BS MATHEMATICS CURRICULUM

FOR

FALL 2023 AND ONWARD

WOMEN UNIVERSITY MARDAN

Mathematics is an exciting and challenging subject which continues to develop at a rapid rate across many research areas in science and engineering. It has natural elegance and beauty. Mathematicians are making a lasting contribution to the sciences by developing models and solution methods in diverse fields such as physics, engineering, R&D organizations, computer sciences, machines learning & data sciences, medicine, management, psychology, and social sciences. The generic nature of mathematics means that almost all industries require graduates with analytical and quantitative skills in mathematics.

The Department of Mathematics provides services to the entire Institute, from undergraduate students to graduate students in Mathematics.

Introduction

The Department of Mathematics is established in October, 2021. It is a new department which starts BS program in the subject of Mathematics. The mission of the Department is to enhance the research skills of the creative minds through active involvement in the research oriented activities. The department has qualified and experienced teachers who are devotedly inculcating in the students, the zeal, spirit and determination necessary to compete with the new scientific challenges in every walk of life.

Vision

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

Mission

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

Scheme of Studies for BS Mathematics

BS Mathematics is a 123 credit hours' program of studies spread over eight semesters. The Domains and the number of courses and their credit hours assigned to these domains are as follows.

Domains	**Number of Courses**	**Number of Credit Hours**
General Courses	12	30
Interdisciplinary	04	12
Major Disciplinary Specific	25	75
Field Experience	01	03
Capstone Project	01	03
Total CHrs		123

WOMEN UNIVERSITY MARDAN

Undergraduate Scheme of Studies (New Policy-2023)
BS MATHEMATICS

Course Code	Course Name	Credit Hours	General Education Course /Major/Interdisciplinary
Semester-I			
	Entrepreneurship	02	General Education Course
	Introduction to Economics	02	General Education Course
	Functional English	03	General Education Course
	Islamic Studies	02	General Education Course
	Civic and Community Engagement	02	General Education Course
MTH-311	Calculus-I	03	Major Disciplinary Specific
MTH-312	Elements of Set Theory and Mathematical Logic	03	Major Disciplinary Specific
Semester Credit Hours		**17**	
Semester-II			
	Everyday Science	3(2+1)	General Education Course
	Expository Writing	03	General Education Course
	History of Islamic civilization	02	General Education Course
	Ideology and Constitution of Pakistan	02	General Education Course
	Application of Information and Communication Technology	3 (2+1)	General Education Course
MTH-321	Calculus-II	03	Major Disciplinary Specific
Semester Credit Hours		**16**	
Semester-III			
	Introduction to Statistics	03	Interdisciplinary
MTH-433	Exploring Quantitative Skills (QR-I)	03	General Education Course
	Mechanics	03	Interdisciplinary
MTH-431	Calculus-III	03	Major Disciplinary Specific
MTH-432	Discrete Mathematics	03	Major Disciplinary Specific
Semester Credit Hours		**15**	
Semester-IV			
MTH-444	Tools for Quantitative Reasoning (QR-II)	03	General Education Course
	Electricity and Magnetism	03	Interdisciplinary
MTH-441	Group Theory	03	Major Disciplinary Specific
MTH-442	Number Theory	03	Major Disciplinary Specific
MTH-443	Vector Analysis	03	Major Disciplinary Specific
Semester Credit Hours		**15**	
Semester-V			
	Probability and Statistics	03	Interdisciplinary
MTH-551	Real Analysis-I	03	Major Disciplinary Specific
MTH-552	Ordinary Differential Equations	03	Major Disciplinary Specific
MTH-553	Computing Tools	03	Major Disciplinary Specific
MTH-554	Linear Algebra	03	Major Disciplinary Specific
Semester Credit Hours		**15**	
Semester-VI			
MTH-561	Real Analysis-II	03	Major Disciplinary Specific
MTH-562	Partial Differential Equations	03	Major Disciplinary Specific

MTH-563	Numerical Analysis-I	03	Major Disciplinary Specific
MTH-564	Differential Geometry	03	Major Disciplinary Specific
MTH-565	Topology	03	Major Disciplinary Specific
Semester Credit Hours		**15**	
Semester-VII			
MTH-671	Classical Mechanics	03	Major Disciplinary Specific
MTH-672	Complex Analysis	03	Major Disciplinary Specific
MTH-673	Numerical Analysis-II	03	Major Disciplinary Specific
MTH-674	E1	03	Major Disciplinary Specific
	Field Experience	03	
Semester Credit Hours		**15**	
Semester-VIII			
MTH-681	Mathematical Methods	03	Major Disciplinary Specific
MTH-682	Functional Analysis	03	Major Disciplinary Specific
MTH-683	Mathematical Statistics	03	Major Disciplinary Specific
MTH-684	E2	03	Major Disciplinary Specific
	Capstone Project	03	Major
Semester Credit Hours		**15**	
Total Credit Hours		**123**	

LIST OF GENERAL EDUCATION COURSES

Course Category	S. No.	Course Title	Credit Hours
HEC Model Courses	1.	Islamic Studies	2(2+0)
	2.	Ideology and Constitution of Pakistan	2(2+0)
	3.	Functional English	3(3+0)
	4.	Expository Writing	3(3+0)
	5.	Civic and Community Engagement	2(2+0)
	6.	Entrepreneurship	2(2+0)
	7.	Application of Information and Communication Technology	3(2+1)
Arts and Humanities	1.	Arabic	2(2+0)
	2.	Urdu	2(2+0)
	3.	History of Islamic civilization	2(2+0)
	4.	Ancient Indian History	2(2+0)
	5.	History of Muslim Rule in India	2(2+0)
Quantitative Reasoning	1.	QR-I---Exploring Quantitative Skills	3(3+0)
	2.	QR-II----Tools for Quantitative Reasoning	3(3+0)
Social Sciences	1.	Principles of Political Science	2(2+0)
	2.	Principles of International Relations	2(2+0)
	3.	Introduction to Economics	2(2+0)
	4.	Introduction to Sociology	2(2+0)
	5.	Introduction to Psychology	2(2+0)
	6.	Introduction to Management Sciences	2(2+0)
	7.	Introduction to accounting	
Natural Sciences	1.	Introduction to Botany	3(2+1)
	2.	Everyday Science	3(2+1)
	3.	Biological Physics	3(2+1)
	4.	Chemistry I	3(2+1)
	5.	Chemistry II	3(2+1)
	6.	Introduction to Physics	3(3+0)
	7.	Introduction to Microbiology	3(2+1)
	8.	Introduction to Zoology	3(2+1)
	9.	Introduction to Biochemistry	3(2+1)
	10.	Introduction to Biotechnology	3(2+1)

