz and Milford, *Introduction to Electromagnetic Field and Waves*
- R.J. Reitz, and J. Milford Fredrick, *Foundations to Electromagnetic Theory*, 2nd edition, Addison-Wesley Publishing Co. 1970

MFC-233 CALCULUS-III

Prerequisite(s): Calculus II

Credit Hours: 3+0

Specific Objectives of the Course:

This is the third course of the basic sequence, Calculus I-III, serving as the foundation of advanced subjects in all areas of mathematics. The sequence, equally, emphasizes the basic concepts and skills needed for mathematical manipulation. The main focus will be on the study of functions having two, three or more variables.

Course Outline:

Vectors and analytic geometry of two and three dimensional space, vector valued functions and space curves, functions of several variables; limit and continuity, partial derivatives, the chain rule, the double and triple integrals with applications, line integrals, the Green's theorem, surface area and surface integrals, the Green's, the divergence and the Stokes theorems with applications.

Recommended Books:

- James Stewart, *Calculus* (5^{th} edition or latest edition), 2002, Brooks/Cole (suggested text)
- H Anton, I Bevens, S Davis, *Calculus: A New Horizen* (8^{th} edition or latest), 2005, John Wiley, New York
- GB Thomas, AR Finney, *Calculus* (11^{th} edition or latest), 2005, Addison-Wesley, Reading, Ma, USA

4th SEMESTER

MCC-207 COMPUTING TOOLS
Prerequisite(s): Introduction to Computer
Credit Hours: 3+0
Specific Objectives of the Course:
The purpose of this course is to teach students the use of mathematical software's like MATLAB, MAPLE, and MATHEMATICA for solving computationally-difficult problems in mathematics. The students shall become well-versed in using at least one mathematical software and shall learn a number of techniques that are useful in calculus as well as in other areas of mathematics.
Course Outline:
The contents of the course are not fixed, however the following points should be kept in mind while teaching the course. The course should be taught in a computer lab setting. Besides learning to use the software, the students must be able to utilize the software to solve the computationally difficult problems in calculus and other areas of mathematics. At the end of the course, the students should have a good command on at least two of the three programs mentioned above.
Recommended Books:

- DM. Etter, D, Kuncicky, D. Hull, *Introduction to MATLAB*, Prentice Hall, Englewood Cliffs,NJ, USA, 2001
- F. Garven, *The Mapple Book*, Chapman & Hall/CRC, 2002
- S. Kaufmann, *Mathematica As a Tool, An Introduction with Practical Examples*, Springer, New York, 1994

MGC-228 INTRODUCTION TO PSYCHOLOGY
Pre-requisite(s): None
Credit Hours: 3+0
Specific Objectives of the Course:
The subject aims to explore the psychological concepts, techniques, analysis among the students of mathematics. In additions, the course seeks to inculcate the behavior formation and personality development of individuals.
Course Outline:
Introduction to psychology, methods and framework of psychology, development of psychology, modern approaches of social behavior and their implications, the dynamics of human behavior and personality, psychological dynamics, socio-cultural dynamics, man as a psycho bio-social unit, group and social interaction, the nature and types of groups, dimension of group effectives, group change, leadership, and its various forms, characteristics of a good leader, functions of a leader, theories of the leadership, introduction to socialization, agencies of socialization, types of socialization, personality and self, factors of personality development, theories of personality and self, Jean Piaget, Erickson, CH Cooley, Freud, culture and personality, cognition, attitudes, stereotypes, motivation and emotions, perception, public opinion, measurement of public opinion and manipulation of public opinion, mass communication, propaganda, press, film, radio and television, psycho-social problems, suicides, depression, schizophrenia, stress, phobia, psychosis, neurosis.

Recommended Books:

- Sheriff and Sharif, *An Outline of Social Psychology* 1950. New York, Harper and Row Publishing
- D. Krech, R.S. Crutch Field and Sheri Ballachey, *Individual in Society* 1950, McGraw Hill Book, Company
- Bonner And Hobert, *Social Psychology* 1955, New York, Holt Rinehart And Weston

MGC-229 MODERN PHYSICS

Prerequisite(s): None

Credit Hours: 3 + 0

Course Outline:

Origin of quantum theory: Black body radiation, Stefan Boltzmann, Wien's and Planck's law, consequences. The quantization of energy, Photoelectric and Compton effect, Line spectra, Explanation using quantum theory, Wave Nature of Matter: Wave behavior of particle (wave function etc) its definition and relation to probability of particle, De-broglie hypothesis and its testing, Davisson-Germer Experiment and J.P. Thomson experiment, Wave Packets and particles, localizing a wave in space and time, wave function, Normalization, expectation value, Atomic Physics: Bohr's theory (review), Frank-Hertz experiment, energy levels of electron, Atomic spectrum, Angular momentum of electrons, vector atom model, Orbital angular momentum. Spin quantization, Bohr's Magneton. X-ray spectrum (Continuous and Discrete) Moseley's law, Pauli's exclusion principle and its use in developing the periodic table, Nuclear Physics: Basic properties of a nucleus, Mass and Atomic Numbers, Isotopes, mass and size of a nucleus, Nuclear force (Basic Idea), Nuclear Radii, Nuclear masses, Binding energy, mass defect, Nuclear Spin and Magnetism, Natural Radioactivity: Laws of radioactive decay, half-life, mean life, chain disintegration; Alpha- Beta and Gamma decays (Basics idea), Measuring ionizing radiation (units i.e. Curie, Rad etc.), Nuclear Reactions: Basic Nuclear reaction, Q-value, Exothermic, Endothermic Nuclear model , Nuclear Fusion, Thermonuclear Fusion.

Recommended Books:

- Halliday, D. Resnick, Krane, *Physics,* Vol. I & II, John Wiley, 5th edition, 1999
- Halliday, D. Resnick and Walker, *Fundamental of Physics*, Extended ed. John Wiley, 5th edition
- A. Beiser, *Concepts of Modern Physics*, 4th edition McGraw-Hill book Company, 1987

MFC-234 ALGEBRA-I

Prerequisite(s): None

Credit Hours: 3 + 0

Specific Objectives of the Course:

This is the first course in groups, matrices and linear algebra, which provides basic background needed for all mathematics majors, a prerequisite for many courses. Many concepts presented in the course are based on the familiar setting of plane and real three-space, and are developed with an awareness of how linear algebra is applied.

Course Outline:

Basic axioms of a group with examples, subgroups, order of a group, subgroups generated by subset of a group, system of generators cyclic groups, cosets, Lagrange's theorem, introduction to permutations, even and odd permutations, cycles, lengths of cycles, transpositions, symmetric group, alternating groups, rings, fields (definitions and examples), vector spaces, subspaces,

linear dependence and independence, linear span of a subset of a vector space, bases and dimensions of a vector space, algebra of matrices, determinants, matrix of a linear transformation, row and column operations, rank, inverse of matrices, solution of homogeneous and non-homogeneous equations, orthogonal transformation.

Recommended Books:

- H. Anton, *Linear Algebra with Applications* (latest edition), John Wiley, New York
- I. N. Herstein, *Topics in Algebra* (latest edition), John Wiley, New York
- RO. Hill, *Elementary Linear Algebra with Application* (3rd edition), 1995, Brooks/Cole
- A. Majeed, *Group Theory*, Ilmi kitab Khana
- Zia-Ul-Haq, *Mathematical Techniques*, Carvan Books Publishers
- S. J. Leon, *Linear Algebra with Applications* (6th edition), 2002, Prentice Hall, Englewood Cliffs, NJ, USA
- WK. Nicholson, *Elementary Linear Algebra with Applications* (2nd edition), 1994, PWS Publishing Company

MMC-253 PROBABILITY THEORY

Pre-requisite(s): Calculus

Credit Hours: 3 + 0

Specific Objectives of the Course:

This course is designed to teach the students how to handle data numerically and graphically. If data are influenced by chance effect, the concepts and rules of probability theory may be employed, being the theoretical counterpart of the observable reality, whenever *chance* is at work.

Course Outline:

Statistical measures, statistical description and graphical representation of data, Sets, introduction to probability theory, permutations and combinations, random variables, probability distributions, mean, standard deviation, variance and expectation, Binomial, Poisson, hyper geometric and normal distributions, normal approximation to binomial distribution, distributions of several random variables.

Recommended Books:

- M. H. DeGroot, M. J. Schervish, *Probability and Statistics* (3rd edition), 2002, Addison-Wesley, Reading, Ma, USA
- Papoulis, Probability, *Random Variables, and Stochastic Processes*, (3rd edition), 1991, McGraw Hill, New York
- T. Sincich, *Statistics by Examples*, 1990, Dellen Publishing Company

MMC-254 BASIC TOPOLOGY

Prerequisites: Calculus-I

Credit Hours: 3 + 0

Specific Objectives of the Course:

This course provides a simple concept of set and the action of functions on various sets. It also gives the detailed what is Topology and metric spaces and how they are formed from specific sets. It also discusses the continuity rule upon the Topological and metric spaces. In this course a brief introduction is discussed about closed, derived open set exterior, interior, neighborhood, sphere, open sphere and closed sphere.

Course Outlines:

Basic set theory; Topological Spaces; Limit Points (or Accumulation points), Derived set, Closure of a set, Interior, Exterior and boundary points; Sub-Space and relative Topology, Real line topology and its examples, Metric spaces; Limit point, Adherent point, Closure of a set, Sequences in Metric space, complete metric spaces and its basic theorems and examples, Continuity and Homeomorphism; Continuous functions, Continuous functions in Topological spaces, Convergent sequences, Homeomorphism, Open function, Closed functions, Bases and sub-bases: Definitions of base and sub-bases of Topological and metric spaces and fundamental results and examples.

Recommended Books:

- M. Iqbal, *Introduction to Topology*
- Dr. A. Majeed, *Introduction to general Topology and Functional Analysis*
- *General Topology*, Schaum's Outlines Series
- C. Adams, R. Franze, *Introduction to Topology pure and Applied*

5th SEMESTER

MFC-235 ALGEBRA-II
Prerequisite(s): Algebra-I
Credit Hours: 3 + 0
Specific Objectives of the Course:
This is a course in advanced abstract algebra, which builds on the concepts learnt in Algebra-I.
Course Outline:
Preliminaries, normalizers and centralizers of a group, center of a group, normal subgroup, quotient groups, conjugacy relation between elements and subgroups, homomorphism and isomorphism between groups, homomorphism and isomorphism theorems, finite p-groups, internal and external direct products, 1st , 2nd and 3rd sylow theorems, types of rings, matrix rings, rings of endomorphism, polynomial rings, integral domain, characteristic of a ring, ideal, types of ideals, quotient rings, homomorphism of rings, fundamental theorem of homomorphism of rings.
Recommended Books:

- E. Arnold, *Rings, Fields and Groups: An Introduction to Abstract Algebra*, 1983
- A Majeed, *Group Theory*, Ilmi kitab Khana
- Zia-Ul-Haq, *Mathematical Techniques*, Carvan Books Publishing Company
- J. B. Farleigh, *A First Course in Abstract Algebra* (7th edition), Addison-Wesley, Reading, Ma., USA
- I. D. Macdonald, *The Theory of Groups*, 1975, Oxford Clarendon Press, Ma., USA

MFC-236 REAL ANALYSIS-I
Prerequisite(s): Calculus-I and Calculus-II
Credit Hours: 3 + 0
Specific Objectives of the Course:
This is the first rigorous course in analysis and has a theoretical emphasis. It rigorously develops the fundamental ideas of calculus and is aimed to develop the students' ability to deal with abstract mathematics and mathematical proofs.
Course Outline:
Real number system: Set and function, completeness properties of real numbers, Absolute value of real number, Supremum and Infimum, open set, closed set, neighborhood, properties of open and closed set, Sequences and series: Convergent sequences and divergent sequences, subsequences, limit of a sequences, properties of a sequences, Cauchy sequences, Properties of Cauchy sequences, Limit and continuity: Limit of a function, Properties of limit, Continuity of a function, properties of continuous function on closed bounded intervals, discontinuity, types of discontinuity, Differentiability and derivability: Derivability and Differentiability, Derivative in one variable, Higher order derivatives, properties of derivable function, Rolle's Theorem, Lagrange's Mean value Theorem, Cauchy Mean Value Theorem, Taylor's Theorem, Generalized mean value theorem, Application to limit Operations, L'Hopital's Rule, Application to maxima and minima, Function of bounded variation: Bounded variation, the decomposition theorem.
Recommended Books:

- R. G. Bartle, DR. Sherbert, *Introduction to Real Analysis* (3rd edition), 1999, John Wiley, New York
- W. Rudin *Introduction to Mathematical Analysis*

- Apostal, *Mathematical Analysis*
- E. G. Philips, *A course of Analysis*
- W. Kaplan, *Advance Calculus*
- W. Fulks, *Advanced Calculus*, John Wiley, New York
- S. C. Malik, *Mathematical Analysis*

MFC-237 ORDINARY DIFFERENTIAL EQUATIONS

Pre-requisite(s)**:** Calculus-I, Calculus-II

Credit Hours: 3+0

Specific Objectives of the Course:

This course will provide the foundation for all advanced subjects in Mathematics. Strong foundation and applications of Ordinary Differential Equations is the goal of the course.

Course Outline:

Basic definition of differential equations, formation of differential equations, initial and boundary value problems, differential equations of the first order and first degree, equations with separable variable, homogeneous differential equations, equations reducible to homogeneous form, exact differential equations, integrating factors, rules for determinations of integrating factors, linear equations of the first order, Non-linear equations of the first order, linear differential equations of high order, solution of homogeneous linear equations, determination of particular integral, short methods for finding particular integral, orthogonal trajectories, Cauchy-Euler equations, 2^{nd} order linear differential equations, reduction of order method, undetermined Coefficient method, variations of parameters method, Sturm-Liouville system and boundary value problems, series solution and its limitations, Frobenius methods, solution of the Bessel, the Hypergeometric, the Legendre, and the Hermite equations.

Recommended Books:

- D.G. Zill, M.R, Cullen, *Differential Equations with Boundary-Value Problems*, (latest Edition), PWS Publishing Company
- D.G. Zill, *Advanced Engineering Mathematics*, Jones and Bartlett Publishers, 2005
- Erwin Kreyszig, *Advanced Engineering Mathematics*, John Wiley and Sons (9^{th} edition)
- G.E. Andrews, R. Askey, and R. Roy, *Special Functions*, Cambridge University Press, 2000

MMC-255 VECTOR AND TENSOR ANALYSIS

Prerequisite(s): Calculus-I, Calculus II and Calculus-III

Credit Hours: 3 + 0

Specific Objectives of the Course:

This course shall assume background in calculus. It covers basic principles of vector and tensor analysis which are frequently used in applied mathematics.

Course Outline:

3-D vectors, scalar-and vector-triple products, scalar- and vector-point functions, differentiation and integration of vectors, line integrals, path independence, surface integrals, volume integrals, gradient, divergence and curl with physical significance and applications, vector identities, Green's theorem in a plane, divergence theorem, Stokes' theorem, coordinate systems and their bases, the polar, spherical and the cylindrical-coordinates, tensors of first, second and higher orders, algebra of tensors, contraction of tensors, quotient theorem, quotient theorem, symmetric and skew-symmetric tensors, summation convention, kronecker delta, Levi-Civita symbol,

vectors as quantities transforming under rotations with notation, alternating symbol, relation between alternating symbol and kronecker delta, invariance property, isotropic tensors, differentiation of tensors, application of tensors in modeling anisotropic systems, study of physical tensors (moment of inertia, index of refraction, etc.), diagnolization of inertia tensor as aligning coordinate frame with natural symmetries of the system.

Recommended Books:

- Bourne D. E, Kendall PC, *Vector Analysis and Cartesian Tensors* (2nd edition)
- N. A. Shah, *Vector and Tensor Analysis*, 2005, A-One Publishers, Lahore
- G. D. Smith, *Vector Analysis*, Oxford University Press, Oxford
- M. R. Spiegel, *Vector Analysis*, 1974, McGraw Hill, New York

MMC-256 MATHEMATICAL STATISTICS

Prerequisite(s): Probability Theory

Credit Hours: 3 + 0

Specific Objectives of the Course:

In the course "Probability Theory" the students learnt how to set up mathematical models of processes and systems that are affected by *chance*. In the present course the students would learn how to check these models against reality, to determine whether they are reliable/accurate enough for practical purposes or otherwise. This helps in making predictions and decisions.

Course Outline:

Sampling theory, sampling distributions, sampling procedures, Estimation of parameters, estimation of mean, variance, confidence intervals, decision theory, hypothesis testing and decision making, types of errors in tests, quality control, control charts for mean, standard deviation, variance, range, goodness of fit, chi-square test, Regression analysis, method of least squares, correlation analysis.

Recommended Books:

- MH. DeGroot, MJ, Schervish, *Probability and Statistics* (3^{rd} edition), 2002, Addison-Wesley, Reading, Ma, USA
- RA. Johnson, *Probability and Statistics for Engineers*, 1994, Prentice-Hall, Englewood Cliffs, NJ, USA
- A.Papoulis, *Probability, Random Variables, and Stochastic Processes*, (3^{rd} edition), 1991, McGraw Hill, New York
- T.Sincich, *Statistics by Examples*, 1990, Dellen Publication Company

MMC-257 NUMERICAL ANALYSIS

Prerequisite(s): Ordinary Differential Equations

Credit Hours: 3 + 0

Specific Objectives of the Course:

This course is designed to teach the students about numerical methods and their theoretical bases. The students are expected to know computer programming (i.e. Matlab, Mathcad etc.) to be able to write program for each numerical method. Knowledge of calculus and linear algebra would help in learning these methods.

Course Outline:

Introduction to Error Analysis, Method for the solution of nonlinear equation and their convergence: Bisection method, Regula Falsi method, Fixed point iteration method, Newton-Rapson method, Secant method, Interpolation and polynomial approximation: Lagrange's

interpolation, Newton's divided difference, Forward difference and Backward difference formulae, Numerical integration and error estimates: Rectangular, Trapezoidal and Simpson rule, Numerical solution of system of algebraic linear equation: Gauss elimination method, Gauss Jordon method, Matrix inversion, Cramer's rule, LU decomposition, Choleski's Factorization method, Tridiagonal method, Jacobi and Gauss Seidal methods.

Recommended Books:

- K. E. Atkinson, *An Introduction to Numerical Analysis* (2^{nd} edition), 1989, John Wiley, New York
- R. L. Burden, J. D. Faires, *Numerical Analysis* (5^{th} edition), 1993, PWS Publishing Company
- S. C. Chapra, R. P. Canale, *Numerical Methods for Engineers*, 1988, McGraw Hill, New York
- N. Bhatti, *Numerical Analysis with C++* (5^{th} edition

6th SEMESTER

MFC-238 ALGEBRA-III
Prerequisite(s): Algebra-I
Credit Hours: 3 + 0
Specific Objectives of the Course:
This is a course in abstract linear algebra. The majority of follow up courses in both pure and applied mathematics assume the material covered in this course.
Course Outline:
Vector spaces, sums and direct sums of subspaces of a finite dimensional vector space, dimension theorem, linear transformation, null space, image space of linear transformation, rank and nullity of a linear transformation, relation between rank, nullity and dimension of the domain of a linear transformation, matrix of linear transformation, change of basis, inner product spaces, projection of a vector along another vector, norm of a vector, Cauchy Schwartz inequality, orthogonal and orthonormal basis, similar matrices and diagonalization of a matrix, Home (V,W), dimension and basis of Home (V,W), dual space and dual basis, annihilators, Eigen values and Eigen vectors,
Recommended Books:

- S. J. Axle, Linear Algebra Done Right, *Undergraduate Texts in Mathematics,* 1996, Springer, New York, Schaum's outlines series
- G. Birkhoff, S. Maclane, *A Survey of Modern Algebra* (4th edition), AKP
- W. L. C. Perry, *Elementary Linear Algebra,* 1988, McGraw-Hill, New York

MFC-239 REAL ANALYSIS-II
Prerequisite(s): Real Analysis-I
Credit Hours: 3 + 0
Specific Objectives of the Course:
A continuation of Real Analysis I, this course rigorously develops integration theory. Like Real Analysis I, Real Analysis II emphasizes on proofs.
Course Outline:
Function of Several Variables: Limit and continuity, Derivability and Differentiability, properties of several variable function, Implicit function, Jacobean, Relative Maxima and Minima, Absolute Maxima and Minima, Riemann Integration: Definition, Riemann integrability, Integrable function, Some fundamental Theorems, Mean value Theorem, Alternative Approaches, Improper Integrals: Definition, test for convergence, Absolute Convergence, The gamma and Beta Functions, Some standard integrals, Multiple Integrals: Double Integration, Double and Triple integral with arbitrary Domain, Riemann-Stieltjes Integrals: The basic notion, Riemann-Stieltjes integral as the limit of a sum, Relation between Riemann and Riemann-Stieltjes Integrals, Properties of Riemann-Stieltjes Integrals.
Recommended Books:

- R. G. Bartle, D. R. Sherbert, *Introduction to Real Analysis* (3rd edition), 1999, John Wiley, New York
- W. Rudin, *Introduction to Mathematical Analysis*
- Apostal, *Mathematical Analysis*
- E. G. Philips, *A Course of Analysis*
- W. Kaplan, *Advance Calculus*

- W. Fulks, *Advanced Calculus*, John Wiley, New York
- S. C. Malik, *Mathematical Analysis*

MFC-240 COMPLEX ANALYSIS
Prerequisites: Real Analysis I
Credit Hours: 3 + 0
Specific Objectives of the Course:
This is an introductory course in Complex Analysis, giving the basics of the theory along with applications, with an emphasis on applications of complex analysis and especially conformal mappings. Students should have a background in real analysis (as in the course Real Analysis I), including the ability to write a simple proof in an analysis context.
Course Outlines:
The algebra and the Geometry of complex numbers, Cauchy-Riemann equations, harmonic functions, elementary functions, branches of logarithm, complex exponents, Contours and contour integrals, the Cauchy-Goursat theorem, Cauchy integrals formulas, the Morera theorem, maximum modules principle, the Liouville theorem, the Roche theorem, fundamental theorem of Algebra, Convergence of sequences and series, the Taylor series, the Laurent series, uniqueness of representation, zeros of analytic functions, Residues and poles and the residue theorem, evaluation of improper integrals involving trigonometric functions, integrals around a branch point, the argument principle, Special function Beta, Gamma functions and hyper geometric and Legender functions.
Recommended Books:
- R. V. Churchill, JW.Brown, *Complex Variables and Applications* (5^{th} edition), 1989, McGraw Hill, New York
- *Complex Analysis*, Schaum's Outlines Series

MMC-258 CLASSICAL MECHANICS
Prerequisite(s): Vector and Tensor Analysis
Credit Hours: 3 + 0
Specific Objectives of the Course:
This course builds grounds in principles of classical mechanics, which are to be used while studying quantum mechanics, statistical mechanics, electromagnetism, fluid dynamics, spaceflight dynamics, astrodynamics and continuum mechanics.
Course Outlines:
Introduction: Space and Time, Newton's Laws, The Concepts of Mass and Force, External Forces.
Linear Motion: Conservative Forces; Conservation of Energy, Motion near Equilibrium; the Harmonic Oscillator, Complex Representation, The Law of Conservation of Energy, The Damped Oscillator, Oscillator under Simple Periodic Force, General Periodic Force, Impulsive Forces; the Green's Function Method, Collision Problems.
Energy and Angular Momentum: Energy; Conservative Forces, Projectiles, Moments; Angular Momentum, Central Forces; Conservation of Angular Momentum, Polar Co-ordinates, The Calculus of Variations, Hamilton's Principle; Lagrange's Equations.
Central Conservative Forces: The Isotropic Harmonic Oscillator, The Conservation Laws, The Inverse Square Law, Orbits, Scattering Cross-sections, Mean Free Path, Rutherford Scattering.

Rotating Frames: Angular Velocity; Rate of Change of a Vector, Particle in a Uniform Magnetic Field, Acceleration; Apparent Gravity, Coriolis Force, Larmor Effect, Angular Momentum and the Larmor Effec.
Potential Theory: Gravitational and Electrostatic Potentials, The Dipole and Quadrupole, Spherical Charge Distributions, Expansion of Potential at Large Distances, The Shape of the Earth, The Tides, The Field Equations.
The Two-Body Problem: Centre-of-mass and Relative Co-ordinates, The Centre-of-mass Frame, Elastic Collisions, CM and Lab Cross-sections.
Many-Body Systems: Momentum; Centre-of-mass Motion, Angular Momentum; Central Internal Forces, The Earth–Moon System, Energy; Conservative Forces, Lagrange's Equations
Rigid Bodies: Basic Principles, Rotation about an Axis, Perpendicular Components of Angular Momentum, Principal Axes of Inertia, Calculation of Moments of Inertia, Effect of a Small Force on the Axis, Instantaneous Angular Velocity, Rotation about a Principal Axis, Euler's Angles.
Lagrangian Mechanics: Generalized Co-ordinates; Holonomic Systems, Lagrange's Equations, Precession of a Symmetric Top, Pendulum Constrained to Rotate about an Axis, Charged Particle in an Electromagnetic Field, The Stretched String, Small Oscillations and Normal Modes, Orthogonal Co-ordinates, Equations of Motion for Small Oscillations, Normal Modes, Coupled Oscillators, Oscillations of Particles on a String, Normal Modes of a Stretched String
Hamiltonian Mechanics: Hamilton's Equations, Conservation of Energy, Ignorable Co-ordinates, General Motion of the Symmetric Top, Liouville's Theorem, Symmetries and Conservation Laws, Galilean Transformations.

Recommended Books:

- T. Kibble and F. Berkshire, "Classical Mechanics", World Scientific, 5th ed. 2004.
- T. L. Chow, "Classical Mechanics", John Wiley, 1995.
- S.T. Thornton, J.B. Marion, "Classical Dynamics of Particles and Systems", Brooks Cole; 5th ed. 2003.

MMC-259 PARTIAL DIFFERENTIAL EQUATIONS

Pre-requisite(s)**:** Ordinary Differential Equations

Credit Hours: 3+0

Specific Objectives of the Course:

This course will provide a strong foundation to solve different kinds of PDEs using different techniques.

Course Outline:

Basics concepts of PDEs, origin of PDEs, Derivations of PDEs, solution of linear differential equations of order one using Lagrange's method and its different types, integral surface passing through a given curve, surface orthogonal to a given system of surfaces, linear PDEs with n dependent variables and its solutions, linear homogeneous and non-homogeneous PDEs with constant coefficients and its solutions, PDEs of order two with variable coefficients and its solutions, solution of equations under given geometrical conditions, canonical forms of different kinds of PDEs especially Heat, Wave and Laplace equations, Riemann method of solutions of general linear hyperbolic equations of order two, Monge's method of integration, solution of non-linear PDEs of order one using different techniques, Charpit method for solution of PDEs of order one and of any degree, special methods of solution of PDEs applicable to certain standard forms, the Jacobi method for solution of PDEs with three or more independent variables.

Recommended Books:

- M. D. Raisinghania, *Ordinary and Partial Differential Equations*, 2006, S Chand Group
- M. D. Raisinghania, *Advanced Differential Equations*, S Chand Group
- D.G. Zill, M.R. Cullen, *Differential Equations with Boundary-Value Problems*, (latest Edition), PWS Publishing Company
- K.Sankara Rao, *Introduction to Partial Differential Equations* (3rd edition) 2002 Prentice Hall of India New Delhi
- A.K. Sharma, *Advanced Differential Equations*, Discovery Publishing House, 2010
- C.R.Chester, *Techniques in Partial Differential Equations*, McGraw Hill Book Company, 1971

MGC- 230 ECONOMETRICS

Prerequisite (s): Introduction to Economics, Mathematical Statistics

Credit Hours: 3+0

Specific Objectives of Course:

The course provides a foundation to estimate econometric models with special emphasis on ordinary least square method.

Course Outline:

Introduction; Definition and scope of econometrics, Econometric models vs. Statistical models. Ingredients of econometric modeling, Specification, estimation, verification or evaluation and forecasting, The Classical Linear Regression Model, The Simple Linear Regression Model (SLRM); Estimation of SLRM by Ordinary Least Squares (OLS) Interpretation of Estimated Coefficients and their Economic Meanings, Hypothesis testing and Analysis of Variance, The Multiple Linear Regression Model (MLRM), Estimation of MLR model by OLS and its assumptions Interpretation of estimated coefficients and their economic meanings, Regression through Origin, Double log estimation and Computation of elasticities. Using R-square and Adjusted R-square as a measure of 'Goodness of Fit' and some Problems with its use, Testing the significance of individual coefficients, Testing the significance of the model as a whole, Analysis of Variance.

Recommended Books:

- D. Gujrati, *Basic Econometrics*, McGraw Hill, (latest edition)
- Koutsoyiannis, *Theory of Econometrics*, McMillan, (latest edition)
- G.M.K Madnani, *Introduction to Econometrics Principles and Applications*, (latest edition)
- R.J. Wonnacot, *Econometrics*, John Wiley, New York &
- Wonnacot, E.Pindyck, *Econometric Models & Economic Forecasts*, 3rd edition
- Griffiths, Judge, *The Theory and Practice of Econometrics*, John Willey and Sons

7th SEMESTER

MCC-208 TECHNICAL WRITING

Prerequisite(s): English Structure, Communication Skills

Credit Hours: 3 + 0

Specific Objectives of the Course:

The course aims at enhancing the language skills and developing critical thinking of the students.

Course Outline:

Practice of paragraph writing, Essay writing (descriptive, narrative, discursive, argumentative), Academic writing (How to write a proposal for research paper/term paper with emphasis on style, content, language, form, clarity, consistency), Technical Report Writing, Progress Report Writing, CV and job application.

Recommended Books:

- R.White, *Writing Advanced, Oxford Supplementary Skills*
- J. Langan, *College Writing Skills, McGraw Hill*
- L.G.Kirszner, S.R. Mandell, *Patterns of College Writing, St. Martin's Press*
- J.Neulib, K.S.Cain, S.Ruffus, M.Scharton, The Mercury Reader, Custom Publication, Illinois University

ELECTIVE COURSES (for 7th and 8th Semesters)

MMC-271 GENERAL TOPOLOGY

Prerequisite: Basic Topology

Credit hours: 3+0

Specific Objectives of the Course:

This course deals with the topological properties of figures with the help of which we can study complicated geometrical figures by decomposing them into simplest geometrical figures. It is used in Geography, Physics, Computer and studying different crystal structure and Allotropic forms of various elements in Chemistry.

Course Outlines:

Separation Axioms: Introduction T_0, T_1, T_2,T_3, T_4 Spaces, Normal and regular and completely regular spaces, Urysohn's lemma and metrization theorem, Countability: Introduction to first and second countable, hereditary properties, Bair's Category theorems, Cantor set and Canter intersection theorem, Compactness: Covers and open covers, Compact set and compact subset, Hein Borel theorem for compactness and sequentially compact sets and locally compact spaces, Connectedness : Connect and separated sets and spaces, Connectedness on the real line, Components, locally connectedness, Path and arc wise connectedness, Product spaces: Product topology and product of metric spaces, Base for finite product topology, examples of product spaces.

Recommended Books:

- Dr. A. Majeed, *Introduction to general Topology and Functional Analysis*
- S. Willards, *General Topology* Adison Wesley N.Y. 1970
- C. Adams, R. Franze, *Introduction to Topology pure and Applied*
- G. F Simmon, *Introduction to Topology and Modern Analysis,* McGraw Hill book Company

MMC-272 FUNCTIONAL ANALYSIS

Prerequisite(s): Complex Analysis, Basic Topology

Credit Hours: 3 + 0

Course Outline:

Review of metric spaces, Normed spaces: Definition and examples of Normed spaces, convergent sequences, Cauchy sequences, equivalent norm, quotient norm, and theorems on normed space, Banach Spaces: Definition and examples of Banach spaces, Characterization of Banach spaces, Bounded Linear Transformations; Bounded linear operators, Functional and their examples, Various characterizations of bounded (continuous) linear operators, The space of all bounded linear operators, The open mapping and closed graph theorems, The dual (conjugate) spaces, Reflexive spaces, Hahn-Banach Theorem: Hahn-Banach theorem (without proof), Some important consequences of the Hahn-Banach theorem, Hilbert Spaces: Inner product spaces and their examples, The Cauchy-Schwarz inequality, Hilbert spaces, Orthogonal complements, The projection theorem, The Riesz representation theorem.

Recommended Book:

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

MEC-273 MODELING AND SIMULATIONS

Prerequisite(s): Differential Equations

Credit Hours: 3 + 0

Specific Objectives of the Course:

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

Course Outline:

Concepts of model, modeling and simulation Functions, linear equations, linear-differential equations, nonlinear differential equations and integral equations as models, introduction to simulation techniques Ordinary-Differential Equations*:* Modeling with first order differential Equations: Newton's law of cooling; radioactive decay; motion in a Gravitational field; population growth; mixing problem; Newtonian Mechanics. Modeling with second order differential equations: vibrations; Modeling with periodic or impulse forcing functions, Modeling with systems of first order differential equations; Partial-Differential Equations: Methodology of mathematical modeling; objective, background, approximation and idealization, model validation, compounding, Modeling wave phenomena (wave equation); Modeling the heat equation and some application to heat conduction problems in rods, Modeling the potential equation (Laplace equation), Applications in fluid mechanics, gravitational problems, Equation of Continuity.

Recommended Books:

- F. R. Giordano, MD.Weir, *Differential Equations: A Modeling Approach*, 1994, Addison- Wesley, Reading, Ma, USA
- K. K. Tung, *Topics in Mathematical Modeling*
- U. T. Myint, L. Debnath, *Partial Differential Equations for Scientists and Engineers* (3rd edition), 1987, North Holland, Amsterdam
- S. Robert, *An Introduction to Programming and Numerical Methods in MATLAB*

MEC- 274 ADVANCED NUMBER THEORY

Prerequisite(s): Number Theory

Credit Hours: 3+0

Specific Objective of the Course:

This course contains some advance topics of number theory, this course enable the students to solve higher degree congruence's. In this course the students also learn to solve an equation containing three variables using modulo concepts etc. This course also familiarize the students with the solutions of an equation in Z_n where n is prime or composite. This subject covers some topics of graduate level.

Course Outline:

Primitive roots, The order of appositive integer, Theory of indices, Lagrange theorem, Polynomials congruence, Quadratic congruence Divisibility in rings, Solutions of Congruence using indices, Quadratic residues, Quadratic residues of primes, Euler Criteria for quadratic residues, Legendre's symbols, Quadratic reciprocity law, The Jacobi symbol, Solution of the problem of the type $ax + by + c = 0$, Farey sequences, Continued fractions, Finite continued fraction, Infinite continued fraction, Quadratics congruence with composite moduli, Composites with primitive roots.

Recommended Books:

- Ivan Niven, Herbert S. Zuckerman and Hugh L. Montgomery, *An Introduction to the Theory of Number*, John Wiley & Sons, Inc.
- K. C. Chowdhury, *A First Course in Number Theory*, Asian Book Private Limited
- Thomas Koshy, *Elementary Number Theory with Applications*, Academic Press is an imprint of Elsevier Kenneth
- H. Rosen, *Elementary Number Theory and its Applications*, Addison-wesley publishing Company

MEC- 275 ADVANCED PARTIAL DIFFERENTIAL EQUATIONS

Pre-requisite(s): Differential Equations

Credit Hours: 3+0

Specific Objectives of the Course:

The course provides a foundation to solve partial differential equations with special emphasis on Wave, Heat and Laplace equations. Formulation and some theory of these equations will also be discussed.

Course Outline:

Review of important topics in differential equations, Heat, Wave and Laplace equations and its solution by the method of separation of variable in rectangular, polar, cylindrical and spherical coordinates, Method of Eigen functions and its application, Poisson equation and its solution,

Introduction to Laplace Transform and its properties, Important theorems of Laplace transform method, Laplace transform of some important functions, Inverse Laplace transform and its properties, Convolution theorem, Solution of ODEs and PDEs by Laplace transform method, Introduction to Fourier Transform and its properties, Important theorems of Fourier Transform, Fourier Transform of some important functions, inverse Fourier Transform, Solution of PDEs using Fourier Transform.