Elective Courses for BS Mathematics

- Rings and Fields
- Fluid Mechanics
- Algebraic Topology
- Galois Theory
- Electromagnetism
- Modeling and Simulations
- Measure Theory
- Projective Geometry
- Riemannian Geometry
- General Relativity
- Mathematical Modeling
- Axiomatic Set Theory
- Dynamical Systems
- Computational fluid dynamics
- History of Mathematics
- Pointless Topology
- Quantum Mechanics
- Lie Groups and Lie Algebra
- Introduction to Econometrics
- Module Theory
- Graph Theory
- Special Relativity
- Optimization Theory
- Category Theory
- Convex Analysis
- Advanced Group Theory

BS 1st

Semester-I			
Course Code	**Course Name**	**Credit Hours**	**General Education Course /Major/Interdisciplinary**
	Entrepreneurship	02	General Education Course
	Introduction to Economics	02	General Education Course
	Functional English	03	General Education Course
	Islamic Studies	02	General Education Course
	Civic and Community Engagement	02	General Education Course
MTH-311	Calculus-I	03	Major Disciplinary Specific
MTH-312	Elements of Set Theory and Mathematical Logic	03	Major Disciplinary Specific
Semester Credit Hours		**17**	

BBA-322 Entrepreneurship Credit Hours 02

COURSE OBJECTIVE

With more than half of the new jobs being created in the world economy by small businesses, the particular problems and experiences encountered in starting and developing new enterprises are clearly worth studying. This course of Entrepreneurship has been designed to provide the participants with an overall understanding of the concept of entrepreneurship and small business management. Participants will be prepared to start, survive, and succeed in their own businesses.

COURSE CONTENT

Week 1	Entrepreneurship: an evolving concept Entrepreneurship – a perspective
Week 2	The Role of Entrepreneurship Kinds of Entrepreneurs Role and Functions of Entrepreneurs
Week 3	Understanding strategic issues in business plan development
Week 4	Pitfalls in selecting new ventures
Week 5	Innovation: the creative pursuit of ideas Opportunity identification: the search for new ideas
Week 6	Reason for failures of new ventures
Week 7	Legal challenges for entrepreneurial ventures
Week 8	Sources of capital for entrepreneurial ventures
Week 9	**Mid-Term Examination**
Week 10	Assessment of entrepreneurial plan
Week 11	Marketing challenges for entrepreneurial ventures

Week 12	Developing an effective business plan
Week 13	Strategic entrepreneurial growth
Week 14	Problems Faced by Newly Established Company Post and Field Problems Faced by a New Enterprise
Week 15	Franchising and the Entrepreneur
Week 16	**Final-Term Examination**

Recommended Books:

- Small Business Management:Entrepreneurship and Beyond, Timothy S. Hatten.South-Western, Cengage Learning
- Norman M. Scarborough., Essentials of Entrepreneurship and Small Business Management.Pearson Education
- Donald F. Koratko , Entrepreneurship –Theory Process Practice (10th Edition), South Western -Cengage Learning.
- David L. Kurtz& Louis E. Boone, Contemporary Business (latest edition).
- Philip Kotler &Gary Armstrong, Principles of marketing (latest edition).
- Any Other Resources such as: Internet and Resource Notes and Modules
- Local and international newspapers and financial journals

INTRODUCTION TO ECONOMICS

Course Code: ECON-301 **Credit hour: 2 hours**

Objectives:

- Students will be able to identify and explain economic concepts and theories related to the behavior of economic agents, markets, industry and firm structures, legal institutions, social norms, and government policies.
- Students will be able to evaluate the consequences of economic activities and institutions for individual and social welfare.
- Students will be able to identify the basic features of alternative representations of human behavior in economics.
- Students will be able to identify the determinants of various macroeconomic aggregates such as output, unemployment, inflation, productivity and the major challenges associated with the measurement of these aggregates.

- Students will be able to discuss the linkages between financial markets and the real economy, and how these linkages influence the impact of economic policies over differing time horizons.

Nature and Scope of Economics

Introduction to

- Economy
- Human wants
  - Necessities
  - Comforts
  - Luxuries
- Utilities
- Scarcity
- Resources
- Goods and commodities
- Services
- Definitions by Adam Smith, Marshall, Robbins & Modern view of Economics

Branches of Economics

Main two branches of Economics

- Micro Economics

  Definition, Explanation & Significance of Micro Economics
- Macro Economics

  Definition, Explanation &Significance of Macro Economics

Consumer Behavior

- Cardinal Analysis
- Definition of Utility Approach
- Explanation of total Marginal and Average Utility
- Consumer's equilibrium

Ordinal Analysis

- Definition
- Explanation of indifference curve and Budget line
- Properties of indifference curve
- MRTS
- Budget Line
- Slope of Budget Line
- Consumer's Equilibrium

Law of Demand

- Demand, want and wish
- Law of Demand
- Changes/Shifts in Demand Curve

- Rise and fall in Demand
- Contraction and extension in quantity Demand
- Equation of Demand

Law of Supply

Supply

- Difference between supply and stocks
- Law of Supply
- Changes/Shifts in Supply
  - Rise and fall
  - Extension and contraction
- Equation of Law of Supply

Elasticity

- Definition of Elasticity
- Measurement of Elasticity
- Point Elasticity
- Arc Elasticity

➢ Kinds of Elasticity of Demand

- Price Elasticity of Demand
- Income
- Cross Price

Market Equilibrium

- ➢ Definition of Market Equilibrium
- ➢ Determination of Market Price by Demand and Supply Curve
- ➢ Disequilibrium in Market Condition
  - Surplus
  - Shortage
- ➢ Changes in Demand Conditions
- ➢ Changes in Supply Conditions
- ➢ Effects on Market Equilibrium

Macro Economics

- ➢ National Income
- ➢ National Accounting
- ➢ National Income Concepts
  - GDP
  - GNP
  - NNP
  - National Income at factor prices
  - Personal Income

Circular Flow of Income

- Definition of Circular flow of Income
- Production side
- Consumption side
- Money flow
- Goods flow
- Circular flow of income in 2- section economy

Banks

- Definition of Bank
- Kinds of Banks
  - Central Bank
  - Commercial Bank
  - Specialized Banks
- Industrial Banks
- Agriculture Banks
- Saving Banks
- Investment Banks

Commercial Banks

- Definition of Commercial Banks
- Function of Commercial Banks
- Importance of a Central Bank and Commercial Bank in an economy

Central Bank

- Definition of Central Bank
- Function of a Central Bank
  - Primary Functions
  - Secondary Functions
  - Importance of a Central Bank and Commercial Bank in an economy

Inflation

- Definition of Inflation
- Causes of Inflation
- Types of Inflation
  - Demand Pull Inflation
  - Cost Push Inflation
- Effects of Inflation
  - Adverse Effects
  - Favorable Effects
- Deflation (Short Review)

Balance of Payment (BOP)

- Definition of BOP
- Balance sheet of BOT
  - Current Account

- ❖ Capital Account
- ❖ Financial Account

➢ Disequilibrium in BOP

- ❖ Surplus
- ❖ Deficit

Text Books and Supplies:

1. Mankiw, "Principles of Economics" 7th Edition, (2008), south west publishers.
2. Miller, R.L. Economics Today. 14th Edition (2005) Addison Wesley.
3. Shapiro, E. Macroeconomic Analysis. Galgotia Publications (Latest Edition).
4. Dornbusch, R. & Fisher, S. Macro Economics. McGraw Hill, International Latest Edition.