Recommended Books:

- Richard Haberman, *Elementary Applied Partial Differential Equations with Fourier Series and Boundary Value Problems* (3^{rd} edition), 1997
- Dennis G. Zill, *Differential Equations with Boundary Value Problem* (6^{th} edition) PWS Publishing Company
- Stanley J. Farlow, *Partial Differential Equations for Scientists and Engineers*, 1993
- K.Sankara Rao, *Introduction to Partial Differential Equations* (3^{rd} edition) 2002 Prentice Hall of India New Delhi
- UT Myint, *Partial Differential Equations for Scientists and Engineers* (3^{rd} edition) 1987, North Holand, Amsterdam
- Nakhle H.Asmar, *Partial differential Equation with Fourier Series and Boundary Value Problem* (2^{nd} edition) New Jersey

MEC-276 ADVANCED NUMERICAL ANALYSIS

Prerequisite(s): Numerical Analysis

Credit Hours: 3 + 0

Course Outline:

Differentiation and integration in multidimensional, Ordinary differential equations, Predictor methods, Modified Euler's method, Truncation error and stability, The Taylor series method, Runge-Kutta methods, Differential equations of higher order, System of differential equations; Runge-Kutta methods, shooting methods, finite difference methods, Partial differential equations: Elliptic hyperbolic and parabolic equations; Explicit and implicit finite difference methods, stability, convergence and consistency analysis, The method of characteristics, Eigen value problems; Estimation of Eigen values and corresponding error bounds, Gerschgorins theorem and its applications Schurs theorem, Power method, Shift of origin, Deflation method for the subdominant Eigen values.

Recommended Books:

- R. L. Burden, J. D, Faires, *Numerical Analysis*, 9^{th} edition
- C. F.Gerald, *Applied Numerical Analysis*, Addison Wesely, 1984
- C. E. Froberg, *Introduction to Numerical Analysis*, Addison Wesely, 1972
- A. R.Gourlay, and G. A.Watson, *Computational Methods for Matrix Eigen Problems*, John Wiley & Sons 1973
- F. Ahmad, and M. A.Rana, *Elements of Numerical Analysis*, National Book Foundation, Islamabad, 1995

MEC-277 ADVANCED FUNCTIONAL ANALYSIS

Prerequisite(s): Functional Analysis

Credit Hours: 3 + 0

Course Outline:

The Hahn-Banach theorem, principle of uniform roundedness, open mapping theorem, closed graph theorem, Weak topologies and the Banach-Alouglu theorem, extreme points and the Klein-Milman theorem, The dual and bidual spaces, reflexive spaces, compact operators, Spectrum and Eigenvalues of an operator, elementary spectral theory.

Recommended Books:

- Kreyszing, E., Introductory Functional Analysis and Applications, John Wiley, 1973
- Taylor, A.E., and Lay, D.C., Introduction of Functional Analysis, John Wiley, 1979
- Heuser, H.G., Functional Analysis, John Wiley, 1982
- Groetsch, C.W., Elements of Applicable Functional Analysis, Marcel Dekker, 1980

MEC- 278 DIFFERENTIAL GEOMETRY

Prerequisites: Differential Equations

Credit Hours: 3 + 0

Specific Objectives of the Course:

In this course the students will be familiarizing with planes and planes curves and the action of total and partial differentials on varies planes.

Course Outlines:

Space Curve, The moving trihedral Curvature, Torsion and skew curvature, Serret-Frenet formula, Osculating circle and sphere, Curves of constant slope or cylindrical helices, The spherical indicaterices and their curvature and torsion, Concepts of surface. Tangent plane, Envelope and characteristics relating to one parameter family of surfaces, Edge of regression, Developable surfaces and developable associate with a space curve, Parametric curves, Two fundamental forms, Meosnier's theorem, Principal directions and principal curvature, Lines of curvature, Euler's theorem, Geodesics and Geodesic equations.

Recommended Books:

- C. E. Weatherburn, *Differential Geometry of three Dimensions*, Cambridge University Press
- D. J. Struik, *Lecture on classical Differential Geometry*, Addison Wesley Publishing Co. London
- T. J. Wilmore, *An Introduction to Differential Geometry*, Clarendon Press, Oxford

MEC-279 OPTIMIZATION THEORY

Prerequisite(s): Algebra-I, Real Analysis-I

Credit Hours: 3 + 0

Specific Objectives of the Course:

The main objective is to teach the basic notions and results of mathematical programming and optimization. The focus will be to understand the concept of optimality conditions and the construction of solutions. Students should have a good background in analysis, linear algebra and differential equations.

Course Outline:

Linear programming: simplex method, duality theory, dual and primal-dual simplex methods, Unconstrained optimization: optimality conditions, one-dimensional problems, multi-

dimensional problems and the method of steepest descent. Constrained optimization with equality constraints: optimality conditions, Lagrange multipliers, Hessians and bordered Hessians. Inequality constraints and the Kuhn-Tucker Theorem, The calculus of variations, the Euler-Lagrange equations, functional depending on several variables, variational problems in parametric form, transportation models and networks.

Recommended Books:

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

MEC-280 MEASURE THEORY AND INTEGRATIONS

Prerequisite(s): Real analysis-I, II

Credit Hours: 3+0

Specific Objective of the Course:

This course is devoted to Lebesgue integration and related topics, a basic part of modern analysis. There are classical and abstract approaches to the integral, and we have chosen the classical one. The classical approach is based on the theory of measure. Measure can be defined and studied in various spaces, but we will primarily consider n-dimensional Euclidean spaces.

Course Outlines:

Limit superior , Limit inferior, Measure, Outer measure, Lebesgue measure, Counting Measure, Lebesgue Measurable set, Measurable functions, Elementary properties of measurable function, Lebesgue integral, Riemann integral, Relationship between Riemann and Lebesgue integral, Properties of the Lebesgue integral, The integral of arbitrary measurable functions, Relation between Riemann–Stieltjes and Lebesgue integrals, L^p spaces, Properties of L^p spaces, Holder inequality, Minkowski inequality.

Recommended Books:

- Richard L. Wheeden and Antoni Zygmund, *Measure and Integral, An Introduction to Real Analysis*
- Elias M. Stein & Rami Shakarchi, *Real Analysis Measure Theory, Integration and Hilbert Spaces*, Princeton University Press Princeton and Oxford
- N. L. Carothers, *Real Analysis*, Cambridge University press

MEC-281 FLUID MECHANICS

Prerequisite(s): Calculus, Basics of Physic

Credit Hours: 3 + 0

Course Outline:

Real and ideal fluids, Force , Pressure, Density, Specific volume, Specific weight, Stress and strain, Young's modulus, Viscosity, Surface tension, Steady and unsteady flow, turbulent flow, laminar flow, two-dimensional flow, three-dimensional flow, Eulerian and Lagrangian Flow Descriptions, Path line, Streamline, stream tube, Stream filament, Stream surface, Streak line, The equation of continuity, The acceleration field, The Euler equation, The total derivative, Bernoulli's theorem, Flow of dry water continued, Flux, Vorticity and rotation, The velocity potential, Laplace's equation, Uniform flow, Source and sink, Viscosity, Deformation, The

equations of motion for viscous (wet) fluids, The Navier-Stokes equation, Viscous, incompressible, laminar flow, A. channel flow (2D counterpart of pipe flow), No-Slip Condition, Channel flow, Laminar flow in a pipe, Viscous flow past a circular cylinder, Reynolds number, Reynolds number.

Recommended Books:

- Buffler, *Introduction to fluid mechanics PHY2009S*, Department of Physics, University of Cape Town
- Kundu and Cohen, *Fluid Mechanics*, 4th Edition, by Academic Press, NY. 2008
- G. K. Batchelor, *An Introduction to Fluid Dynamics*, 2nd Edition, by Cambridge University Press, Cambridge. 2000
- F. M. White, *Fluid Mechanics*, 7th Edition, McGraw Hill, NY, 2011

MEC-282 STOCHASTIC PROCESSES

Prerequisite(s): Calculus and Mathematical Statistics

Credit Hours: 3+ 0

Specific Objectives of the Course:

The objectives of this course is to make certain that each student knows the theoretical methods of probability models and stochastic processes including Markov chains, Brownian Motion, Queuing theory, and stochastic differential equations.

Course Outline:

Review of probability theory with main emphasis on conditional probability and conditional expectation, Theory of Markov chains, Continuous-time Markov chains, Renewal theory and its application, Queuing theory, stochastic processes, stopping times, continuous times martingales, the Doob-Meyer Decomposition theorem, continuous square-integrable Martingales, Random Walk, Brownian motion, the strong Markov property and the reflection principal, Brownian Filtration, the Brownian sample path, stochastic integrals, The Ito rule, The Girsanov's Theorem, stochastic differential equations, strong solutions, weak solutions, Gauss-Markov processes, the general one dimensional linear equation, connections with partial differential equations.

Recommended Books:

- H. Taylor and S. Karlin, *An Introduction to Stochastic Modeling*, 3rd edition, 1998
- Sheldon M. Ross, *Introduction to Probability Models*, 10th edition, 2010
- N. Shiryaev, *Probability*, Springer, New York, 1995
- Karatzas, St. Shreve, *Brownian Motion and Stochastic Calculus*, Springer-Verlag, New York 1992

MEC- 283 INTEGRAL EQUATIONS

Prerequisite(s): Differential Equations

Credit Hours: 3 + 0

Course Outline:

Introduction to Integral equation, there origin and classification, some important identities, Laplace, Fourier and other Transforms, Volterra Integral equation, Volterra Integral equation of first kind and second kind, Numerical solution of Volterra integral equation, Fredholm Integral equation, Fredholm Integral equation with degenerate kernel, and with symmetric Kernel, Fredholm Integral equation of the second kind with numerical Solution, the Green's function of Fredholm Integral equation and the Green's function existence of the solution, Basic fixed point theorem.

Recommended Books:

- Abdul J. Jerri, *Introduction to Integral Equations with Applications*, 1985
- W. V. Lovitt, *Linear Integral Equations*, Dover Publications 1950
  F. Smith, *Integral Equations*, Cambridge University Press
  F. G. Tricomi, *Integral Equations*, Interscience, 1957

MEC-284 RELATIVITY
Prerequisite(s): Modern Physics
Credit Hours: 3+0
Course Outline:
Introduction to Einstein's Theory of Special Relativity, Lorentz transformations (one dimensional), length contraction, time dilation and simultaneity, Covariant and contravariant tensors and Einstein Summation convention, velocity addition formulae, 3- dimensional Lorentz transformations, introduction to 4-vector formalism, Lorentz transformations in the 4-vector formalism, the Lorentz and Poincare groups, introduction to classical mechanics, Minkowski space time and null cone, 4-velocity, 4-momentum and 4-force, application of special relativity to Doppler shift and Compton effect, particle scattering, binding energy, particle production and decay, electromagnetism in relativity, electric current, Maxwell's equations and electromagnetic waves, the 4-vector formulation of Maxwell's equations, special relativity with small acceleration. Review of analytic geometry in three dimension, Tensors and differential geometry, Isometries and Killing equations, Einstein's theory of relativity, Schwarzschild solution, Gravitational deflection of light, Field theory, Black holes, Relativistic cosmology.
Recommended Books

- H. Golstein, *Classical Mechanics*, Addison Wesley, 1962
- J. B. Kogut, *Introduction to Relativity*
- H. N. Ohanian, *Special relativity: A Modern Introduction*
- R. D. Inverno, *Introducing Einstein's Relativity*, Oxford University Press, 1992
- S. W. Hawking and G. F. R. Ellis, *The Large Scale Structure of Space-time*

MEC-285 ELECTRODYNAMICS-I
Prerequisite(s): Electromagnetic Theory, Calculus-II
Credit Hours: 3 + 0
Course Outline:
Review of Vector Calculus: vector algebra and calculus, Cartesian coordinates spherical coordinates, differential operators (grad, div, curl).
The Dirac Delta Function: Review of vector calculus using example of Dirac Delta function, The divergence of $\frac{r}{r^2}$, the one-dimensional and the three-dimensional Dirac delta functions. The theory of vector fields: the Helmoholtz theorem, potentials.
Electrostatics: The electric field: introduction, Coulomb's law, the electric field, continuous charge distributions. Divergence and curl of electrostatic fields: field lines, flux and Gauss's law, the divergence of E, applications of Gauss's law, the curl of E. Electric potential: introduction to potential, comments on potential, Poisson's equation and Laplace's equation, the potential of a localized charge distribution, summary, electrostatics boundary conditions, Work and energy in electrostatics: the work done to move a charge, the energy of a point charge distribution, the

energy of a continuous charge distribution, comments on electrostatic energy. Conductors: basic properties, induced charges, surface charge and the force on a conductor, capacitors.
Special Techniques: Laplace's equation: introduction, Laplace's equation in one, two and three dimensions, boundary conditions and uniqueness theorems, conductors and second uniqueness theorems.
The Method of Images: The classic image problem, induced surface charge, force and energy, other image problems.
Multipole Expansion: Approximate potential at large, the monopole and dipole terms, origin of coordinates in multipole, expansions, the electric field of a dipole.
Electric Fields in Matter-Polarization: dielectrics, induced dipoles, alignment of polar molecules, polarization. The field of a polarized object: bound charges, physical interpretation of bound charges, and the field inside a dielectric. The electric displacement: Gauss's law in the presence of dielectrics, a deceptive parallel, boundary conditions. Linear Dielectrics: susceptibility, permittivity, dielectric constant, boundary value problems with linear dielectrics, energy in dielectric systems, forces on dielectrics.
Magnetostatics: The Lorentz Force law: magnetic fields, magnetic forces, currents. The Biot-Savart Law: steady currents, the magnetic field of a steady current. The divergence and curl of B: straight-line currents, the divergence and curl of B, applications of Ampere's law, comparison of magnetostatics and electrostatics. Magnetic Vector Potential: the vector potential, summary, magnetic boundary conditions, multipole expansion of the vector potential.
Magnetic Fields in Matter: Magnetization, diamagnets, paramagnets, ferromagnets, torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits, magnetization. The Field of a Magnetized Object: bound currents, physical interpretation of bound currents, and the magnetic field inside matter. The auxiliary field H: Ampere's law in magnetized materials, a deceptive parallel, boundary conditions. Linear and nonlinear media: magnetic susceptibility and permeability, ferromagnetism.

Recommended Books:

- D. J. Griffiths, "Introduction to Electrodynamics", Prentice Hall, 3rd ed. 1999.
- M. N. O. Sadiku, "Elements of Electromagnetics", . Oxford University Press, 5th ed. 2009.
- F. Melia, "Electrodynamics", University of Chicago Press, 2001.
- Hearld J and W. Muller-Kristen, "Electrodynamics", World Scientific Pub, 2nd ed. 2011.

MEC-286 ELECTRODYNAMICS-II

Prerequisite(s): Electrodynamics-I

Credit Hours: 3 + 0

Specific Objectives of the Course:

This course is the second part of the core level undergraduate course on Electromagnetic Theory and a previous knowledge of Electromagnetic Theory I is expected.

Course Outline:

Electrodynamics: Electromotive force: Ohm's law, electromotive force, motional emf, electromagnetic induction: Faraday's law, the induced electric field, inductance, energy in magnetic fields, Maxwell's equations: electrodynamics before Maxwell, how Maxwell fixed Ampere's law, Maxwell's equations, magnetic charges, Maxwell's equations in matter, boundary conditions.

Conservation Laws: Charge and energy: the continuity equation, Poynting's theorem, momentum: Newton's third law in electrodynamics, Maxwell's stress tensor, conservation of momentum, angular momentum.
Electromagnetic Waves: Waves in one dimension: the wave equation, sinusoidal waves, boundary conditions, reflection and transmission, polarization, electromagnetic waves in vacuum: the wave equation for E and B, monochromatic plane waves, energy and momentum in electromagnetic waves, electromagnetic waves in matter: propagation in linear media, reflection and transmission at normal incidence, reflection and transmission at oblique incidence, absorption and dispersion: electromagnetic waves in conductors, reflection at a conducting surface, the frequency dependence of permittivity, guided waves: wave guides, the waves in a rectangular wave guide, the coaxial transmission line.
Potentials and Fields: The potential formulation: scalar and vector potentials, gauge transformations, Coulomb gauge and Lorentz gauge, continuous distributions: retarded potentials, Jefimenko's equations, point charges: Lienard-Wiechert potentials, the field of a moving point charge.
Radiation, Dipole Radiation: What is radiation, electric dipole radiation, magnetic dipole radiation, radiation from an arbitrary source, point charges: power radiated by a point charge, radiation reaction, the physical basis of the radiation reaction.
Electrodynamics and Relativity: The special theory of relativity: Einstein's postulates, the geometry of relativity, the Lorentz transformations, the structure of space-time, relativistic mechanics: proper time and proper velocity, relativistic energy and momentum, relativistic kinematics, relativistic dynamics, relativistic electrodynamics: magnetism as a relativistic phenomenon, how the field transform, the field tensor, electrodynamics in tensor notation, relativistic potentials.

Recommended Books:

- D. J. Griffiths, "Introduction to Electrodynamics", ed. Prentice Hall, 3rd ed. 1999.
- M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Press, 5th Ed, 2009.
- F. Melia, "Electrodynamics", University of Chicago Press, 1st ed. 2001.
- Hearld J and W. Muller-Kristen, "Electrodynamics", World Scientific Publishing, 2011.

MEC-287 QUANTUM MECHANICS-I

Prerequisite(s): Modern Physics

Credit Hours: 3 + 0

Course Outline:

Waves and Particles: Introduction to the fundamental ideas of quantum mechanics: Electromagnetic waves and photon, material particles and matter waves, quantum description of a particle, wave packets, particle in a time-independent scalar potential, order of magnitude of the wavelength associated with material particles, constraints imposed by uncertainty relations, one-dimensional Gaussian wave packet: Spreading of the wave packet, stationary states of a particle in one-dimensional square potential, behavior of a wave packet at a potential step.
The Mathematical Tools of Quantum Mechanics: One-particle wave function space, state space, Dirac notation, representations in the state space, observable, representations, review of some useful properties of linear operators, unitary operators, study of the $\{|r\rangle\}$ and $\{|p\rangle\}$ representations, some general properties of two observable, Q and P, whose commutator is equal to $i\hbar$, the two-dimensional infinite well.

The Postulates of Quantum Mechanics: Statement of the postulates and their physical interpretation, the physical implications of the Schrodinger equation, the superposition principle, particle in an infinite potential well, study of the probability current in some special case, root-mean-square deviations of two conjugate observables, the density and evolution operators, Schrodinger and Heisenberg pictures, Gguge invariance, bound states of a particle in a potential well of arbitrary shape, unbound states of a particle in the presence of a potential well or barrier of arbitrary shape, quantum properties of a particle in a one-dimensional periodic structure.
Application of The Postulates to Simple Cases: Spin ½ And Two-Level Quantum Systems: Spin ½ particles, quantization of the angular momentum, illustration of the postulates in the case of a spin ½, general study of two level systems, Pauli matrices, diagonalization of a 2×2 hermitian matrix, System of two spin ½ particles, Spin ½ density matrix, Spin ½ particle in a static magnetic field and a rotating field, Magnetic resonance.
The One-Dimensional Harmonic Oscillator: Importance of the harmonic oscillator in physics, eigenvalues and eigenstates of the Hamiltonian, mean value and root-mean-square deviations of X and P in state $|\varphi_n\rangle$, Some examples of harmonic oscillators, study of the stationary states in the $\{|r\rangle\}$ representation, Hermite polynomials, solving the Eigenvalues of the harmonic oscillators by the polynomial method, study of the stationary states in the $\{|p\rangle\}$ representation, isotropic three-dimensional harmonic oscillator, charged harmonic oscillator placed in a uniform electric field, coherent states, Normal vibrational modes of coupled harmonic oscillators, vibrational modes of an infinite linear chain of coupled harmonic oscillators, phonons, one-dimensional harmonic oscillator in thermodynamics equilibrium at a temperature T.
General Properties of Angular Momentum in Quantum Mechanics: concept of angular momentum in quantum mechanics, commutation relations, application to orbital angular momentum, spherical harmonics, rotation operators, rotation of diatomic molecules, angular momentum of stationary states of a two-dimensional harmonic oscillator, charged particle in a magnetic field and Landau levels.
Particle in a Central Potential: The Hydrogen atom, Stationary states of a particle in a central potential, motion of the center of mass and relative motion for a system of two interacting particles, Hydrogen atom, Hydrogen-like systems, A solvable example of a central potential: the isotropic three-dimensional harmonic oscillator, probability currents associated with the stationary states of the hydrogen atom, The hydrogen atom placed in a uniform magnetic field, paramagnetism and diamagnetism, Zeeman effect, study of some atomic orbitals, vibrational-rotational levels of diatomic molecules.
Recommended Books:

- D.J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. 2004.
- R. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4 ed. 2002.
- N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. 2009.

MEC-288 QUANTUM MECHANICS-II
Prerequisite(s): Quantum Mechanics-I
Credit Hours: 3 + 0
Course Outline:
Addition of Angular Momenta: Total angular momentum in classical mechanics, total angular momentum in quantum mechanics, addition of two spin ½ angular momenta, addition of two arbitrary angular momenta, Clebsch-Gordon coefficients, sddition of spherical harmonics, vector

operators, Wigner-Eckart theorem, electric Multipole moments, Evolution of two angular momenta J_1 and J_2 coupled by an interaction a $J_1 . J_2$.

Stationary Perturbation Theory: Description of the method, perturbation of a non-degenerate level, perturbation of a degenerate level, one-dimensional harmonic oscillator subjected to a perturbing potential, interaction between the magnetic dipoles of two spin ½ particles, Van der waals forces, volume effect and The influence of the spatial extension of the nucleus on the atomic levels, variational method, energy bands of electrons in solids, a simple example of the chemical bond: The H_2^+ ion.

Applications of Perturbation Theory to Atomic Systems: fine and hyperfine structure of atomic levels in hydrogen, Calculation of the mean values of the spin-orbit coupling in the 1s, 2s and 2p levels, hyperfine structure And the Zeeman effect for muonium and positronium, Stark effect.

Approximation Methods for Time-Dependent Problems: Statement of the problem, approximate solution of the Schrodinger equation, An important special case: Sinusoidal or constant perturbation, Interaction of an atom with electromagnetic waves, linear and non-linear response of a two-level system subjected to a sinusoidal perturbation, Ooscillations of a system between two discrete states under the effect of a resonant perturbation, Rabi flopping, decay of discrete state resonantly coupled to a continuum of final states, Fermi's golden rule.

Systems of Identical Particles: Identical particles, Permutation operators, The symmetrization postulate, difference between bosons and fermions, Pauli's exclusion principle, many-electrons atom and their electronic configurations, energy levels of the helium atom, configurations, terms, multiplets, spin isomers of hydrogen (ortho and parahydrogen).

Scattering by a Potential: Importance of collision phenomena, Stationary scattering states, scattering cross section, scattering by a central potential, method of partial waves, phenomenological description of collisions with absorption.

Recommended Books:

- D.J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. 2004.
- R. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4th ed. 2002.
- N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. 2009.

Annexure-B1

Item No: 2
Master Program in Mathematics (Annual System)

Degree Awarded: M.Sc Mathematics

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

Duration of the Program: 2 years

Total Marks: 1100

SCHEME OF STUDIES

(Year-Wise Breakdown)

M.Sc Previous

Paper No.	Course Title	Marks
Paper-I	Real Analysis	100
Paper-II	Algebra –I	100
Paper-III	Complex Analysis	100
Paper-IV	Topology	100
Paper-V	Programming in C	100
Total		**500**

M.Sc Final

Paper No.	Course Title	Marks
---	Optional	100
---	Optional	100
---	Optional	100
---	Optional	100
---	Optional	100
	Viva Voce	100
Total		**600**

List of Optional Courses

Paper-VI	Algebra-II	Paper-XII	Number Theory
Paper-VII	Electromagnetic Theory	Paper-XIII	Measure Theory and Integrations
Paper-VIII	Functional Analysis	Paper-XIV	Dynamics
Paper-IX	Mathematical Statistics	Paper-XV	Differential Equations
Paper-X	Differential Geometry	Paper-XVI	Fluid Mechanics
Paper-XI	Numerical Analysis	Paper-XVII	Classical Mechanics

Note: Final year courses will be offered from the above optional courses:

COURSE CONTENTS

M.Sc PREVIOUS

Paper-I REAL ANALYSIS

Course Outline:

Real number system and extended real number system, Convergence of sequence, sub-sequences, Cauchy sequences and competence, Continuous functions and their properties, discontinuity, monotonic functions, Differentiation, Mean value theorems, Definition and existence of the integral, the integral as a limit of sum , integration and differentiation, Uniform convergence and uniform continuity, term by term Differentiation and integration, functions of several variables, linear transformations, Differentiation, inverse function theorem, implicit function theorem, Jacobian, maxima and minima, improper integrals.

Recommended books:

- W. Rudin, Introduction to Mathematical Analysis
- Apostal, Mathematical Analysis
- E. G. Philips, A course of Analysis
- W. Kaplan, Advance Calculus

Paper-II ALGEBRA-I

Course Outline:

Definition of a group, order of a group and order of an element of a group, Cyclic group, Subgroups, product of groups, Cosets and coset decomposition of groups, Lagrange's Theorem and its cosequences, Normal subgroups, Quotient groups, Concept of Normalizers and Centrelizers, Center of groups, Commutator and derived group, Homomorphism of groups, Kernal of Homomorphism, Concept of an Isomorphism in groups, Isomorphism between groups, Permutation, groups of permutation, Cyclic permutations, Even and Odd permutations, Symetric and Alternating groups, Cayley's theorem,Vector Spaces; Concept of a vector space with Examples, Subspaces, Linear combinations, Internal and External direct sums, Bases and dimension of vector spaces, Quotetient spaces and their dimentions, Linear Transformations, Nullity and rank of linear transformation, Singular and invertible linear transformation, Algebra of linear transformation, Minimal Polynomials of linear transformations, Matrix of a Linear Transformation, Eigen values and Eigen vectors of Linear Transformation and Matrices, Diagonalization, inner direct product spaces and linear functional.

Recommended books:

- I. N. Hertein, Topics in Algebra, Xerox College Publishing Company 1972
- Mac Lane & Brikhoff, Algebra, McMillan N.Y, 1967
- P. M. Cohn, Algebra Vol-I, John Willey & Sons 1974
- Karamat Hussain, A First Step to Abstract Algebra, Feroz Sons (Pvt Ltd) Lahore 1999

Paper-III COMPLEX ANALYSIS

Course Outline:

Analytic Function; Function of a complex variable, Limits, Theorems on limits, Continuity, Differentiation, Cauchy-Riemann conditions, Sufficient conditions Analytic functions, Harmonic functions, L, Hospital's Rule, Singular points and their types, Elementary Functions; The

Exponential function, Trigonometric functions, Logarithmic functions, Branches, Complex exponents, Inverse Trigonometric functions, Integrals; Definite integrals, Contours, Line Integrals, Simply and Multiply connected regions, Cauchy Integral theorem, Cauchy-Goursat theorem for the case of triangle, closed polygon, simple closed curve and Multiply connected region, indefinite integrals, Cauchy Integral formula, Derivatives of analytic functions, Morera's theorem, Cauchy inequality, Liouville's theorem, fundamental theorem of Algebra, Maximum and Minimum modulus theorems, Roche's theorem, Power Series; Taylor's Series, Laurent's Series, Properties of Series, Uniform convergence, Integration and Differentiation n of Power Series, Uniqueness of representations by Power Series. Multiplication and Division of Series, Zeros of Analytic functions, Residues and Poles; Residues, Residue theorem, Poles, quotient of analytic functions, Cauchy principle value of integrals, Evaluation of improper real integrals, improper integrals involving Trigonometric functions, Definite integral of Trigonometric functions, Integration around a branch point, Mapping by Elementary Functions; Linear functions, the function Z^n, the function $1/Z$, the point at infinity, The linear fractional transformation, special linear fractional Transformations, the function $Z^{1/2}$, the transformation $w = e^Z$, the Transformation $w = \sin z$, Conformal Mapping; Rotation of tangents, conformal mapping, Conjugate Harmonic functions, inverse function. Transformations of Harmonic functions, Jacobean of Transformation, Transformation of boundary conditions, Special Functions; Gamma function, Beta function, Hypergeometric function and Legendre function.

Recommended books:

- Ruel V-Churchill, Complex Variable and Applications, Mc-Graw-Hill
- Erwin Kreszig, Advance Engineering Mathematics, John Wiley and Sons
- E. T. Whitaker, & C. N. Watson, A course of Modern Analysis

Paper-IV TOPOLOGY

Course Outline:

Topological spaces, Neighborhood, Limit Points, Closure of set, Interior, Exterior and Boundary of a Set, Bases and Sub-bases, Continuous Maps, Open and Closed Maps, Homeomorphism, Induced Topology, Topological Product, Hausdorff Spaces, Regular Spaces, Completely Regular Spaces, Normal Spaces, Metric spaces, Properties of Metric Spaces, Metrizability, Compact spaces, Open Cover, Finite Intersection Property, Locally Compact Spaces, Compactness in Metric Spaces, Connected Spaces, Topological Product of Connected Spaces, Locally Connected Spaces, Path wise and Arc wise Connected Spaces, Complete Metric Spaces, Concept of Category and Bair's Category theorem.

Recommended Books:

- J. R. Munkres, Topology (A first course) Prentice Hall Inc. 1975
- G. F. Simmons, Introduction to Topology and Modem Analysis, McGraw-Hill Book Company, 1963
- S. Willards, General Topology, Addison WesleyN.Y.1970
- A. Majeed, Elements of Topology and Functional Analysis, IImi Kitab Khana Lahore, 1990

Paper-V PROGRAMMING IN C

Course Outline:

Introduction to C Programming, Variables, Input/Output, Operators, Comments Loops, The for loop, the While loop, the do while loop Decisions, The if statement, the if-else statement, the else-if construct, The switch statement, the Conditional Operator simple Functions, functions that Return a Value, Using Arguments to Pass Data to a Function, Using More Than One Functions, External Variables, Static Variables, Preprocessor Directives. Arrays, Declaring Arrays, Passing Arrays to Functions, Sorting Arrays, String Constants, String Variables, String Functions, Pointer Overview, Returning Data from Functions, Pointer and Arrays, Pointer and Strings, File, Graphics, Preparing for Graphics Functions, Line Width and Style, Color, Ellipses and Polygons, Filling and Patterns, Graphs, Viewports, The Aspect Ration Problem, Pixels, Bit Images and Animation, Text with Graphics.

Recommended Books:

- Robert Lafore, C Programming Using Turbo C++, Sams, 1997
- Deitel and Deitel, C How to Program, Third Edition, Prentice Hall, 2000

M.Sc FINAL

(OPTIONAL COURSES)

Paper-VI ALGEBRA-II

Course Outline:

Isomorphism theorems, Conjugacy classes, Centralizers and Normalizers, Generating systems for finite symmetric and alternating groups, Endomorphism and Automorphism of a group, Characteristic and Fully Invariant subgroups, direct Product of groups, 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.

Recommended Books:

- John. B Fraleigh, A first Course in Abstract Algebra, Addison-Wesley Pub Co. London (1980)
- 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)

Paper-VII ELECTROMAGNETIC THEORY

Course Outline:

The Electromagnetic Law of force, potential and fields for several charges, Equipotent and lines of force, conductors, capacity, Gauss's flux theorem, Mechanical force on a charged surface and on a conductor, electrostatics potential energy of a system of charges, energy of a system of conductors, dielectrics, simple examples of fields in two or three dimensions, The magnetostatic law of force, magnetic doublets, magnetic shells, forces on magnetic doublets, magnetic induction, electric currents, linear conductors, conductivity, resistances, Kirchoff's laws, maximum energy theorem, effects produced by resistance of voltmeters, ammeters heat production, current density vector, magnetic field of straight and circular currents, magnetic field and energy law of electromagnetic induction, current of A.C. Maxwell's equations in free space and in material media and their solution in simple cases, Electromagnetic waves, reflection, refraction and polarization.

Recommended Books:

- Ferroro, Electromagnetic Theory
- S. Ramsey, Electricity and Magnetism

Paper-VIII FUNCTIONAL ANALYSIS

Course Outline:

Normed Linear Spaces, Bounded Linear Operators, Finite Dimensional Normed Linear Spaces, The Holder and Minkowski Inequalities, Banach Spaces, Quotient Spaces, Conjugate Spaces, the Hahn-Banach Theorem for Normed Linear Spaces, the Principle of Uniform Boundedness, the Open Mapping Theorem and the Closed Graph Theorem and Their Applications, Hilbert Spaces and related results, Orthogonal and Orthonormal Sets, Orthogonal Complements in Hilbert Spaces and properties, The Conjugate Spaces, The Adjoint of an Operator, Self-Adjoint Operators, Invariant Subspaces, Normal and Unitary Operators, Projections, The Definition of

Spectrum of an Operator and Some Examples, Spectral Properties of Self-Adjoint Operators, The Spectral Mapping Theorem for Finite Dimensional Hilbert Spaces.

Recommended Books:

- A. E. Taylor and D. C. Lay, Introduction to Functional Analysis, John Wiley & Sons
- G. F. Simmons, Introduction to Topology and Modem Analysis, McGraw-HiII Book company, 1963
- E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons,
- W. Rudin, Functional Analysis, Tata McGraw Hill Publishing Company, 1970

Paper-IX MATHEMATICAL STATISTICS

Course Outline:

Frequency distributions, Measures of dispersion, Skewness and Kurtosis, Probability, Total and compound probability, Bayes' formula and Bayes' theorem of probability, Geometrical problem, Mathematical expectation, Moment generating and cumulative functions, Discrete probability distributions, The Binomial distribution, The Poisson's distribution, Uniform distribution, Continuous distributions, The normal distribution, Gamma and beta distributions, Cauchy distribution, Bivariate Distributions, Correlation and Regression, Correlation Ratios, Correlation of ranks, Intraclass correlation, Multiple and partial correlations, Fitting of curves upto second degree parabolas, Reduction formulas for standard deviations and regression coefficients, Sampling, sampling of Attributes, Large samples, Fiducial limits, Poissonion and Lexian sampling, Large sample tests of significances, Comparison of large sample, sampling distributions, X^2 distribution, its properties, students' T-distribution, F-distribution, Interrelations between T and F distributions.

Recommended Books:

- J. V. Uspensky, An Introduction to Theory of Probability McGraw-HiII
- J. Freund, Mathematical Statistics, Prentice Hall
- C. E. Weatherbum, A First in Mathematical Statistics. Cambridge University Press
- S. S. Wilks, Elementary Statistical Analysis, Princeton University Press
- Kenney and Keeping, Mathematical Statistics
- W. Feller, Probability Theory and Applications
- M. Graybill, An Introduction to Mathematical Probability

Paper-X DIFFERENTIAL GEOMETRY

Course Outline:

Space curve, The moving trihedral Curvature, Torsion and skew curvature, Serret-Frenet Formula, Osculating circle and sphere, Curves of constant slope or cylindrical helices, The spherical indicaterices and their curvature and torsion, Concepts of surface, Tangent plane, Envelopes and characteristics relating to one parameter family of surfaces, Edge of regression, Developable surfaces and developables associate with a space curve, Parametric curves, Two fundamental forms, Meusnier's theorem, Principal directions and principal curvature, Lines of curvatures, Euler's theorem, Geodesics and Geodesic Equations.