Supplemantary Material:
Samuelson Nordons, Economics. 18th Edition (2004), McGraw Hill, Inc.
Mc Connell and Bruce, Principles of Economics. 17th Edition, (2006) McGraw Hill, Inc.

ENG-301 Functional English Credit hours:03

Course Description:

This course introduces the students with the basic grammatical / structural rules of English Language. It will help the students in improving their basic Language Skills to an optimum level so as to enable them to communicate effectively in English language through proper usage of vocabulary & knowledge of English grammar.

Outcomes:

1. Students will be familiarized with the technical methods of reading / comprehension.
2. They will be exposed to different reading materials, which will help them in improving their vocabulary, grammar and sentence structure etc.
3. The experience of this course will also help them to overcome those problems due to which they are unable to express themselves properly Parts of Speech

Course Contents:

- Vocabulary (Frequently confused / misused words,
- Phrases,
- synonyms,
- antonyms,
- idioms & General vocabulary),

- Practical Use of Grammar (Nouns, Pronouns, Verbs, Adjectives, Adverbs, Prepositions, Conjunctions, Articles, Interjections & Tenses),
- Sentences (Types of sentences, Parts of sentences),
- Direct and Indirect Speech,
- Active & Passive Voice & Conditional Sentences),

Recommended Books:

1. High School English Grammar & Composition by Wren and Martin.
2. Practical English Grammar by A.J. Thomson &A.V. Martinet. Exercises 1 & 2. 3rdedition. Oxford University Press.
3. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand& Francoise Grellet. Oxford Supplementary Skills. 4thImpression 1993.4.Reading. Upper Intermediate. Brian Tomilson& Rod Ellis. Oxford Supplementary Skills. 3rdImpression 1992.
4. Précis writing by R. Dhillon.
5. Systems Student Companion English for lower secondary schools by Magdalene Chew &Surinder Kaur.

ISL-301 Islamic Studies Credit Hours 2

Aims and Objectives

The course is aimed

- To learn about Islam and its application in day to day life.
- To provide basic information about Islamic studies.
- To improve students skill to perform prayers and other worships.
- To enhance the skills of the students for understanding of issues related to faith andreligious life.

Course outline

- Holy Quran
- Sunnah
- Fundamentals Doctrine of Islam
- Life of Holy Prophet

- Islamic Economic system
- Islam and science
- Political system of Islam
- Social System of Islam
- Introduction to Islamic law and jurisprudence
- Islamic culture and civilization

Recommended Books

1. Hafiz Ahmed Yar, Madhamin.e.Quran
2. Prof. Arif Naseem, Islamiat for degree classes.
3. Hameed Ullah Muhammad, Introduction of Islam.
4. Islamiat, Compulsory for degree classes Published by Allama Iqbal University.
5. Syed Suleman Nadvi, Nabi Rehmat (P.B.U.H).

PSC-301 Civic and Community Engagement 02

Learning Outcomes:

- Understand, critically think about, and reflect upon the history of democracy and civic engagement in the Pakistan.
- Identify and utilize - civic/community engagement skills such as: (advocacy, organizing, communications) and knowledge- (working in groups and teams, leadership, diversity, how systems work)
- Create civic sense and establish importance of civic and community engagement.
- Identify and explain the values and ethics for community engagement.
- Carry out a civic engagement activity incorporating some of their new knowledge and skills of civic engagement and reflect on their learning about the community, the issue addressed, and about themselves.

Course Contents-

Divided into categories for in-depth comprehension-

Category A: General

1. The historical background of civic and community engagement
2. Conceptual understanding of Human Rights and Minority Rights
3. Dimensions of Citizens engagement in Community: Political, Social, Economic
4. Rights and duties of Citizens in Community
5. Organizations (National & International) and Groups

6. Role of non-governmental organizations and their contributions
7. NGOs: Nature and Scope
8. International Commission for Red Cross (ICRC)
9. Amnesty International
10. Asia Watch

Category B: Pakistan's context

1. Role of Citizens in Governance of Pakistan
2. Democratic Accountability and Civic Engagement
3. Enhancement of leadership skills among women and youth of Pakistan through civic community engagement programs

Recommended Books

1. Hoefer, R. (2012). Advocacy
2. for Practice. 3rd Edition. Chicago, IL: Lyceum Books, Inc. (ISBN-13: 978-1935871828)
3. Putnam, R. and Feldstein, L (2003). Better Together. New York, NY: Simon and Schuster. (ISBN-13: 978-0743235471)
4. Civic Engagement—What Is It and Why Is It Important? Kerry J. Kennedy
5. Universal Human Rights in Theory and Practice by Jack Donnelly
6. Adamantia Pollis and Peter Schwab, Human Rights Cultural and Ideological Perspectives. Preager Publishers, Preager Publishers, London, 1980.
7. Promoting and Protecting Minority Rights- A Guide for Advocates by United Nations.
8. Human Rights in International Law, Council of Europe press, 1992.
9. United Nations, Human Rights Status of International Instruments, United Nations, Baltimore, New York, 1987.

Calculus-I	**Credit Hours (3)**

Prerequisites: Knowledge of Intermediate Calculus

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

Course Outline:

Equations and Inequalities: Solving linear and quadratic equations linear inequalities, division of polynomials, synthetic division, Roots of a polynomial, rational roots, Viete relations, Descartesrule of signs. Solutions of equations with absolute value sign, Solution of linear and non-linear inequalities with absolute value sign.

Functions and Graphs: Domain and range of a function examples polynomial, rational, piecewise defined functions, absolute value functions, and evaluation of such functions. Operations with functions: sum, product, quotient and composition Graphs of functions: linear, quadratic, piecewise defined functions,

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

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

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

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

Real life applications of derivatives

Recommended Books:

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

A. Kaseberg, "*Intermediate Algebra",* Thomson Brooks/cole, 2004

Elements of set theory and Mathematical logic	**Credit Hours (3)**

Prerequisites: Knowledge of Intermediate Mathematics

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

Course Outline:

Set theory: Sets, subsets, operations with sets: union, intersection, difference, symmetric difference, Cartesian product and disjoint union. Functions: graph of a function, Composition, injections,

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

Recommended Books:

1. M. Liebeck, "*A Concise Introduction to Pure Mathematics",* CRC Press, 2011.
2. N. L. Biggs, " *Discrete Mathematics",* Oxford University Press, 2002. 3
3. R. Gamier, J. Taylor, "*Discrete Mathematics",* Chapters 1,3,4,5,CRC Press, 2010
4. A.A. Fraenkal, "*Abstract Set Theory",* North-Holland Publishing Company, 1966.5 . P. Suppes, "*Axiomatic Set Theory",* Dover Publication, 1972.
6 . P.R. Halmos, "*Naive'Set Theory",* New York, Van Nostrand, 1950.
7. B. Rotman, G.T. Kneebone, "*The Theory of sets and Transfinite Numbers",* old bourne London.1968.
8. D. Smith, M. Eggen, R.St. Andre, "*A Transition to Advanced Mathematics",* Books/Cole, 2001.

BS 2nd

Semester-II			
	Everyday Science	3(2+1)	General Education Course
	Expository Writing	03	General Education Course
	History of Islamic civilization	02	General Education Course
	Ideology and Constitution of Pakistan	02	General Education Course
	Application of Information and Communication Technology	3 (2+1)	General Education Course
MTH-321	Calculus-II	03	Major Disciplinary Specific
Semester Credit Hours		**16**	

Everyday Science

SCI-121 **Credit Hours: 03**

Objectives:

The aims of the teaching and study of sciences are to encourage and enable students to: develop inquiring minds and curiosity about science and the natural world.

Course Outline

1. **Biological Sciences**

The Basis of Life: Cell Structures and Functions (Subcellular Organelles such as Nucleus, Mitochondria and Ribosomes).

Biomolecules: Proteins, Lipids, Carbohydrates, Fats and Enzymes.

Common diseases and Epidemics: Polio, Diarrhoea, Malaria, Hepatitis, Dengue their Causes and Prevention.

Environment and Pollution: The Atmosphere (Layered Structure and Composition), Hydrosphere (Water Cycle, Major Water Compartments), Biosphere (Major Biomes) and Lithosphere (Minerals and Rocks, Rock Types, Plate Tectonics).

Concept of Balance Diet: Vitamins, Carbohydrates, Protein, Fats and oil, Minerals, Fiber.

Quality of Food: Bioavailability of Nutrients, Appearance, Texture, Flavor, Quality of Packed and Frozen Food, Food Additives, Preservatives and Antioxidants

2. **Physical Science:**

Constituents and Structure: Universe, Galaxy, Light, Year, Solar System, Sun, Earth, Astronomical System of Units

Process of Nature: Solar and Lunar Eclipses, Rotation and Revolution, Weather Variables (Global Temperature, Pressure, Circulation, Precipitation, Humidity) and Weather Variations.

Nature Hazards and Disasters: Earthquake, Volcanic Eruption, Tsunami, Floods, Avalanche, Travelling Cyclone (Tropical Cyclone, Middle Latitude Cyclone and Tornadoes), Drought, Wildfire, Urban Fire. Disaster Risk Management.

3. **Chemistry:**

Atomic Structure: Chemical Bonding, Electromagnetic Radiations.
Modern Materials /Chemicals: Ceramics, Plastics, Semiconductors. Antibiotics, Vaccines, Fertilizers, Pesticides.
Communication: Basics of Wireless Communication (Mobile, Satellite, Surveillance and GPS and Fiber Optic etc.

Recommended Books:

- Exploring Life Science 1975 Walter A. Thurber, Robert E. Kilburn, Peter S. Howell.
- Food Science 1998 Norman N. Potter, Joseph H. Hotchkiss.
- Environmental Science: Systems and Solutions. 5th ed. 2013 Michael L. McKinney, Robert Schoch and Logan Yonavjak.
- Environmental Science: A Global Concern 2012 William P. Cunningham, Barbara Woodworth Saigo.
- Fundamentals of Telecommunications 2005 Roger L. Freeman.
- Exploring Life Science 1975 Walter A. Thurber, Robert E. Kilburn, Peter S. Howell
- Principles of Animal Biology 2011 Lancelot Hogben.
- Forensic Science Fundamentals & Investigation 2008 Anthony J. Bertino.
- Basics of Environmental Science 2002 Michael Allaby.
- Food Science 1998 Norman N. Potter, Joseph H. Hotchkiss.
- Environmental Science: Systems and Solutions. 5th ed. 2013 Michael L. McKinney, Robert Schoch and Logan Yonavjak.
- Environmental Science: A Global Concern 2012. William P. Cunningham, Barbara Woodworth Saigo.

ENG-302 Expository Writing C.Hour: 03

Course Description:

This course will introduce students to the basic principles of effective / skillful writing and will develop the understanding of the students on academic and technical writing skills. Students will understand and know how to follow the stages of writing process and will apply these to technical and workplace writing tasks. Students will learn how to incorporate clarity and utility in their writing, learn stylistic methods for effective writing and to be aware of ethical issues in technical writing. Also, Students will read, analyze, and interpret material from technical fields, and will practice research and writing skills appropriate for technical topics.

Outcomes:

- Students will be familiarized with basic sources and methods of research and documentation on topics including on-line research.

1. They will be able to synthesize and integrate material from primary and secondary sources wedded to their own ideas in research papers.

Course Contents:

- Topic sentence
- Paragraph writing:
- Essay writing:
- Introduction and Practice: Essay types: descriptive, narrative, discursive, argumentative.
- CV and job application
- Letter and memo writing
- Minutes of meetings
- Summary and précis writing
- Comprehension

Recommended Books:

1. Boutin, M.,& Brinand,S.,& Grellet, F. (1993). Oxford Supplementary Skills. Fourth Impression. Pages 45-53.
2. Nolasco, R. (1992). Oxford Supplementary Skills (3rd ed.). Fourth Impression.
3. Langan, J. (2004). *College Writing Skills*. Mc-Graw-Hill Higher Education.

ISL- 302 History of Islamic civilization C. Hour: 02

Objectives of the Course

1. Definition of Islamic Culture & Civilization
2. Analysis of the Rise and Fall of Islamic Culture in various parts of the World
3. A Critical Study of the Effect and benefits of Islamic Civilization on other Cultures

Course Description

	Title	Description
1	Introduction to civilization- 1 Important Civilization in the Pre-Islamic Era Important Civilization in the Pre-Islamic Era	Introduction of Civilization Foundation of Civilization Elements of Civilization
2	Principles of Islamic Civilization Foundations of Islamic Civilization in the Era of the Prophet (SAW) and the Caliphates	Greek Civilization Roman Civilization
3	Islamic Civilization in the era of Banu Ummayads- 1	Egypt Civilization Hindu Civilization
4	Islamic Civilization in the era of Banu Ummayads- 2 Islamic Civilization in the era of Banu Ummayads- 3	Pillars of Culture & Civilization
5	Islamic Civilization in the era of Abbasids- 1 Islamic Civilization in the era of Abbasids- 2	Reasons for the evolution of Islamic Civilization in the Era of the Prophet (SAW)