Recommended Books:

- C. E. Weatherburn, Differential Geometry of three Dimentions, Cambridge University
- D. J. Struik, Lecture on Classical Differential Geometry, Addison Wesley
- T. J. Wilmore, An Introduction to Difft3rential Geometry, Clarendon Press, Oxford

Paper-XI NUMERICAL ANALYSIS

Course Outline:

Solution of Non-Linear Equations; The bisection Method, Fixed-point Iteration, The Method of False Position, the Newton-Raphson Method, Rate of Convergence of Iterative Methods, Solution of Linear System of Equations; Iterative Methods (Jacobi, Gauss-Seidel, S.O.R.), Eigen Value Problems; The Power Method and Inverse Power Method, Jacobi's Method, Given's Method and House-Holder's Method, Interpolation; Lagrange Interpolation, Divided Differences, Newton Forward-Difference Formula, Newton Backward-Difference Formula, Aitkin's and Inverse Interpolations, Cubic Spines, finite Difference Operators (Forward, Backward, Central and Shift), Numerical Differentiation; Forward Difference Formulas, Central Difference Formulas, Error in Numerical Differentiation, Extrapolation to the Limit; Numerical Integration; The Rectangular, Trapezoidal and Simpson's Rules, Romberg Integration, Method of Undermined Coefficients; Difference and Differential Equations; Formation of Difference Equations, Numerical solution of Linear (Homogeneous and Non-Homogeneous) Difference Equations with Constant Coefficients, Euler's Methods, Taylor's Methods, Runge-Kutta Method, Milne-Simpson Method, Adam-Bash forth-Moulton Method for Solving Initial Value Problems along with Convergence and Instability Criteria, Finite Difference Method and The Shooting Method for Boundary Value Problems.

Recommended Books:

- Richard L. Burden and J. Douglas Faires, Numerical Analysis, Brooks/Cole
- C. E. Froberg, Introduction to Numerical Analysis, Addison-Wesley Co., 1974
- M. K. Jain, Numerical Methods for Scientific and Engg. Computation, Wiley Eastern
- Dr. Faiz Ahmed and M. Afzal Rana, Elements of Numerical Analysis, N. B. Foundation

Paper-XII NUMBER THEORY

Course Outline:

Analytic Number Theory; Division and Division algorithm, different bases G.C.D. and L.C.M. of inegers, the equation ax+ by= h, primes, Fundamental theorem of arithmetic and its applications, Congruence, Elementary properties, Residue classes and Euler's function, Linear congruence and congruence of higher degree, congruence with prime moduli, The theorems of Fermat, Euler and Wilson, Primitive roots and indices, Integers belonging to a given exponent, Composite moduli, Indices, Quadratic Residues, Composite moduli, Legendre Symbol, Law of Quadratic reciprocity, The Jacobi Symbol, Number Theoretic Functions, Mobius Function, The function [x], symbols 0 and ~ and their basic properties, Diophantine Equations and Fermat's conjecture for N=2, N=4, Algebraic Number Theory; Algebraic Number and integers, Units and primes R(v) Ideals, Arithmetic of Ideals, Congruence, The norm of a prime Ideal, Unit of Algebraic number field, Applications to Rational Number Theory, Equivalence and class number Cyclotomic field K, Fermat's equations, Kummer's theorem, The equation -2+2 = *l.* Pure cubic fields, Distribution of primes and Rimes and Riemann zeta function, The prime Number Theorem.

Recommended Books:

- W. J. Leveque, Topics in Number Theory, Vol: I & 11, Addison-Wesley
- E. Gross, Topics from the theory of Numbers, The Mc-Millan Company, New York
- Hardy & Wright, Number Theory, Clarendon Press, Oxford
- The Theory of Algebraic Numbers, John Wiley

Paper-XIII MEASURE THEORY & INTEGRATIONS

Course Outline:

Foundation of Analysis, A development of Integral, rational, real and complex number system from the Peano axioms, Denumerable and non-denumerable sets, cardinal and ordinal numbers, partially ordered sets and totally ordered sets, well-ordered sets, transfinite induction, axiom of choice and well ordering theorem, Theory of set of points, covering theorems, theory of measure. Measurable functions, the Lebesgue Integral Convergence theorems, the fundamental theorem of the integral calculus, derivative, non differentiable functions, functions of bounded variation and absolutely continuous functions, the Lebesgue set, the Lebesgue classes ~p, Strong convergence, Simple treatment of Riemann-Stieltjes and Lebesgue Stieltjes integrals.

Recommended Books:

- Natonson, Theory of Functions of Real Variables
- Titchmarsh, Theory of Functions
- Edmond Landau, Foundation of the Analysis
- Seymour Lipschutz, Set Theory and Related Topics

Paper-XIV DYNAMICS

Course Outline:

Dynamics of a Rigid Body; Moments and product of inertia, D' Alembert's principle, Motion about a fixed axis, Linear Momentum and Kinetic energy of a rigid body, Compound pendulum, Motion in two dimension, Finite forces; impulsive forces, Lagrange's equations in generalized coordinates, Dynamics of a Particle; Uniplanar motion, acceleration parallel to fixed axes, polar coordinates, moving axes, central forces, stability of orbits, acceleration varying as the inverse square of the distance, Kapler's laws, Planetary motions, Tangential and Normal accelerations, Motion in a resisting medium, Angular momentum and rate of change of angular momentum for a system of particles.

Recommended Books:

- S. L. Loney, Dynamics of a particle and Rigid Bodies
- F. Charlton, A Text Book of Dynamics

Paper-XV DIFFERENTIAL EQUATIONS

Course Outline:

Review of basics of differential equations, Ordinary differential equations, First order ODEs, Higher order ODEs, Methods for solving constant coefficient problems, Methods for solving non-homogeneous equations, second order ODEs with variable coefficients --- power series and Frobenius methods, Geometric interpretation of solutions of differential equations, Euler lines, Lipschitz condition, Successive approximation's Cauchy's theorem, Dependence of solution on initial value and on parameters, Singular curves, General theory of systems of ODEs: reduction of an arbitrary system to a system of first-order equations, geometric interpretation, basic theorems, Basic theory of linear systems of ODEs, Formation of homogeneous linear system from fundamental set of solutions, Implication for equations of order n, Reducing the order of a homogeneous linear system, Non-homogeneous systems of ODEs, Linear systems with constant coefficients, Determination of fundamental set of solutions of homogeneous system, Implications for homogeneous equations of order n, The Sturm-Liouville system and problem, The orthogonality of solutions of SL problems, PDEs and their classification, Solutions of PDEs, Boundary value problems (BVPs), Method of separation of variables for PDEs.

Recommended Books:

- G. Petrovski, Ordinary Differential Equations, Dover Publications, Inc., New York 1966
- E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, New York, 1999
- D.G. Zill, M.R, Cullen, Differential Equations with Boundary-Value Problems, (latest Edition), PWS Publishing Company
- D.G. Zill, Advanced Engineering Mathematics, Jones and Bartlett Publishers, 2005
- Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons (9^{th} edition)
- G.E. Andrews, R. Askey, and R. Roy, Special Functions, Cambridge University Press,

Paper-XVI FLUID MECHANICS

Course Outline:

Real and ideal fluids, Force , Pressure, Density, Specific volume, Specific weight, Stress and strain, Young's modulus, Viscosity, Surface tension, Steady and unsteady flow, turbulent flow, laminar flow, two-dimensional flow, three-dimensional flow, Eulerian and Lagrangian Flow Descriptions, Pathline, Streamline, streamtube, Stream filament, Stream surface, Streakline, The equation of continuity, The acceleration field, The Euler equation, The total derivative, Bernoulli's theorem, Flow of dry water continued, Flux, Vorticity and rotation, The velocity potential, Laplace's equation, Uniform flow, Source and sink, Viscosity, Deformation, The equations of motion for viscous (wet) fluids, The Navier-Stokes equation, Viscous, incompressible, laminar flow, A. channel flow (2D counterpart of pipe flow), No-Slip Condition, Channel flow, Laminar flow in a pipe, Viscous flow past a circular cylinder, Reynolds number, Reynolds number.

Recommended Books:

- A. Buffler, Introduction to fluid mechanics PHY2009S, Department of Physics, University of Cape Town
- Kundu and Cohen, Fluid Mechanics, 4^{th} Edition, by Academic Press, NY. 2008
- G. K. Batchelor, An Introduction to Fluid Dynamics, 2^{nd} Edition, by Cambridge University Press, Cambridge. 2000
- F. M. White, Fluid Mechanics, 7^{th} Edition, McGraw Hill, New York, 2011

Paper-XVII CLASSICAL MECHANICS

Course Outlines:

Introduction: Space and Time, Newton's Laws, The Concepts of Mass and Force, External Forces.

Linear Motion: Conservative Forces; Conservation of Energy, Motion near Equilibrium; the Harmonic Oscillator, Complex Representation, The Law of Conservation of Energy, The Damped Oscillator, Oscillator under Simple Periodic Force, General Periodic Force, Impulsive Forces; the Green's Function Method, Collision Problems.

Energy and Angular Momentum: Energy; Conservative Forces, Projectiles, Moments; Angular Momentum, Central Forces; Conservation of Angular Momentum, Polar Co-ordinates, The Calculus of Variations, Hamilton's Principle; Lagrange's Equations.

Central Conservative Forces: The Isotropic Harmonic Oscillator, The Conservation Laws, The Inverse Square Law, Orbits, Scattering Cross-sections, Mean Free Path, Rutherford Scattering.

Rotating Frames: Angular Velocity; Rate of Change of a Vector, Particle in a Uniform Magnetic Field, Acceleration; Apparent Gravity, Coriolis Force, Larmor Effect, Angular Momentum and the Larmor Effec.

Potential Theory: Gravitational and Electrostatic Potentials, The Dipole and Quadrupole, Spherical Charge Distributions, Expansion of Potential at Large Distances, The Shape of the Earth, The Tides, The Field Equations.

The Two-Body Problem: Centre-of-mass and Relative Co-ordinates, The Centre-of-mass Frame, Elastic Collisions, CM and Lab Cross-sections.

Many-Body Systems: Momentum; Centre-of-mass Motion, Angular Momentum; Central Internal Forces, The Earth–Moon System, Energy; Conservative Forces, Lagrange's Equations

Rigid Bodies: Basic Principles, Rotation about an Axis, Perpendicular Components of Angular Momentum, Principal Axes of Inertia, Calculation of Moments of Inertia, Effect of a Small Force on the Axis, Instantaneous Angular Velocity, Rotation about a Principal Axis, Euler's Angles.

Lagrangian Mechanics: Generalized Co-ordinates; Holonomic Systems, Lagrange's Equations, Precession of a Symmetric Top, Pendulum Constrained to Rotate about an Axis, Charged Particle in an Electromagnetic Field, The Stretched String, Small Oscillations and Normal Modes, Orthogonal Co-ordinates, Equations of Motion for Small Oscillations, Normal Modes, Coupled Oscillators, Oscillations of Particles on a String, Normal Modes of a Stretched String

Hamiltonian Mechanics: Hamilton's Equations, Conservation of Energy, Ignorable Co-ordinates, General Motion of the Symmetric Top, Liouville's Theorem, Symmetries and Conservation Laws, Galilean Transformations.

Recommended Books:

- T. Kibble and F. Berkshire, "Classical Mechanics", World Scientific, 5th ed. 2004.
- T. L. Chow, "Classical Mechanics", John Wiley, 1995.
- S.T. Thornton, J.B. Marion, "Classical Dynamics of Particles and Systems", Brooks Cole; 5th ed. 2003.

Annexure-B2

Master Program in Mathematics (Semester System)

Degree Awarded: Master of Science in Mathematics

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

Duration of the Program: 2 years

Total Credit Hours: 60

Total Marks: 2000

Marks Breakdown for Courses

Item	**Maximum Marks for Courses (without Laboratory)**	**Maximum Marks for Courses with Laboratory (2 + 1)**
Mid-Term Examination	30%	15%
Internal Marks (Assignments, Quizzes, Presentations)	20%	20%
Laboratory	----	15%
Semester Examination	50%	50%
Total	100%	100%

SCHEME OF STUDIES
(Semester-Wise Breakdown)
FIRST YEAR
First Semester

Course Code	Course Title	Marks	Credit Hours
MCC-501	Advanced Calculus	100	3+0
MCC-502	Linear Algebra	100	3+0
MCC-503	Set Topology	100	3+0
MCC-504	Ordinary Differential Equations	100	3+0
MCC-505	Programming Language C/C++/ Computing Tools	80+20	2+1
Total		**500**	**15**

Second Semester

Course Code	Course Title	Marks	Credit Hours
MCC-506	Real Analysis	100	3+0
MCC-507	Group Theory	100	3+0
MCC-508	Vector and Tensor Analysis	100	3+0
MCC-509	Complex Analysis	100	3+0
MCC-510	Numerical Methods	100	3+0
Total		**500**	**15**

SECOND YEAR
Third Semester

Course Code	Course Title	Marks	Credit Hours
MCC-511	Partial Differential Equations	100	3+0
MCC-512	Mathematical Statistics	100	3+0
----	Optional Course	100	3+0
----	Optional Course	100	3+0
----	Optional Course	100	3+0
Total		**500**	**15**

Fourth Semester

Course Code	Course Title	Marks	Credit Hours
----	Optional Course	100	3+0
----	Optional Course	100	3+0
----	Optional Course	100	3+0
----	Optional Course	100	3+0
----	Project **OR** Optional Course	100	3+0
Total		**500**	**15**

NOTE:
MCC means Mathematics Compulsory Course
MAC means Mathematics Applied Course
MPC means Mathematics Pure Course

List of Optional Courses

S. No.	Course Code	Course Title	Credit Hours	Marks
1	MAC-521	Analytical Mechanics	3	100
2	MAC-522	Differential Geometry	3	100
3	MAC-523	Numerical Analysis	3	100
4	MAC-524	Advanced Partial Differential Equations	3	100
5	MAC-525	Advanced Mathematical Statistics	3	100
6	MAC-526	Advanced Differential Geometry	3	100
7	MAC-527	Integral Equations	3	100
8	MAC-528	Fluid Mechanics	3	100
9	MAC-529	Analytical Dynamics	3	100
10	MAC-530	Electrodynamics-I	3	100
11	MAC-531	Electrodynamics-II	3	100
12	MAC-532	Quantum Mechanics-I	3	100
13	MAC-533	Quantum Mechanics-II	3	100
14	MAC-534	Modeling and Simulations	3	100
15	MAC-535	Optimization Theory	3	100
16	MPC-541	Functional Analysis	3	100
17	MPC-542	Rings and Fields	3	100
18	MPC-543	Advanced Functional Analysis	3	100
19	MPC-544	Advanced Group Theory	3	100
20	MPC-545	Theory of Modules	3	100
21	MPC-546	Measure Theory and Integrations	3	100
22	MPC-547	Advanced Complex Analysis	3	100
23	MPC-548	Advanced Number Theory	3	100

COURSE CONTENTS
1st SEMESTER

MCC-501 ADVANCED CALCULUS
Prerequisite(s): Mathematics A, and B at BA/BSc level
Credit Hours: 3 + 0
Course Outline:
The real numbers, algebraic and order properties of R, the completeness property, cluster points, open and closed sets in R, Sequences, the limit of a function, limit theorems, Continuous functions on intervals, boundedness theorem, maximum-minimum theorem and the intermediate value theorem, uniform continuity, The derivative, the mean value theorem, Taylor's theorem, Functions of several variables, Limit and continuity of functions of two and three variables, partial derivatives ,differentiable functions, Multiple Integrals, regions in the x-y plane, iterated integrals, double integrals, change in the order of integration, transformation of double integrals.
Recommended Book:

- R. G. Bartle, and D. R. Sherbert, Introduction to Real Analysis, John Wiley & Sons 1994
- D. V. Widder, Advanced Calculus, Prentice-Hall, 1982
- W. Rudin, Principles of Real Analysis, McGraw-Hill, 1995
- S.C. Malik Mathematical Analysis

MCC-502 LINEAR ALGEBRA
Prerequisite(s): Mathematics B at BA/BSc level
Credit Hours: 3 + 0
Course Outline:
Review of matrices and determinants, Linear spaces, Bases and dimensions, Subspaces, Direct sums of subspaces, Factor spaces, Linear forms, Linear operators, Matrix representation and sums and products of linear operators, The range and null space of linear operators, Invariant subspaces, Eigen values and Eigen vectors of linear transformation and matrices, transformation of matrix linear operator, diagonalization, inner direct product spaces and linear functional, minimal polynomial of linear transformations.
Recommended Book:

- G.E. Shilov, Linear Algebra, Dover Publication, Inc., New York, 1997
- D.G. Zill, and M. R. Culle, Advanced Engineering Mathematics, PWS
- Herstein, Topics in Algebra, John-Wiley, 1975
- A. M. Trooper, Linear Algebra, Thomas Nelson and Sons, 1969

MCC-503 SET TOPOLOGY
Prerequisite(s): Mathematics B at BA/BSc level
Credit Hours: 3 + 0
Course Outline:
Motivation and introduction to sets and their operations, countable and uncountable sets, Topological spaces, open and closed sets, interior, closure and boundary of a set, neighborhoods and neighborhood systems, isolated points, some topological theorems, limit points, the derived and perfect sets, dense sets and separable spaces, Bases and sub bases, continuous maps, open and closed maps, Metric spaces, topology induced by a metric, equivalent topologies,

formulation with closed sets, Cauchy sequence, complete metric spaces, characterization of completeness, Cantors intersection theorem, the completion of metric space, metrizable spaces. Continuous functions, various characterizations of continuous functions, homeomorphisms, open and closed continuous functions, topological properties and homeomorphisms, Separation axioms, T1 and T2 spaces, regular and normal spaces, Compact spaces their characterization and some theorems, construction of compact spaces, compactness in metric spaces, compactness and completeness, local compactness. Connected spaces, topological product of connected spaces, locally connected spaces, concept of category and Bair's category theorem.