6	Islamic Civilization in the era of Abbasids- 3 Islamic Civilization in Spain Islamic Culture and Civilization in the Sub-Continent	Islamic Civilization in the Era of the Caliphates
7		Elements of Islamic Civilization in the era of Caliphates
8		Introduction of Banu Ummayads Intellectual development among the Banu Ummayads Educational Centers for the Banu Ummayads
9		Social developments of the Banu Ummayads Causes of the civilization development of the Banu Ummayads Results of the civilization development of the Banu Ummayads
10		Religious Movements in the era of Ummayads Internal Disputes in Ummayads era Reasons for the decline of the Ummayads
11		Beginning of Abbasid civilization Educational movements of the Abbasid period
12		Cultural development in the Abbasid period Social development in the Abbasid period A Comparative study of the Islamic Culture of Abbasids with other Civilization
13		Battles of Crusades Battlers of Tartarians The Causes of the Fall of the Abbasids and its Effects on Islamic Civilization
14		Causes of the spread of Islamic civilization in Spain Manifestations of Islamic civilization in Spain Influence of Islamic civilization in Spain on European civilization
15		Islamic civilization achievements in the Sub-Continent Reasons for the spread of Islamic cultural in Sub-Content
16.		The effects of the publication of Islamic civilization in the Sub-content on other civilization

Recommended Books

1. Muslim History and Civilization by Ehsan ul Karim
2. Islamic Religion History and Civilization, Seyyed Hossein Nasr
3. Tareekh-e-Islam Shah Nadvu Moin-ud-din
4. Islamic History by Dr. Kabeer Ali
5. An Atlas of Islamic History, H.W.Hazard
6. A Short History of Islam, S.F.Mehmood

7. تاریخ تمدن اسلامی، شاہ معین الدین ندوی
8. تاریخ اسلام، اکبر شاہ نجیب آبادی

PSC-302 Ideology and Constitutional Development of Pakistan 02

Learning Objectives

- To develop critical thinking for understanding Constitutional development in Pakistan;
- To develop understanding of the legal and constitutional structure of the state;
- To develop comprehension of the interconnectivity between the Constitutional provisions and political practice;
- To develop the understanding of students regarding ideological basis of Pakistan as well as role of ideology in building national character.

Contents of the Course

Course is divided into two sections to cover the maximum portion of the course.

Section A: Ideological understanding and development of Pakistan

1. Basis of Ideology of Pakistan and Two Nations Theory
2. Ideology of Pakistan: Vision of Quaide e Azam and Allama Iqbal
3. Role of ideology in building national character
4. Democratic system of Pakistan (Issues)
5. Major causes of the Imposition of martial Law (1958, 1969, 1977&1999).

Section B: Constitutional Development of Pakistan

6. Pakistan's Constitutional Development from 1947 onward.
7. An Overview of the Constitution of Pakistan (Features of 1973 Constitution).
8. Basic Concepts—Federalism and the 1973 Constitution.

9. Islam and the Constitution of Pakistan -1973.
10. Constitutional Amendments and Reforms- 1973.

Recommended Books:

1. Constitution of Pakistan
2. The Constitutional History of Pakistan—1947-2012, Malik Muhammad Owais Khalid, 2012
3. Constitutional History and Political Development, Hamid Khan, 2005
4. Constitutional Development in Pakistan, G.W. Chaudhary
5. Constitution Making in Pakistan 1947-85, Dr. Baz Muhammad
6. Allen Gledhill, Pakistan: The Development of its Laws and Constitution
7. "Military, State and Society in Pakistan" by Hasan Askari Rizvi, 2000.
8. Kazmi, Raza, Pakistan Studies, Karachi Oxford University Press.
9. Qureshi, I. H., A Short History of Pakistan, University of Karachi Press.
10. Qureshi, I. H., Struggle for Pakistan, University of Karachi Press.
11. Sayeed, K. B., Pakistan Formative Phase, National Book Service
12. Ziring, Lawrance, Pakistan in Twentieth Century: A Political History, London; Oxford University Press
13. Government and politics in Pakistan by Mushtaq Ahmad
14. Ideology and Dynamics of Politics in Pakistan by Muhammad Asif Malik.

CS-301 Applications of Information and Communication Technologies Credit Hours: 3 (2+1)

Course Content

- Brief history of Computers.
- Types of computers (Super, Mainframe, Mini and Micro Computer)
- Computer elements: Hardware, software, Storage Devices, Input Devices, Output Devices.
- Software: Operating Systems, Programming and Application Software.
- Introduction to Programming Languages.
- Databases and Information Systems.
- Data Communication and Networks.

- The internet: browsers and search engines.
- Email, collaborative computing, and social networking.
- E-commerce.
- IT Security and other issues.
- Use of Microsoft Office tools (MS Word, MS Powerpoint, MS Excel).

Recommended Books

1. Charles S. Parker, Understanding Computers: Today and Tomorrow, Course Technology, 25 Thomson Place, Boston, Massachusetts 02210, USA
2. Livesley, Robert Kenneth. An introduction to automatic digital computers. Cambridge University Press, 2017.
3. Zawacki-Richter, Olaf, and Colin Latchem. "Exploring four decades of research in Computers & Education." Computers & Education 122 (2018): 136-152.
4. Sinha, Pradeep K., and Priti Sinha. Computer fundamentals. BPB publications, 2010.
5. Goel, Anita. Computer fundamentals. Pearson Education India, 2010.
6. Introduction to Computers, Peter, N. McGraw-Hill

Calculus-II	**Credit Hours (3)**

Prerequisites: Calculus I

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

Course Outline:

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

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

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

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

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

Recommended Books:

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

BS 3rd

Semester-III			
	Introduction to Statistics	03	Interdisciplinary
MTH-433	Exploring Quantitative Skills (QR-I)	03	General Education Course
	Mechanics	03	Interdisciplinary
MTH-431	Calculus-III	03	Major Disciplinary Specific
MTH-432	Discrete Mathematics	03	Major Disciplinary Specific
Semester Credit Hours		**15**	

INTRODUCTION TO STATISTICS

COURSE DESCRIPTION/OBJECTIVE

The main objectives of the course are to enhance students‟ competency in application of statistics. Statistical analysis help to shape important decisions that have local, national, and global impacts. This discipline can offer insight and support in any situation where relevant data can be collected, analyzed, interpreted, and presented to work toward an effective resolution.

INDENTED LEARNING OUTCOMES

At the conclusion of this course, the student will be:

1. Data description and data presentation
2. Measures of Central Tendency
3. Measure of Relative Dispersion
4. Basic probability concepts
5. Sample Regression and Correlation

COURSE CONTENTS

INTRODUCTION

- Definition
- Descriptive Statistics & Inferential Statistics
- Statistics Applications in other fields
-

DATA CONDENSATION AND PRESENTATION

- Data and Data Classification
- Tabulation

- Data Array and Frequency Distribution
- Cumulative Frequency Distribution

DATA PRESENTATION

- Graphical Representation
- Pie Chart
- Frequency Bar Chart
- Frequency Histogram

MEASURES OF CENTRAL TENDENCY

- Means: (Arithmetic, Geometric, Harmonic)
- The Median
- The Mode

MEASURES OF DISPERSION FOR GROUPED ANDUNGROUPED DATA

- Range
- Mean absolute deviation
- Variance
- Standard Deviation

RANDOM EXPERIMENTS

- Sample Space
- Events
- Counting Sample Points

PROBABILITY DISTRIBUTION

- Basic concept
- Types of Probability Distribution.
- Random variables

SAMPLE REGRESSION AND CORRELATION

- Least-Squares estimates in Simple Linear Regression
- Standard Deviation of Regression
- Correlation
- Pearson Product Moment Correlation Coefficient

TEXT/REFERENCE BOOKS

1. David, S Moore et.al, Introduction to the Practice of Statistics, 6th Edition WH. Freeman.
2. Levin I. Richard., Statistics for Management, 4th ed; McGraw Hill.
3. Walpole, R, Introduction to Statistics, Edition 3.

4. Professor Sher M. Chaudhry, Introduction to Statistical Theory Part-1 & 2.

MTH-433	QR-I---Exploring Quantitative Skills	Credit Hours: 03

Specific Objectives of the Course:
Introduce students to importance of quantitative reasoning skills, history of mathematics and numbers inthe real World.

Course Outline:

- Different types of standard numbers and their operations.
- Understanding relationship between parts and whole
- Practical life scenarios involving parts & whole
- Money management (profit, loss, discount, zakat, simple interest, compound interest and taxation)
- Practical life scenarios involving units and rate, percentage, ratio, proportions
- Basic of Geometry (line, angles, circles, polygon etc)
- Golden ratio in sculptures
- Equating two expressions in one variable & using it to solve practical problems
- Sets and their operations, Venn diagrams
- Relations, Functions and their graphs
- Algebraic solution of quadratic equations and inequalities
- System of linear equations and their solutions
- Introduction to logic, prepositions, logical connectives, truth tables etc

Recommended Books:

- Bennett, J. & Briggs, W. (2015). Using and understanding mathematics (6th Edition). PearsonEducation, Limited.

http://xn--webducation-dbb.com/wp-content/uploads/2019/09/Jeffrey-Bennett-William-Briggs-Using-Understanding-Mathematics_-A-Quantitative-Reasoning-Approach-Pearson-2015.pdf

- Blitzer, R. (2014). Precalculus. (5th Edition). Pearson Education, Limited. https://www.ilearnacademy.net/uploads/3/9/2/2/3922443/precalculus edition_5f.pdf

PHY- 311 MECHANICS

Credit Hours: Four (3)

Objectives: The main objective of this course is to understand different motions of objects on 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, Inter-conversion of 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, 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 a disc, bar and solid sphere; Elasticity; Stress; Strain and Properties of Materials

Angular Momentum: Angular Velocity; Conservation of angular momentum; effect 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 Books:

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 9th ed. (2010).
2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed. (2010).
3. 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).
4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern, McGraw Hill, 2nd ed. (1992).
5. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4th ed., (2008).

Calculus-III	**Credit Hours (3)**

Prerequisites: Calculus-II

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

Course Outline:

Vectors and analytic geometry in space: Coordinate system, Rectangular, cylindrical and spherical coordinates, the dot product, the cross product, Equations of lines and planes, Quadric surfaces.

Vector-valued functions: Vector-valued functions and space curves. Derivatives and integrals of vector valued functions, Arc length Curvature, normal and binormal vectors.
Multivariable functions and partial derivatives: Functions of several variables, Limits and Continuity. Partial derivatives, Composition and chain rule, Directional derivatives and the gradient vector, Implicit function theorem for several variables, Maximum and minimum values, Optimization problems, Lagrange Multipliers.
Multiple integrals: Double integrals over rectangular domains and iterated integrals, Non-rectangular domains, Double integrals in polar coordinates. Triple integrals in rectangular, cylindrical and spherical coordinates, Applications of double and triple integrals. Change of variables in multiple integrals.
Vector calculus: Vector fields, Line integrals, Green's theorem, Curl and divergence, Surface integrals over scalar and vector fields, Divergence theorem, Stokes' theorem.

Recommended Books:

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

Discrete Mathematics	**Credit Hours (3)**

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

Course Outline:

Counting methods: Basic methods, product, inclusion-exclusion; formulae, Permutations and combinations Recurrence relations and their solutions, Generating functions, Double counting, Applications, pigeonhole principle, applications.
Relations: Binary relations, n-array Relations, Closures of relations, Composition of relations, inverse relation.
Graphs: Graph terminology, Representation of graphs, Graphs isomorphism. Algebraic methods: the incidence matrix, Connectivity, Eulerian and Hamiltonian paths, Shortest path problem, Trees and spanning trees. Complete graphs and bivalent graphs.

Recommended Books:

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

BS 4th

Semester-IV			
MTH-444	Tools for Quantitative Reasoning (QR-II)	03	General Education Course
	Electricity and Magnetism	03	Interdisciplinary
MTH-441	Group Theory	03	Major Disciplinary Specific
MTH-442	Number Theory	03	Major Disciplinary Specific
MTH-443	Vector Analysis	03	Major Disciplinary Specific
Semester Credit Hours		**15**	

QR-II----Tools for Quantitative Reasoning	**Credit Hours: 03**

Specific Objectives of the Course:
Introduce students to variables, sampling data and statistical approach in decision making.

Course Outline:

- Investigating relationships between variables
- Exploring tools to find relationship between variables
- Population and samples,
- Exploring and summarizing data
- Finding a representative value in a data
- Measure and spread of a data,measuring degree of relationship among variables
- Measure of central tendency, dispersion, data interpretation
- Basic probability theory
- Basics of estimation and confidence interval
- Testing hypothesis
- Statistical inferences in decision making
- Survey sampling

Recommended Books:

- Heumann, Christian, and Schomaker, Michael. Introduction to Statistics and Data Analysis: With Exercises, Solutions and Applications in R. Switzerland, Springer International Publishing, 2023.
- James, Gareth, et al. An Introduction to Statistical Learning: With Applications in R. Germany, Springer New York, 2013.
- Reid, Howard M.. Introduction to Statistics: Fundamental Concepts and Procedures of Data Analysis. United States, SAGE Publications, 2013.