Recommended Book:

- J. R. Munkres, Topology A First Course, Prentice - Hall, Inc. London
- G. F. Simon, Introduction to Topology and Modern Analysis McGraw-Hill, New York
- W. J. Pervin, Foundation of General Topology, Academic Press, London, 2nd, ed
- Dr. A. Majeed, Introduction to Topology and Functional Analysis

MCC-504 ORDINARY DIFFERENTIAL EQUATIONS

Prerequisite(s): Mathematics A at B.A/B.Sc level

Credit Hours: 3 + 0

Course Outline:

Definitions and occurrence of differential equations, remarks on existence and uniqueness of solution, First order and simple higher order differential equations, special equations of 1st order, Elementary applications of 1st order differential equations, Theory of linear differential equations. Linear equations with constant coefficients, Methods of undetermined coefficients and variation of parameters, S-L boundary value problems; self Adjoint operators, Fourier series, Series solution of differential equations, The Bessel modified Bessel Legendre, Hermit, Hyper geometric, Lauguere equations and their solutions, Orthogonal polynomials.

Recommended Book:

- M. Morris, and O. E. Brown, Differential Equations, Englewood Cliffs, Prentice-Hall
- M. R. Spiegel, Applied Differential Equations, Prentice-Hall
- L. Brand, Differential and Difference Equations, John-Wiley
- D. G. Zill, and M. R. Cullen, Advanced Engineering Mathematics PWS, Publishing Co.

MCC-505 PROGRAMMING LANGUAGE C/C++

Prerequisite(s): None

Credit Hours: 2+1

Course Outline:

Introduction to C Programming, Variables, Input/Output, Operators, Comments Loops, The for loop, the While loop, the do while loop Decisions, The if statement, the if-else statement, the else-if construct, The switch statement, the Conditional Operator simple Functions, functions that Return a Value, Using Arguments to Pass Data to a Function, Using More Than One Functions, External Variables, Static Variables, Preprocessor Directives. Arrays, Declaring Arrays, Passing Arrays to Functions, Sorting Arrays, String Constants, String Variables, String Functions, structure.

Recommended Book:

- Robert Lafore, C Programming Using Turbo C++, Sams, 1997
- Deitel & Deitel, C How to Program, Third Edition, Prentice Hall, 2000

MCC-505 COMPUTING TOOLS

Prerequisite(s): None

Credit Hours: 2+1

Specific Objectives of the Course:

The purpose of this course is to teach students the use of mathematical software's like MATLAB, MAPLE, and MATHEMATICA for solving computationally-difficult problems in mathematics. The students shall become well-versed in using at least one mathematical software and shall learn a number of techniques that are useful in calculus as well as in other areas of mathematics.

Course Outline:

The contents of the course are not fixed, however the following points should be kept in mind while teaching the course. The course should be taught in a computer lab setting. Besides learning to use the software, the students must be able to utilize the software to solve the computationally difficult problems in calculus and other areas of mathematics. At the end of the course, the students should have a good command on at least two of the three programs mentioned above.

Recommended Books:

- DM. Etter, D, Kuncicky, D. Hull, *Introduction to MATLAB*, Prentice Hall, Englewood Cliffs,NJ, USA, 2001
- F. Garven, *The Mapple Book*, Chapman & Hall/CRC, 2002
- S. Kaufmann, *Mathematica As a Tool, An Introduction with Practical Examples*, Springer, New York, 1994

2nd SEMESTER

MCC-506 REAL ANALYSIS
Prerequisite(s): Advanced Calculus
Credit Hours: 3 + 0
Course Outline:
The Riemann Integral: Upper and lower sums, definition of a Riemann integral, integrability criterion, classes of integrable functions, properties of the Riemann integral, Infinite Series, Review of sequences, the geometric series, tests for convergence, conditional and absolute convergence, Regrouping and rearrangement of series. Power series, radius of convergence, Uniform Convergence: Uniform convergence of a sequence and a series, the M-test, properties of uniformly convergent series, Weierstrass approximation theorem, Improper Integrals, Classification, tests for convergence, absolute and conditional convergence, convergence of $f(x)\sin xdx$, the gamma function, Uniform convergence of integrals, the M-text, properties of uniformly convergent integrals.
Recommended Book:

- R. G. Bartle, and D. R. Sherbert, Introduction to Real Analysis, John Wile Sons
- D. V. Widder, Advanced Calculus, Prentice Hall
- W. Rudin, Principles of Real Analysis, McGraw-Hill
- S. C. Malik Mathematical Analysis

MCC-507 GROUP THEORY
Prerequisite(s): None
Credit Hours: 3 + 0
Course Outline:
Introduction to Sets and Structures, Motivation for groups, Finite groups, Product of Subgroups, Permutations and cyclic groups, Homomorphism of a group, kernel of Homomorphism, Concept of an Isomorphism of a group, Isomorphism between Cyclic groups, Cosets, Normal groups, Factor groups and Simple groups, Concept of Normalizer and Centralizers, Centre of a group, Series of groups.
Recommended Book:

- J. B. Fraleigh, A First Course in Algebra, Addison-Wesley
- M. Hamermesh, Group Theory, Addison-Wesley
- N. Herstein, Topics in Algebra, John Wiley

MCC-508 VECTOR AND TENSOR ANALYSIS
Prerequisite(s): Ordinary Differential Equations
Credit Hours: 3 + 0
Course Outline:
Vectors in 3 dimension scalars, the dot and the cross products, Triple products, vector differentiation, vector integration, the gradient, divergence and curl, and their applications, the divergence theorems of Gauss, Stokes's theorem, and Green's theorem in the plane, curvilinear coordinates, introduction to tensor analysis, summation convention, kronecker delta, contra variant and covariant vectors and tensor, Fundamental operations with tensors, symmetric, and skew symmetric tensors, Metric tensor, conjugate or reciprocal tensors, christoffel's symbols,

Geodesics, Geodesics equation, Covariant derivatives, permutation symbols and tensors, tensors form of gradient, divergence and Curl.

Recommended Book:

- D. E. Bourne, P. C. Kendall, Vector Analysis and Cartesian Tensors (latest edition)
- N. A. Shah, Vector and Tensor Analysis, A-One Publishers, Lahore
- G. D. Smith, Vector Analysis, Oxford University Press, Oxford

MCC-509 COMPLEX ANALYSIS

Prerequisite(s): Advanced Calculus

Credit Hours: 3 + 0

Course Outline:

Algebra of complex numbers, analytic functions, C-R equations, harmonic functions, elementary functions, branches of log z, complex exponents, Integrals: Contours, Cauchy-Goursat theorem, Cauchy integral formula, Moreras theorem, Liouvilles theorem, Series: Convergence of sequences and series, Taylor series, Laurent series, zeros of analytic function, Residues and poles: the residue theorem, evaluation of improper integrals, integrals involving trigonometric functions, integration around a branch point, Special Functions: Gamma, Beta, Hyper geometric and Legendre polynomial.

Recommended Books:

- R Churchill, Verhey and Brown R., Complex Variables and Applications McGraw-Hill
- J. E. Marsden, Basic Complex Analysis, W.H.Freeman and Co
- E. Hille, Analytic Function Theory, Vols.I and II, Chelsea Publishing Co. New York

MCC-510 NUMERICAL METHODS

Prerequisite(s): BA/B.Sc Numerical Analysis

Credit Hours: 3 + 0

Course Outline:

Number Systems and Errors; Loss of significance and error propagation, condition and instability; error estimation; floating point arithmetic; loss of significance and error propagation, Interpolation by Polynomials; Existence and uniqueness of the interpolating polynomial, Lagrangian interpolation, the divided difference table, Error of the interpolating polynomial; interpolation with equally spaced data, Newton's forward and backward difference formulas, Bessel's interpolation formula, Solution of non-linear Equations, Bisection method, iterative methods, secant and regula falsi methods; fixed point iteration, convergence criterion for a fixed point iteration, Newton-Raphson method, order of convergence of Newton-Raphson and secant methods, System of Linear Equations: Gauss elimination methods, triangular factorization, Crout method, Iterative methods, Jacobi method, Gauss-Seidel method, SOR method, convergence of iterative methods, Numerical Differentiation: Numerical differentiation formulae based on interpolation polynomials, error estimates, Numerical Integration: Newton-Cotes formulae; trapezoidal rule, Simpsons formulas, composite rules, Error estimation of integration formulas.

Recommended Book:

- R. L. Burden, J.D, Faires, Numerical Analysis, 9^{th} edition
- D. D. McCracken, A guide to Fortran IV programme, Second Edition
- S. D. Conte, and C. Boor, Elementary Numerical Analysis, McGraw-Hill
- F. Ahmad, and M. A. Rana, Elements of Numerical Analysis, National Book Foundation

3rd SEMESTER

MCC-511 PARTIAL DIFFERENTIAL EQUATIONS

Pre-requisite(s)**:** Ordinary Differential Equations
Credit Hours: 3+0
Course Outline:
Basics concepts of PDEs, origin of PDEs, Derivations of PDEs, solution of linear differential equations of order one using Lagrange's method and its different types, integral surface passing through a given curve, surface orthogonal to a given system of surfaces, linear PDEs with n dependent variables and its solutions, linear homogeneous and non-homogeneous PDEs with constant coefficients and its solutions, PDEs of order two with variable coefficients and its solutions, solution of equations under given geometrical conditions, canonical forms of different kinds of PDEs especially Heat, Wave and Laplace equations, Riemann method of solutions of general linear hyperbolic equations of order two, Monge's method of integration, solution of non-linear PDEs of order one using different techniques, Charpit method for solution of PDEs of order one and of any degree, special methods of solution of PDEs applicable to certain standard forms, the Jacobi method for solution of PDEs with three or more independent variables.

Recommended Books:

- M. D. Raisinghania, Ordinary and Partial Differential Equations, 2006, S Chand Group
- M. D. Raisinghania, Advanced Differential Equations, S Chand Group
- D. G. Zill, M. R. Cullen, Differential Equations with Boundary-Value Problems
- K.Sankara Rao, Introduction to Partial Differential Equations
- A.K. Sharma, Advanced Differential Equations, Discovery Publishing House

MCC-512 MATHEMATICAL STATISTICS

Prerequisite(s): Mathematics A at B.Sc level
Credit Hours: 3 + 0
Course Outline:
Frequency distributions, Measure of central tendency, Measure of dispersion, Moments, Kurtosis, Probability, Conditional and Marginal Interpretations of Probability, Bays formula and Bay's theorem of Probability, Random variable, Discrete and continuous Random variable, Mathematical expectation, Discrete distribution: Moment generating and cumulative distributions, Discrete probability distribution, The Binomial distribution, Hyper geometric distribution, Negative Binomial distribution, the Poisson distribution, Geometric distribution, Uniform distribution, Continuous distribution: Uniform distribution, the normal exponential distributions, Gamma and Beta distributions, Cauchy distribution, Log-Normal distribution, Weibull distribution.

Recommended Books:

- M. H. Degroot, Probability and Statistics, 2nd Edition
- K. V. Mardia, J. T. Kent, and J. M. Bibby, Multivariate Analysis
- Freund J-1962, Mathematical Statistics, Prentice Hall
- Mathematical Statistics Schaum's outline series
- M. R. Spiegel, J. Schiller, R. A. Srinivasan, Probability and Statistics
- J. N. Kapur and H. C. Sexena S. Mathematical Statistics

OPTIONAL COURSES

MAC-521 ANALYTICAL MECHANICS
Prerequisite(s): Advanced Calculus, Ordinary Differential Equations
Credit Hours: 3 + 0
Course Outline:
Review of basic principles, Kinematics of particle and rigid body in three dimension; Work, Power, Energy, Conservative field of force, Impulsive forces, rectilinear particle motion, S.H.M, Damped and forced oscillation, Moments and products of inertia, Angular momentum, motion of a projectile, orbital motion, Keplar's laws, Kinetic energy about a fixed point, systems of particles, principal axes, Motion replacing relative to the rotating earth, D'Alembert's principal, Generalized coordinates.
Recommended Books:

- F. Chorlton, Principles of Mechanics, McGraw Hill, N. Y
- K. R. Symon, Mechanics, Addison Wesley
- H. Goldstein, Classical Mechanics, Addison Wesley, 2nd Edition
- F. P. Beer and E. R. Johnston, Mechanics for Engineers, Vols-I & II, McGraw

MAC-522 DIFFERENTIAL GEOMETRY
Prerequisite(s): Advanced Calculus, Ordinary Differential Equations
Credit Hours: 3 + 0
Course Outline:
Historical background; Motivation and applications, Space curves, Arc length; the moving trihedran Curvature; Principal normal; Binormal; Torsion; The osculating, the normal and the rectifying planes; The Frenet-Serret Theorem; Spherical images; Osculating Circle and Sphere curves; Spherical contacts; Fundamental theorem of space curves; curves of constant slope and cylindrical helices, the spherical indicaterices and their curvature and torsion, Concept of surface, the tangent and the normal planes, envelope and characteristic relating to one parameter family of surfaces, involutes, edge of regression and evolutes, parametric cuves; two fundamental form and the metric tensor; principal direction and principal curvature, lines of curvatures, Euler's theorem.
Recommended Book:

- R. S. Millman, and G. R. Parker, G. D. Elements of Differential Geometry
- D. J. Struik, Lectures on Classical Differential Geometry, Addison-Wesley
- M. P. Docarmo, Differential Geometry of Curves and Surfaces
- B. O. Neil, Elementary Differential Geometry, Academic Press
- Goetz, Introduction to Differential Geometry, Addison-Wesley
- F. Charlton, Vector and Tensor Methods, Ellis Horwood

MAC-523 NUMERICAL ANALYSIS
Prerequisite(s): Numerical Methods
Credit Hours: 3 + 0
Course Outline:
Differentiation and integration in multi dimension, Ordinary differential equations, Predictor methods, Modified Eulers method, Truncation error and stability, The Taylor series method,

Runge-Kutta methods, Differential equations of higher order, System of differential equations; Runge-Kutta methods, shooting methods, finite difference methods, Partial differential equations: Elliptic hyperbolic and parabolic equations; Explicit and implicit finite difference methods, stability, convergence and consistency analysis, The method of characteristic, Eigen value problems; Estimation of Eigen values and corresponding error bounds, Gerschgorins theorem and its applications Schurs theorem, Power method, Shift of origin, Deflation method for the subdominant Eigen values,

Recommended Books:

- R. L. Burden, J. D, Faires, Numerical Analysis, 9^{th} edition
- C. F. Gerald, Applied Numerical Analysis, Addison Wesely, 1984
- C. E. Froberg, Introduction to Numerical Analysis, Addison Wesely, 1972
- R. Gourlay, and Watson, G.A., Compitational Methods for Matrix Eigene Problems. John W. & Sons
- F. Ahmad, and M. A. Rana, Elements of Numerical Analysis, National Book Foundation, Islamabad.

MAC-524 ADVANCED PARTIAL DIFFERENTIAL EQUATIONS

Prerequisite(s): Differential Equations

Credit Hours: 3 + 0

Contents:

Review of ordinary differential equation in more than one variables, Partial differential equations (P.D.E) of the first order, Nonlinear P.D.E. of first order Applications of 1st order partial differential equations, Partial differential equations of second order: Solution of heat, Laplace and wave equations, Classification of 2nd order P.D.E. Boundary and initial conditions, Reduction to canonical form and the solution of 2nd order P.D.E. Technique of separation of variable for the solution of P.D.E with special emphasis on Heat, Laplace and wave equations, Laplace, Fourier transforms for the solution of P.D.E and their application to boundary value problems.

Recommended Book:

- I. 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

MAC-525 ADVANCED MATHEMATICAL STATISTICS

Prerequisite(s): Mathematical Statistics

Credit Hours: 3 + 0

Course Outline:

Bivariante distribution, Bivariante Normal distribution, Correlation and Regression, Correlation Ratio, Correlation ranks, Intraclass Correlation, Multiple and Particle Correlation, Linear Regression Model, Fitting of curves of the type $y = ab^x$, $y = ax^b$, Degree parabola, Distribution of function of random variable, M.g.t, Commutative and transformation methods,

Sampling, Laws of large Samples, Estimations methods of point estimation, Maximum likelihood Methods, Properties of maximum likelihood estimators, Methods of Moments, Methods of least square, Properties of maximum likelihood estimates, interval estimate, Sampling distributions, The chi square distribution. Its properties, Students T-distributions,F-distribution, Interrelation between T and F distributions.

Recommended Books:

- M. Mood, F. A. Graybill, and D. C. Boes, Introduction to the Theory of Statistics
- M. H. Degroot, Probability and Statistics, 2nd Edition
- K. V. Mardia, J. T. Kent, and J. M. Bibby, Multivariate Analysis
- J. Freund, Mathematical Statistics, Prentice Hall
- M. R. Spiegel, J. Schiller, R. A. Srinivasan, Probability and Statistics

MAC-526 ADVANCED DIFFERENTIAL GEOMETRY

Prerequisite(s): Differential Geometry

Credit Hours: 3 + 0

Course Outline:

Definition and examples of manifolds; Differential maps; Submanifolds; Tangents; Coordinate vector fields; Tangent spaces; Dual spaces; Multilinear functions; Vector fields; Tensor fields; Integral curves; Flows; Lie derivatives; Brackets; Differential forms; Introduction to integration theory on manifolds; Riemannian and semi-Riemannian metrics; Flat spaces; Affine connextions; Parallel translations; Covariant differentiation of tensor fields; Curvature and torsion tensors; Connexion of a semi-Riemannian tensor; Killing equations and Killing vector fields; Geodesics; Sectional curvature.

Recommended Books:

- R. L. Bishop, and S. I. Goldberg, Tensor Analysis on Manifolds, Dover Publications
- M. P. Docarmo, M. P, Riemannian geometry, Birkhauser, Boston
- D. Lovelock, and H. R. Tensors., Differential Forms and Variational Principles
- D. Langwitz, Differential and Riemannian geometry, Academic Press
- R. Abraham, J. E. Marsden, and T. Ratiu, Manifolds, Tensor Analysis and Applications

MAC-527 INTEGRAL EQUATIONS

Prerequisite(s): Differential equations and Real Analysis

Credit Hours: 3 + 0

Course Outline:

Introduction to integral equation, there origin and classification, some important identities, Laplace, Fourier and other Transforms, Volterra Integral equation: Volterra Integral equation of first kind and second kind, Numerical solution of Volterra integral equation, Fredholm Integral equation; Fredholm Integral equation with degenerate kernel, with symmetric Kernel, Fredgholem Integral equation with of the second kind numerical Solution, the Green's function of Fredholm Integral equation and the Green's function existence of the solution, Basic fixed point theorem.