PHY- 321 ELECTRICITY AND MAGNETISM

Pre-requisite: Mechanics

Credit Hours: Three (3)

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

Course Outline: Electrostatics: Electric Charge; Conductors and Insulators; Coulomb's Law; Electric Fields due to a Point Charge and an Electric Dipole; Electric Field due to Charge Distribution; Electric Dipole in an Electric Field; Electric Flux; Gauss' Law and its Applications in Planar; Spherical and Cylindrical Symmetry

Electric Potential: Equipotential Surfaces; Potential due to a Point Charge and a Group of Point Charges; Potential due to an Electric Dipole; Potential due to Charge Distribution; Relation between Electric Field and Electric Potential Energy

Capacitors and Capacitance: Parallel Plate; Cylindrical and Spherical capacitors; Capacitors in Series and Parallel; Energy Stored in an Electric Field; Dielectrics and Gauss' Law

DC Circuits: Electric Current and Current Density; Resistance and Resistivity; Ohm's Law; Power in Electric Circuits; Semiconductors and Superconductors; Work; Energy and EMF; Resistances in Series and Parallel; Single and Multi-loop Circuits; Kirchhoff's Rules; RC Circuits; Charging and Discharging of a Capacitor

Magnetic Field and Magnetic Force: Sources of Magnetic Field; Magnetic Force on a Moving Charge; Crossed Electric and Magnetic Fields and their Applications; Hall Effect; Magnetic Force on a Current Carrying Wire; Torque on a Current Loop; Magnetic Dipole Moment; Magnetic Field Due to a Current; Force between two Parallel Currents; Biot-Savart Law: Magnetic Field due to a Current, Long Straight Wire, Solenoids and Toroids, Ampere's Law; A Current-carrying Coil as a Magnetic Dipole; Inductance; Faraday's Law of Induction; Lenz's Law; Induction and Energy Transfer; Induced Electric Fields; Inductors and Inductance; Self Inductance; RL Circuits; Energy Stored in a Magnetic Field; Energy Density; Mutual Induction

Alternating Fields and Currents: LC Oscillations; Damped Oscillations in an RLC circuit; Alternating Currents; Forced Oscillations; Resistive, Capacitive, and Inductive Loads; RLC series Circuit; Power in AC Circuits; Transformers; Gauss' Law for Magnetism; Induced Magnetic Fields; Displacement Current; Spin & Orbital Magnetic Dipole Moment; Diamagnetism; Paramagnetism; Ferromagnetism and Hysteresis.

Recommended Books:

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 9th ed. (2010).
2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed., (2010).
3. 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).
4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern", McGraw Hill, 2nd ed., (1992).
5. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4th ed., (2008).

Group Theory	**Credit Hours (3)**
Prerequisites: Elements of Set Theory and Mathematical Logic **Specific Objectives of course:** This course introduces basic concepts of groups and their homeomorphisms. The main objective of this course is to prepare students for courses which require a good back ground in group theory like Rings and Modules, Linear Algebra, Group Representation, Galois Theory etc.	

Course Outline:

Groups, Cyclic groups, Cosets, Decomposition of a group, Permutation groups, Lagrange's theorem and its consequences, Normal subgroups, Homomorphism of groups, Quotient groups, Fundamental theorem of homomorphism, Isomorphism theorems, Conjugacy classes. Centralizers and normalizers, Permutation groups, Cayley's theorem. Endomorphism and automorphism of groups, Simple groups. (Definition and Examples).

Recommended Books:

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

Number Theory	**Credit Hours (3)**

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

Course Outline:

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

Recommended Books:

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

Vector Analysis	**Credit Hours (3)**

Prerequisites: Calculus-II

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

Course Outline:

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 spherical-polar and the cylindrical-coordinate.

Recommended Books:

1. Bourne DE, Kendall PC, "Vector Analysis and Cartesian Tensors", 2nd edition, Thomas Nelson
2. Shah NA, "Vector and Tensor Analysis", 2005 A-One Publishers, Lahore
3. Smith GD, "Vector Analysis", Oxford University Press, Oxford
4. Spiegel MR, "Vector Analysis", 1974, McGraw Hill, New York
5. M. Afzal Qazi, "A First Course on Vectors", West Pakistan Publishing Co. Lahore

BS 5th

Semester-V			
	Probability and Statistics	03	Interdisciplinary
MTH-551	Real Analysis-I	03	Major Disciplinary Specific
MTH-552	Ordinary Differential Equations	03	Major Disciplinary Specific
MTH-553	Computing Tools	03	Major Disciplinary Specific
MTH-554	Linear Algebra	03	Major Disciplinary Specific
Semester Credit Hours		**15**	

Probability & Statistics				
Credit Hours:	3 (3,0)	**Prerequisites:**		
Course Learning Outcomes (CLOs):				
At the end of the course the students will be able to:			**Domain**	**BT Level***
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain				

Course Content:

Introduction to Statistics and Data Analysis, Statistical Inference, Samples, Populations, and the Role of Probability. Sampling Procedures. Discrete and Continuous Data. Statistical Modeling. Types of Statistical Studies. Probability: Sample Space, Events, Counting Sample Points, Probability of an Event, Additive Rules, Conditional Probability, Independence, and the Product Rule, Bayes' Rule. Random Variables and Probability Distributions. Mathematical Expectation: Mean of a Random Variable, Variance and Covariance of Random Variables, Means and Variances of Linear Combinations of Random Variables, Chebyshev's Theorem. Discrete Probability Distributions. Continuous Probability Distributions. Fundamental Sampling Distributions and Data Descriptions: Random Sampling, Sampling Distributions, Sampling Distribution of Means and the Central Limit Theorem. Sampling Distribution of S2, t-Distribution, F-Quantile and Probability Plots. Single Sample & One- and Two-Sample Estimation Problems. Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of P-Values for Decision Making in Testing Hypotheses (Single Sample & One- and Two-Sample Tests), Linear Regression and Correlation. Least Squares and the Fitted Model, Multiple Linear Regression and Certain, Nonlinear Regression Models, Linear Regression Model Using Matrices, Properties of the Least Squares Estimators.

Teaching Methodology:

Lecturing, Written Assignments, Presentation, Final Exam
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Report Writing, Presentation, Final Exam
Reference Materials:
1. Probability and Statistics for Engineers and Scientists by Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye, Pearson; 9th Edition (January 6, 2011). ISBN-10: 0321629116 2. Probability and Statistics for Engineers and Scientists by Anthony J. Hayter, Duxbury Press; 3rd Edition (February 3, 2006), ISBN-10:0495107573 3. Schaum's Outline of Probability and Statistics, by John Schiller, R. Alu Srinivasan and Murray Spiegel, McGraw-Hill; 3rd Edition (2008). ISBN-10:0071544259

Real Analysis-I	**Credit Hours (3)**

Prerequisites: Calculus-III

Specific Objectives of Course:

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

Course Outline:

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

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

Sequences and Series of Real Numbers: Limits of sequences, algebra of limits. Bolzano Weierstrass Theorem. Cauchy sequences.

liminf, limsup. Limits of series, convergences tests, absolute and conditional convergence Power series. Continuity: Functions, continuity and compactness, existence of; minimizers and maximizers, uniform continuity. Continuity and connectedness, Intermediate mean Value Theorem. Monotone functions and discontinuities. Differentiation: Mean Value Theorem, L'Hopital's Rule, Taylor's Theorem.