Recommended Books:

- F. Smith, Integral equations, Cambridge University Press
- B. Noble, Methods based on the Wiener-Hopf technique, Pergamon Press
- J. Jerri., Introduction to integral equations with applications, Marcel Dekker Inc

MAC-528 FLUID MECHANICS

Prerequisite(s): Differential equations and Analytical Mechanics

Credit Hours: 3 + 0

Course Outline:

Real and ideal fluids, Force , Pressure, Density, Specific volume, Specific weight, Stress and strain, Young's modulus, Viscosity, Surface tension, Steady and unsteady flow, turbulent flow, laminar flow, two-dimensional flow, three-dimensional flow, Eulerian and Lagrangian Flow Descriptions, Pathline, Streamline, streamtube, Stream filament, Stream surface, Streakline, The equation of continuity, The acceleration field, The Euler equation, The total derivative, Bernoulli's theorem, Flow of dry water continued, Flux, Vorticity and rotation, The velocity potential, Laplace's equation, Uniform flow, Source and sink, Viscosity, Deformation, The equations of motion for viscous (wet) fluids, The Navier-Stokes equation, Viscous, incompressible, laminar flow, A. channel flow (2D counterpart of pipe flow), No-Slip Condition, Channel flow, Laminar flow in a pipe, Viscous flow past a circular cylinder, Reynolds number, Reynolds number.

Recommended Books:

- Buffler, Introduction to fluid mechanics PHY2009S, Deptt. of Physics
- Kundu and Cohen, Fluid Mechanics, 4th Edition
- G. K. Batchelor, An Introduction to Fluid Dynamics, 2nd Edition
- F. Chorlton, Textbook of fluid Dynamics

MAC-529 ANALYTICAL DYNAMICS

Prerequisite(s): Analytical Mechanics

Credit Hours: 3 + 0

Course Outline:

Constraints, generalized co-ordinates, generalized forces, general equation of dynamics, Lagrange's equations, conservation laws, ignorable co-ordinates, Explicit form of Lagranges equation in terms of tensors, Hamiltons principle, principle of least action, Hamiltons equations of motion, Hamilton-Jacobi Method, Poisson Brackets (P.Bs); Poissons theorem; Solution of mechanical problems by algebraic technique based on (P.Bs), Small oscilations and normal modes, vibrations of straings, transverse vibrations, normal modes, forced vibrations and damping, reflection and transmission at a discontinuity, Iongitudinal vibrations, Rayleighs principle.

Recommended Books:

- F. Chorlton, Textbook of dynamics, Van Nostrand
- W. Chester, Mechanics, George Allen and Unwin Ltd., London
- H. Goldstein, Classical Mechanics, Cambridge, Mass Addison-Wesley
- G. L. Meirovitch, Methods of Analytical Dynamics, McGraw-Hill,

MAC-530 ELECTRODYNAMICS-I

Prerequisite(s): Electromagnetic Theory, Calculus-II

Credit Hours: 3 + 0

Course Outline:

Review of Vector Calculus: vector algebra and calculus, Cartesian coordinates spherical coordinates, differential operators (grad, div, curl).

The Dirac Delta Function: Review of vector calculus using example of Dirac Delta function, The divergence of $\frac{r}{r^2}$, the one-dimensional and the three-dimensional Dirac delta functions. The theory of vector fields: the Helmoholtz theorem, potentials.
Electrostatics: The electric field: introduction, Coulomb's law, the electric field, continuous charge distributions. Divergence and curl of electrostatic fields: field lines, flux and Gauss's law, the divergence of E, applications of Gauss's law, the curl of E. Electric potential: introduction to potential, comments on potential, Poisson's equation and Laplace's equation, the potential of a localized charge distribution, summary, electrostatics boundary conditions, Work and energy in electrostatics: the work done to move a charge, the energy of a point charge distribution, the energy of a continuous charge distribution, comments on electrostatic energy. Conductors: basic properties, induced charges, surface charge and the force on a conductor, capacitors.
Special Techniques: Laplace's equation: introduction, Laplace's equation in one, two and three dimensions, boundary conditions and uniqueness theorems, conductors and second uniqueness theorems.
The Method of Images: The classic image problem, induced surface charge, force and energy, other image problems.
Multipole Expansion: Approximate potential at large, the monopole and dipole terms, origin of coordinates in multipole, expansions, the electric field of a dipole.
Electric Fields in Matter-Polarization: dielectrics, induced dipoles, alignment of polar molecules, polarization. The field of a polarized object: bound charges, physical interpretation of bound charges, and the field inside a dielectric. The electric displacement: Gauss's law in the presence of dielectrics, a deceptive parallel, boundary conditions. Linear Dielectrics: susceptibility, permittivity, dielectric constant, boundary value problems with linear dielectrics, energy in dielectric systems, forces on dielectrics.
Magnetostatics: The Lorentz Force law: magnetic fields, magnetic forces, currents. The Biot-Savart Law: steady currents, the magnetic field of a steady current. The divergence and curl of B: straight-line currents, the divergence and curl of B, applications of Ampere's law, comparison of magnetostatics and electrostatics. Magnetic Vector Potential: the vector potential, summary, magnetic boundary conditions, multipole expansion of the vector potential.
Magnetic Fields in Matter: Magnetization, diamagnets, paramagnets, ferromagnets, torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits, magnetization. The Field of a Magnetized Object: bound currents, physical interpretation of bound currents, and the magnetic field inside matter. The auxiliary field H: Ampere's law in magnetized materials, a deceptive parallel, boundary conditions. Linear and nonlinear media: magnetic susceptibility and permeability, ferromagnetism.

Recommended Books:

- D. J. Griffiths, "Introduction to Electrodynamics", Prentice Hall, 3rd ed. 1999.
- M. N. O. Sadiku, "Elements of Electromagnetics", . Oxford University Press, 5th ed. 2009.
- F. Melia, "Electrodynamics", University of Chicago Press, 2001.
- Hearld J and W. Muller-Kristen, "Electrodynamics", World Scientific Pub, 2nd ed. 2011.

MAC-531 ELECTRODYNAMICS-II

Prerequisite(s): Electrodynamics-I

Credit Hours: 3 + 0

Specific Objectives of the Course:

This course is the second part of the core level undergraduate course on Electromagnetic Theory and a previous knowledge of Electromagnetic Theory I is expected.

Course Outline:

Electrodynamics: Electromotive force: Ohm's law, electromotive force, motional emf, electromagnetic induction: Faraday's law, the induced electric field, inductance, energy in magnetic fields, Maxwell's equations: electrodynamics before Maxwell, how Maxwell fixed Ampere's law, Maxwell's equations, magnetic charges, Maxwell's equations in matter, boundary conditions.

Conservation Laws: Charge and energy: the continuity equation, Poynting's theorem, momentum: Newton's third law in electrodynamics, Maxwell's stress tensor, conservation of momentum, angular momentum.

Electromagnetic Waves: Waves in one dimension: the wave equation, sinusoidal waves, boundary conditions, reflection and transmission, polarization, electromagnetic waves in vacuum: the wave equation for E and B, monochromatic plane waves, energy and momentum in electromagnetic waves, electromagnetic waves in matter: propagation in linear media, reflection and transmission at normal incidence, reflection and transmission at oblique incidence, absorption and dispersion: electromagnetic waves in conductors, reflection at a conducting surface, the frequency dependence of permittivity, guided waves: wave guides, the waves in a rectangular wave guide, the coaxial transmission line.

Potentials and Fields: The potential formulation: scalar and vector potentials, gauge transformations, Coulomb gauge and Lorentz gauge, continuous distributions: retarded potentials, Jefimenko's equations, point charges: Lienard-Wiechert potentials, the field of a moving point charge.

Radiation, Dipole Radiation: What is radiation, electric dipole radiation, magnetic dipole radiation, radiation from an arbitrary source, point charges: power radiated by a point charge, radiation reaction, the physical basis of the radiation reaction.

Electrodynamics and Relativity: The special theory of relativity: Einstein's postulates, the geometry of relativity, the Lorentz transformations, the structure of space-time, relativistic mechanics: proper time and proper velocity, relativistic energy and momentum, relativistic kinematics, relativistic dynamics, relativistic electrodynamics: magnetism as a relativistic phenomenon, how the field transform, the field tensor, electrodynamics in tensor notation, relativistic potentials.

Recommended Books:

- D. J. Griffiths, "Introduction to Electrodynamics", ed. Prentice Hall, 3rd ed. 1999.
- M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Press, 5th Ed, 2009.
- F. Melia, "Electrodynamics", University of Chicago Press, 1st ed. 2001.
- Hearld J and W. Muller-Kristen, "Electrodynamics", World Scientific Publishing, 2011.

MAC-532 QUANTUM MECHANICS-I
Prerequisite(s): Modern Physics
Credit Hours: 3 + 0
Course Outline:
Waves and Particles: Introduction to the fundamental ideas of quantum mechanics: Electromagnetic waves and photon, material particles and matter waves, quantum description of a particle, wave packets, particle in a time-independent scalar potential, order of magnitude of the wavelength associated with material particles, constraints imposed by uncertainty relations, one-dimensional Gaussian wave packet: Spreading of the wave packet, stationary states of a particle in one-dimensional square potential, behavior of a wave packet at a potential step.
The Mathematical Tools of Quantum Mechanics: One-particle wave function space, state space, Dirac notation, representations in the state space, observable, representations, review of some useful properties of linear operators, unitary operators, study of the $\{|r\rangle\}$ and $\{|p\rangle\}$ representations, some general properties of two observable, Q and P, whose commutator is equal to iħ, the two-dimensional infinite well.
The Postulates of Quantum Mechanics: Statement of the postulates and their physical interpretation, the physical implications of the Schrodinger equation, the superposition principle, particle in an infinite potential well, study of the probability current in some special case, root-mean-square deviations of two conjugate observables, the density and evolution operators, Schrodinger and Heisenberg pictures, Gguge invariance, bound states of a particle in a potential well of arbitrary shape, unbound states of a particle in the presence of a potential well or barrier of arbitrary shape, quantum properties of a particle in a one-dimensional periodic structure.
Application of The Postulates to Simple Cases: Spin ½ And Two-Level Quantum Systems: Spin ½ particles, quantization of the angular momentum, illustration of the postulates in the case of a spin ½, general study of two level systems, Pauli matrices, diagonalization of a 2×2 hermitian matrix, System of two spin ½ particles, Spin ½ density matrix, Spin ½ particle in a static magnetic field and a rotating field, Magnetic resonance.
The One-Dimensional Harmonic Oscillator: Importance of the harmonic oscillator in physics, eigenvalues and eigenstates of the Hamiltonian, mean value and root-mean-square deviations of X and P in state $|\varphi_n\rangle$, Some examples of harmonic oscillators, study of the stationary states in the $\{|r\rangle\}$ representation, Hermite polynomials, solving the Eigenvalues of the harmonic oscillators by the polynomial method, study of the stationary states in the $\{|p\rangle\}$ representation, isotropic three-dimensional harmonic oscillator, charged harmonic oscillator placed in a uniform electric field, coherent states, Normal vibrational modes of coupled harmonic oscillators, vibrational modes of an infinite linear chain of coupled harmonic oscillators, phonons, one-dimensional harmonic oscillator in thermodynamics equilibrium at a temperature T.
General Properties of Angular Momentum in Quantum Mechanics: concept of angular momentum in quantum mechanics, commutation relations, application to orbital angular momentum, spherical harmonics, rotation operators, rotation of diatomic molecules, angular momentum of stationary states of a two-dimensional harmonic oscillator, charged particle in a magnetic field and Landau levels.
Particle in a Central Potential: The Hydrogen atom, Stationary states of a particle in a central potential, motion of the center of mass and relative motion for a system of two interacting particles, Hydrogen atom, Hydrogen-like systems, A solvable example of a central potential: the isotropic three-dimensional harmonic oscillator, probability currents associated with the stationary states of the hydrogen atom, The hydrogen atom placed in a uniform magnetic field,

paramagnetism and diamagnetism, Zeeman effect, study of some atomic orbitals, vibrational-rotational levels of diatomic molecules.

Recommended Books:

- D.J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. 2004.
- R. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4 ed. 2002.
- N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. 2009.

MAC-533 QUANTUM MECHANICS-II

Prerequisite(s): Quantum Mechanics-I

Credit Hours: 3 + 0

Course Outline:

Addition of Angular Momenta: Total angular momentum in classical mechanics, total angular momentum in quantum mechanics, addition of two spin ½ angular momenta, addition of two arbitrary angular momenta, Clebsch-Gordon coefficients, sddition of spherical harmonics, vector operators, Wigner-Eckart theorem, electric Multipole moments, Evolution of two angular momenta J_1 and J_2 coupled by an interaction a $J_1 . J_2$.

Stationary Perturbation Theory: Description of the method, perturbation of a non-degenerate level, perturbation of a degenerate level, one-dimensional harmonic oscillator subjected to a perturbing potential, interaction between the magnetic dipoles of two spin ½ particles, Van der waals forces, volume effect and The influence of the spatial extension of the nucleus on the atomic levels, variational method, energy bands of electrons in solids, a simple example of the chemical bond: The H_2^+ ion.

Applications of Perturbation Theory to Atomic Systems: fine and hyperfine structure of atomic levels in hydrogen, Calculation of the mean values of the spin-orbit coupling in the 1s, 2s and 2p levels, hyperfine structure And the Zeeman effect for muonium and positronium, Stark effect.

Approximation Methods for Time-Dependent Problems: Statement of the problem, approximate solution of the Schrodinger equation, An important special case: Sinusoidal or constant perturbation, Interaction of an atom with electromagnetic waves, linear and non-linear response of a two-level system subjected to a sinusoidal perturbation, Ooscillations of a system between two discrete states under the effect of a resonant perturbation, Rabi flopping, decay of discrete state resonantly coupled to a continuum of final states, Fermi's golden rule.

Systems of Identical Particles: Identical particles, Permutation operators, The symmetrization postulate, difference between bosons and fermions, Pauli's exclusion principle, many-electrons atom and their electronic configurations, energy levels of the helium atom, configurations, terms, multiplets, spin isomers of hydrogen (ortho and parahydrogen).

Scattering by a Potential: Importance of collision phenomena, Stationary scattering states, scattering cross section, scattering by a central potential, method of partial waves, phenomenological description of collisions with absorption.

Recommended Books:

- D.J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. 2004.
- R. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4th ed. 2002.
- N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. 2009.

MAC-534 MODELING AND SIMULATIONS

Prerequisite(s): Differential Equations

Credit Hours: 3 + 0

Course Outline: Concepts of model, modeling and simulation Functions, linear equations, linear-differential equations, nonlinear differential equations and integral equations as models, introduction to simulation techniques Ordinary-Differential Equations: Modeling with first order differential Equations: Newton's law of cooling; radioactive decay; motion in a Gravitational field; population growth; mixing problem; Newtonian Mechanics. Modeling with second order differential equations: vibrations; Modeling with periodic or impulse forcing functions, Modeling with systems of first order differential equations; Partial-Differential Equations: Methodology of mathematical modeling; objective, background, approximation and idealization, model validation, compounding, Modeling wave phenomena (wave equation); Modeling the heat equation and some application to heat conduction problems in rods, Modeling the potential equation (Laplace equation), Applications in fluid mechanics, gravitational problems, Equation of Continuity.

Recommended Books:

- F. R. Giordano, M. D. Weir, Differential Equations: A Modeling Approach
- K. K. Tung, Topics in Mathematical Modeling
- U. T. Myint, L. Debnath, Partial Differential Equations for Scientists and Eng. N. H. Amsterdam
- S. Robert, An Introduction to Programming and Numerical Methods in MATLAB
- D.G. Zill, M.R. Cullen, Differential Equation with boundary Value Problem
- Erwin Kreszig, Advance Engineering Mathematics (John Willey and Sons)

MAC-535 OPTIMIZATION THEORY

Prerequisite(s): Linear Algebra, Real Analysis

Credit Hours: 3 + 0

Course Outline:

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

Recommended Books:

- L. Elsgolts, Differential Equations and the Calculus of Variations
- B. S. Gotfried, J. Weisman, Introduction to Optimization Theory
- D. G. Luenberger, Introduction to Linear and Non-Linear Programming

MPC-541 FUNCTIONAL ANALYSIS

Prerequisite(s): Complex Analysis.

Credit Hours: 3 + 0

Course Outline:

Review of metric spaces, Normed spaces: Definition and examples of Normed spaces, convergent sequences, Cauchy sequences, equivalent norm, quotient norm, and theorems on normed space, Banach Spaces: Definition and examples of Banach spaces, Characterization of Banach spaces, Bounded Linear Transformations; Bounded linear operators, Functional and their examples, Various characterizations of bounded (continuous) linear operators, The space of all bounded linear operators, The open mapping and closed graph theorems, The dual (conjugate) spaces, Reflexive spaces, Hahn-Banach Theorem: Hahn-Banach theorem (without proof), Some important consequences of the Hahn-Banach theorem, Hilbert Spaces: Inner product spaces and their examples, The Cauchy-Schwarz inequality, Hilbert spaces, Orthogonal complements, The projection theorem, The Riesz representation theorem.

Recommended Book:

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

MPC-542 RINGS AND FIELDS

Prerequisite(s): Group Theory

Credit Hours: 3 + 0

Course Outline:

Introduction to Ring theory and Field and their structure, Quotient Rings, Integral domain, Homomorphism of a Ring, Kernel of a Ring, Isomorphism of a Ring, Maximal ideals, Prime ideals, Euclidian rings, or Euclidian domain, Polynomial rings over a unique factorization domain, the field of quotients of an integral domain, Field structure, Ordered ring and field, introduction to extension field, Algebraic extensions, Finite field.

Recommended Books:

- J. A. Fraleigh, A First Course in Abstract Algebra, Addision Wesley Publishing
- N. Herstein, Topies in Algebra, John Wiley & Sons
- S. Lang, Algebra, Addison Wesley
- B. Hartley, and T. O. Hawkes, Ring, Modules and Linear Algebra, Chapman and Hall

MPC-543 ADVANCED FUNCTIONAL ANALYSIS

Prerequisite(s): Functional Analysis.

Credit Hours: 3 + 0

Course Outline:

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

Recommended Books:

- E. Kreyszing, Introductory Functional Analysis and Applications, John Wiley

- E. Taylor, and D. C. Lay, Introduction of Functional Analysis, John Wiley
- H. G. Heuser, Functional Analysis, John Wiley
- W. Groetsch, Elements of Applicable Functional Analysis, Marcel Dekker

MPC-544 ADVANCED GROUP THEORY
Prerequisite(s): Group Theory
Credit Hours: 3 + 0
Course Outline:
Isomorphism Theorems, Conjugacy Classes, Generating Systems for finite Symmetric and Alternating groups, Endomorphism and Automorphism of a group, Characteristic and Fully invariant subgroups, Direct product of a group, Syllow theory and its applications, Simple group, simplicity of A_n for 5, Zessanhaus lemma, Normal series, Composition series, Jardon Holder theorem, Solvable groups, the derived series of a group, the lower and upper central series of a group and Nilpotent groups, Free group.
Recommended Books:
- J. S. Rose, A course on group theory, Cambridge University Press
- W. Magnus, A. Karrass, and Solitar., Combinatorial group theory
- Husain Taqdir., Introduction to topological groups

MPC-545 THEORY OF MODULES
Prerequisite(s): Group Theory
Credit Hours: 3 + 0
Course Outline:
Elementary notions and examples, Modules, sub modules, quotient modules, finitely generated and cyclic modules, exact sequences and elementary notions of homological algebra, Noetherian and Artinian rings and modules, radicals, semi simple rings and modules.
Recommended Books:
- J. Adamson, Rings and modules. Blyth, T.S., Module theory
- B. Hartley, and T. O. Hawkes, Rings, Modules and Linear algebra
- N. Herstein, Topics in Algebra, John Wiley and Sons

MPC-546 MEASURE THEORY AND INTEGRATIONS
Prerequisite(s): Real Analysis
Credit Hours: 3 + 0
Course Outline:
Foundation of Analysis, A development of integral, relational, real and complex number system from the Peano axioms, Denumerable and no Denumerable sets, Cardinal and ordinal number, Partial ordered sets and Totally ordered sets, well order sets, Transfinite induction, axiom of choice and well ordering theorem, theory of set of points, covering theorems, theory of Measure, Measurable functions, the Lebesgue integral convergence theorem, the fundamental theorem of the integral calculus, derivative, non-differentiable functions, function of bounded variation, the Lebesgue class L^p, strong convergence, simple treatment of Riemann-Stieltjes and Lebesgue-Stieltjes integral.
Recommended Books:
- Natonson, Theory of Functions of Real Variables

- Burkill, Lebesgue Integral
- Edmon Landou, Foundation of the Analysis
- Inder k. Rana. An Introduction to Measure and Integration 2nd Ed. Narosa

MPC-547 ADVANCED COMPLEX ANALYSIS

Prerequisite(s): Complex Analysis

Credit Hours: 3 + 0

Course Outline:

Conformal mapping, Preservation of mapping, Scale Factors, Local inverses, Harmonic Conjugates, Transformation of Harmonic functions, Transformation of boundary conditions, Application of conformal mapping, The Schwarz-Christoffel transformation, Integral formula, the Poisson type, Dirichlet problem for a disk, Schwarz integral formula, Neumann problems, mapping by elementary functions, linear frictional transformation, linear functional, the function $\frac{1}{Z}$, the transformation $w = \exp(z)$ and $w = \sin z$ Analytic continuation.

Recommended Books:

- R. V. Churchill, R. Brown, Complex Variables and Applications McGraw-Hill
- J. E. Marsden, Basic Complex Analysis, W. H. Freeman
- E. Hille, Analytic Function Theory, Vols. I and II

MPC-548 ADVANCED NUMBER THEORY

Prerequisite(s): Number Theory

Credit Hours: 3 + 0

Course Outline:

Review of Basic Algorithm, Congruence, Residue classes and Euler's ϕ function, Linear Congruence and Congruence of higher degree, the theorem of Fermat's, Euler and Wilson's. Primitive roots and indices, Integers belonging to a given exponent, composite module, Indices, Quadratic Residues, Composite module, Legendre Symbols, laws of Quadratic reciprocity, the Jacobi symbol, Number theoretic functions, Mobius functions, Diophantine equation and Fermat's conjecture, for $N = 2,\ N = 4$, Algebraic number and integers, Units and primes R (V) Ideals, Arithmetic of Ideals, the norm of a prime Ideals, Unit of Algebraic number field. Applications to Rational Number Theory, Equivalence and Class number Cyclotomic field K. Fermat's equations, Kummer's Theorem, Pure Cubic field, Distribution of primes and Riemann function, the prime number theorem.

Recommended Books:

- W. J. Leveque, Topics in Number Theory Vol: I and II
- Hardy and Wright, Number Theory, Clarendon presses
- E. W. Grass, Topics from the theory of Numbers
- Niven, S. Herbert, Zuckerman and L. Hugh Montgomery, An Introduction to the Theory of Number
- K. C. Choudhary, A First Course in Number Theory, Asian Book Private Limited
- T. Koshy, Elementary Number Theory with Applications, Academic Press
- H. Rosen, Elementary Number Theory and its Applications

Annexure C1

Item No: 03

MPhil /MPhil leading to PhD/PhD Program in Mathematics

Degree Awarded: MPhil/PhD in Mathematics

Marks Breakdown for Courses

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

MPhil in Mathematics

Degree Awarded: Master of Philosophy in Mathematics

Entrance Requirements: Master in Mathematics or equivalent with at least 45% marks

Total Credit Hours: 24+6

SCHEME OF STUDIES
(Semester-Wise Breakdown)

1th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
1	MCC-701	Graph Theory	100	3(3-0)
2	MCC-702	Ordinary Differential Equations	100	3(3-0)
3	MCC-703	Applied Dimensional Analysis and Modeling	100	3(3-0)
4	MCC-704	Advanced Real Analysis	100	3(3-0)
Total			**400**	**12**

2th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
5	MPC/MAC	Elective-I	100	3(3-0)
6	MPC/MAC	Elective-II	100	3(3-0)
7	MPC/MAC	Elective-III	100	3(3-0)
8	MPC/MAC	Elective-IV	100	3(3-0)
Total			**400**	**12**

MPhil leading to PhD in Mathematics

Degree Awarded: Doctor of Philosophy in Mathematics

Entrance Requirements: Master in Mathematics or equivalent with at least 45 % marks

This program will be governed by University of Malakand MPhil/PhD By-laws

SCHEME OF STUDIES
(Semester-Wise Breakdown)

1th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
1	MCC-701	Graph Theory	100	3(3-0)
2	MCC-702	Ordinary Differential Equations	100	3(3-0)
3	MCC-703	Applied Dimensional Analysis and Modeling	100	3(3-0)
4	MCC-704	Advanced Real Analysis	100	3(3-0)
Total			**400**	**12**

2th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
5	MPC/MAC	Elective-I	100	3(3-0)
6	MPC/MAC	Elective-II	100	3(3-0)
7	MPC/MAC	Elective-III	100	3(3-0)
8	MPC/MAC	Elective-IV	100	3(3-0)
Total			**400**	**12**

3rd Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
9	MPC/MAC	Elective-I	100	3(3-0)
10	MPC/MAC	Elective-II	100	3(3-0)
11	MRR-000	-----	100	3(3-0)
Total			**300**	**9**

4th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
12	MPC/MAC	Elective-I	100	3(3-0)
13	MPC/MAC	Elective-II	100	3(3-0)
14	MRR-000	-----	100	3(3-0)
Total			**300**	**9**

PhD in Mathematics

Degree Awarded: Doctor of Philosophy in Mathematics

Entrance Requirements: MPhil/ MS in Mathematics with at least 3 CGPA

This program will be governed by University of Malakand MPhil/PhD By-laws

SCHEME OF STUDIES
(Semester-Wise Breakdown)

1th Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
1	MPC/MAC	Elective-I	100	3(3-0)
2	MPC/MAC	Elective-II	100	3(3-0)
3	MRR-000*	-----	100	3(3-0)
Total			**300**	**9**

2nd Semester

S. No.	Course Code	Course Title	Marks	Credit Hours
	MPC/MAC	Elective-I	100	3(3-0)
	MPC/MAC	Elective-II	100	3(3-0)
	MRR-000*	-----	100	3(3-0)
Total			**300**	**12**

*Note: Reading and Research courses will be offered by the research supervisor to PhD scholars related to his field of interest.

NOTE:

MCC means Mathematics Compulsory Course
MAC means Mathematics Applied Course
MPC means Mathematics Pure Course
MRR means Mathematics Reading and Research

ELECTIVE COURSES

S. No	Course Code	Course Name	Credit hours
1	MAC-801	Dynamical Systems and Ergodic Theory	03
2	MAC-802	Numerical Methods	03
3	MAC-803	Mathematical Modeling in Physical Sciences	03
4	MAC-804	Methods of Mathematical Physics	03
5	MAC-805	Dynamic Systems and Control Theory	03
6	MAC-901	Nonlinear Dynamics and Nonlinear Waves Phenomena	03
7	MAC-902	Advanced Optimization Theory	03
8	MAC-903	Dynamical System Theory	03
9	MAC-904	Biomechanics	03
10	MAC-905	Applied Numerical Analysis	03
11	MAC-906	Mathematical Biology	03
12	MAC-907	Computational Fluid Dynamics	03
13	MAC-908	Fractional Differential Equations	03
14	MPC-951	Graph Labeling	03
15	MPC-952	AG-groupoids and AG-groups	03
16	MPC-953	Lebesgue Spaces with Variable Exponent	03
17	MPC-954	Ring Theory	03
18	MPC-955	Advanced Measure Theory	03
19	MPC-956	Metric Fixed Point Theory	03
20	MPC-957	Semigroup Theory	03
21	MPC-958	Fuzzy Semigroups	03
22	MPC-959	Fuzzy Group Theory	03

MCC-701 GRAPH THEORY

Credit Hours: 3

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.

References:

- 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

MCC-702 ORDINARY DIFFERENTIAL EQUATIONS

Credit Hours: 3

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:

First Order of Differential Equations, Second Order Linear Equations, Linear Equations With Constant Coefficients, Power Series Solutions, Plane Autonomous Systems, Existence and Uniqueness Theorems, Approximate Solutions, Numerical Integration, Regular Singular Points, Strum-Liouville Systems, Expansions in Eigen Functions.

References:

- 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

MCC-703 APPLIED DIMENSIONAL ANALYSIS AND MODELING

Credit Hours: 3

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.

References:

- Applied Dimensional Analysis and Modeling by Thomas Szirtes Toronto, Ontario, Canada

MCC-704 ADVANCED REAL ANALYSIS

Credit Hours: 3

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 approxi-mation 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.

References:

- 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.

MAC-801 DYNAMICAL SYSTEMS AND ERGODIC THEORY

Credit Hours: 3

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

References:

- 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

MAC-802 NUMERICAL METHODS

Credit Hours: 3

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

References:

- 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

MAC-803 MATHEMATICAL MODELING IN PHYSICAL SCIENCES

Credit Hours: 3

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.

References:

- 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

MAC-804 METHODS OF MATHEMATICAL PHYSICS

Credit Hours: 3

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.

References

- 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

MAC-805 DYNAMIC SYSTEMS AND CONTROL THEORY

Credit Hours: 3

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.

References:

- 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

MAC-901 NONLINEAR DYNAMICS AND NONLINEAR WAVES PHENOMENA
Credit Hours: 3
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 weakly 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 weakly 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

MAC-902 ADVANCE OPTIMIZATION THEORY

Credit Hours: 3

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

MAC-903 DYNAMICAL SYSTEM THEORY

Credit Hours: 3

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, weakly nonlinear and strongly nonlinear dynamical systems. Applying this to models from various fields.

Course Outlines:

Linear Systems: 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

References:

- 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

MAC-904 BIO-MECHANICS

Credit Hours: 3

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.

References:

- Biomechanics Mechanical Properties of Living Tissues Second Edition By Y. C. Fung Department of Bioengineering University of California USA.

MAC-905 APPLIED NUMERICAL ANALYSIS

Credit Hours: 3

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.

References:

- 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.)

MAC-906 MATHEMATICAL BIOLOGY

Credit Hours: 3

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.

References:

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

MAC-907 COMPUTATIONAL FLUID DYNAMICS

Credit Hours: 3

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.

References:

- Computational Fluid Dynamics: Principles and Applications By J. Blazek AlstomPower Ltd.,Baden-Daettwil, Switzerland.
- Principles of Computational Fluid Dynamics By Pieter Wesseling Faculty of Information Technology and Systems Delft University of Technology Netherlands.

MAC-908 FRACTIONAL DIFFERENTIAL EQUATIONS

Credit Hours: 3

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:
Special Functions of the Fractional Calculus, Fractional Derivatives and Integrals, Existence and Uniqueness Theorems, The Laplace Transform Method, Fractional Green's Function, Other Methods for the Solution of Fractional-order Equations, Numerical Evaluation of Fractional Derivatives, Numerical Solution of Fractional Differential Equations, Fractional-order Systems and Controllers, Survey of Applications of the Fractional Calculus.

References:

- An Introduction to Fractional Derivatives, Fractional Differential Equations, by Igor Podlubny Technical 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 Ross University of New Haven.

MPC-951 GRAPH LABELING

Credit Hours: 3

Course Outlines:
Introductory Concepts, Basic definitions and examples, types of graph labeling, Graceful and Harmonious labeling, Magic labeling, Bandwidth labeling, definition and examples, The Cost of a Labeling, Bandwidth in Terms of Adjacency Matrices, Characterizing Bandwidth via Power of the Path Graph, Planarity and Bandwidth of Graphs, Density of a Graph and Bandwidth, Bandwidth of a graph under Edge Addition, Bandwidth of Graphs under graph operations, Bandwidth of Graph Products, Bandwidth Labeling of the Product of two Paths, Bandwidth of Lattice Graphs on a Fan, Bandwidth of Lattice Graphs on a cone, Bandwidth of Classes of Graphs, Bounding and Tight Bounding functions for graphs, Bandwidth of Triangular Grids, Bandwidth Binary Trees, Bandwidth of Mobius Graphs

References:

- A dynamic survey of graph labelling by Joseph A. Gallian
- Handbook of graph theory by Jonathan L Gross, Columbia University, New York, USA
- Graph theory III by Reinhard Diestel, Electronic Edition

MPC-952 AG-GROUPOIDS AND AG-GROUPS

Credit Hours: 3

Course outlines:
Introduction, examples and basic results of AG-groupoids (LA-semigroups), connection with other algebraic structures, Medial and exponential properteis, LA-semigroups definied by commutative inverse semigroups, Homomorphism theorems for LA-semigroups, classes of AG-groupoids, concept of AG-groups, definition and basic properties of AG-groups, enumeration of AG-groups, cancellativity in AG-groups, cosets of AG-subgroups, commutators in AG-groups, normality in AG-groups, application of AG-groups, AG-groups as parallelogram space.

References:

- Fundamentals of Semigroup Theory John M. Howie
- A First course in Abstract Algebra, by G, B. Fraleigh
- Contemporary Abstract Algebra, by J. A. Gallian
- The Algebraic Theory of Semigroups, by A. H. Clifford, Volume I & II

MPC-953 LEBESGUE SPACES WITH VARIABLE EXPONENT

Credit Hours: 3

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, Weak type estimates, Necessary Conditions for the boundedness, Weighted Lebesgue Space, One-sided Potentials.

References:

- 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

MPC-954 RING THEORY

Credit Hours: 3

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 very 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.

References:

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

MPC-955 ADVANCED MEASURE THEORY

Credit Hours: 3

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.

References:

- 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

MPC-956 METRIC FIXED POINT THEORY

Credit Hours: 3

Specific Objective of the Course:

This Course plays an important role in the applied sciences as well as in Mathematics itself. This Course introduce the students to the basics of the field at an early stage of study, also it familiarize the reader with the basics concepts and principle of fixed points and its applications.

Course Outlines:

The Banach contraction principle, Sequence of maps and fixed points, Fixed points of non-expensive maps ,Application of fixed point theory, The implicit function theorem, Introduction to metric fixed point theory, Caristi-Ekeland Principle, Ultrametric Spaces, Some Examples, ODE and Integral Equations, Cantor and Fractal sets, Metric fixed point theory in Banach Spaces, Cone Metric Spaces, Metric fixed point theory in Hyperconvex spaces, Some basic properties of hyperconvex spaces, Generalized metric spaces. Weak contraction.

References:

- E. Kreyszig, Introductory Functional Analysis With Applications, John Wiley
- Vittorino Pata, Fixed Point Theorem and Applications
- M. A. Khamsi, Introduction to Fixed Point Theory

MPC-857 SEMIGROUP THEORY

Credit Hours: 3

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 Tn 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.

References:

- 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 & II

MPC-958 FUZZY SEMIGROUPS

Credit Hours: 3

Specific Objective of the Course:

At the end of the course the readers will be able to know about fuzzy subsemigroups and fuzzy ideals of a semigroup: can provide examples related to the course content as well. This course also helps to understand fuzzy coding theory, fuzzy finite state machines and fuzzy languages.

Course Outlines:

Introduction, fuzzy ideals, regular semigroups, semilattices of groups, fuzzy congruences on semigroups, fuzzy congruences on T^*-pure semigroups, fuzzy codes on free monoids, generalized state machine, regular fuzzy expressions.

References:

- J. N. Mordeson, S. M. Davender and N. Kuroki, Fuzzy Semigroups
- H.T. Nguyen and A. W. Elbert, A first Course in Fuzzy Logic
- D. Dubois and H. Prade, Fuzzy Sets and Systems: Theory and Applications

MPC-959 FUZZY GROUP THEORY

Credit Hours: 3

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, commutator, 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.

References:

- 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