Recommended Books:

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

Ordinary Differential Equations	**Credit Hours (3)**

P**rerequisites:** Calculus I

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

Course Outline:

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

Recommended Books:

1. Dennis G. Zill and Michael R., “Differential equations with boundary-value problems”, 5th Edition Brooks/Cole, 1997.
2. William E. Boyce and Richard C. Diprima', “Elementary differential equations and boundary value problems”, Seventh Edition John Wiley & Sons, Inc.
3. V. I. Arnold, “Ordinary Differential Equations”, Springer, 1991.
4. T.Apostol, “Multi Variable Calculus and Linear Algebra”,2nd ed., J. Wiley and sons. 1997

Computing Tools	**Credit Hours (2+1)**

Specific Objectives of course:

This course emphasizes program structure as well as functional and rule-based programming which is compared to more traditional programming, to help students understand and use Mathematica’s unique features to their advantage. In the coursestudents will learn how to solve

particular problems more efficiently by choosing the appropriate programming paradigm.

Course Outline:

Mathematica:

Introduction

General introduction and basic use of mathematica, numeric and symbolic computation, the note book, working with data, input and output, built-in functions, front end and the kernel, errors, help

Language of Mathematica

Expressions, values, variables, functions and assignments,, immediate vs delayed, patterns and pattern matching, conditional patterns, predicates and Boolean operations, relational and logical operators, attributes.

Lists

Simple and multidirectional list, List construction and manipulation, testing a list, extracting elements, rearranging list, list component assignments, working with several lists.

Programming

Functional programming, Map, Thread, Apply, Inner and Outer, Nest, NestList,
Programs as functions, user defined functions, pure functions, module. Procedural programming, loops, flow control. Rule base programming. Dynamic programming. Graphics programming. Writing packages.

MATLAB:

Introduction, Arithmetic operations, Variables, Mathematical functions, Complex numbers, Beginning calculus, Vectors, Matrices, Programming, Graphs, Equations.

Recommended Books:

1. Paul R. Wellin, Richard J. Gaylord, Samuel N. Kamin, *An introduction to programming with Mathematica, third edition*, Cambridge university press New York, 2005.
2. Hartmut F. W. Hoft, Margret Hoft, *Computing with Mathematica, second edition*. Academic Press, 2003.
3. Martha L. Abell, James P.Braselton, *Mathematica By Example, Third Edition,* Academic Press, 2004.
4. Peter I. Kattan, *MATLAB for Beginners: A Gentle Approach, Revised Edition,* ISBN-13: 978-0-578-03642-7

Linear Algebra	**Credit Hours (3)**

Prerequisites: Calculus I

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

Course Outline:

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

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

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

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

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

Recommended Books:

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

BS 6th

Semester-VI			
MTH-561	Real Analysis-II	03	Major Disciplinary Specific
MTH-562	Partial Differential Equations	03	Major Disciplinary Specific
MTH-563	Numerical Analysis-I	03	Major Disciplinary Specific
MTH-564	Differential Geometry	03	Major Disciplinary Specific
MTH-565	Topology	03	Major Disciplinary Specific
Semester Credit Hours		**15**	

Real Analysis-II	**Credit Hours (3)**

Prerequisites: Analysis-I

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

Course Outline:

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

Recommended Books:

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

Partial Differential Equations	**Credit Hours (3)**

Prerequisites: Ordinary Differential Equations

Specific Objectives of course: Partial Differential Equations (PDEs) are at the heart of applied

mathematics and many other scientific disciplines. The course aims at developing understanding about fundamental concepts of PDEs theory, identification and classification of their different types, how they arise in applications, and analytical methods for solving them. Special emphasis would be on wave, heat and Laplace equations.

Course Outline:

First order PDEs: Introduction, formation of PDEs, solutions of PDEs of first order, The Cauchy's problem for quasilinear first order PDEs, First order nonlinear equations, Special types of first order equations Second order PDEs: Basic concepts and definitions, Mathematical problems, Linear operators, Superposition, Mathematical models: The classical equations, the' vibrating string, the vibrating membrane, conduction of heat solids, canonical forms and variable, PDEs of second order in two independent variables with constant and variable coefficients, Cauchy's problem for second order PDEs in two independent variables Methods of separation of variables: Solutions of elliptic, parabolic hyperbolic PDEs in Cartesian and cylindrical coordinates a place transform: Introduction and properties of Laplace transform, transforms of elementary functions, periodic functions, error function and Dirac delta function, inverse Laplace transform, convolution theorem, solution of PDEs by Laplace transform, Diffusion and wave equations.

Recommended Books:

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

Numerical Analysis-I	**Credit Hours (3)**

Prerequisites: Calculus-I, Linear Algebra

Specific Objective of Course: This course is designed to teach the students about numerical methods and their theoretical bases. The course aims at inculcating in the students the skill to apply various techniques in numerical analysis, understand and do calculations about errors that can occur in numerical methods and understand and be able to use the basics of matrix analysis.

Course Outline of the Course:

Solutions of non-linear equations: the Bisection method, fixed point iteration, the method of false position, the Newton-Raphson's method, Rate of convergence of iterative methods.
Solution of linear system equations: Iterative methods (Jacobi, Guass 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, Nowton Forward Difference formula, Newton Backward formula, Aitken's and Inverse Interpolations, Cubic splines, Finite Difference Operators (Forward, Backward, Central and Shift).

Recommended Books:

1. R. L. Burden and J. Douglas Faires, "Numerical Analysis", 2000, Brooks/Cole Publishing Company.
2. C. E. Froberg, "Introduction to Numerical Analysis", 1974, Addison Wesley Co.
3. M. K. Jain, "Numerical Methods for Scientific and Engineering Computation", 1993, Wiley Eastern Limited.
4. Dr. Faiz Ahmad and M. Afzal Rana, "Elements of Numerical Analysis", 1995, National Book Foundation.

Differential Geometry	**Credit Hours (3)**

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

Course Outline:

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

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

Reference Books:

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

Topology	**Credit Hours (3)**

Prerequisites: Calculus I

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

homeomorphisms are.

Course Outline:

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

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

Recommended Books:

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

BS 7th

Semester-VII			
MTH-671	Classical Mechanics	03	Major Disciplinary Specific
MTH-672	Complex Analysis	03	Major Disciplinary Specific
MTH-673	Numerical Analysis-II	03	Major Disciplinary Specific
MTH-674	E1	03	Major Disciplinary Specific
	Field Experience	03	
Semester Credit Hours		**15**	

Classical Mechanics	**Credit Hours (3)**

Prerequisites: Calculus-I

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

Course Outline:

Statics: Composition of forces, centers of mass and gravity, friction.

Kinematics: Rectilinear motion of particles. Uniform rectilinear motion, uniformly accelerated rectilinear motion. Curvilinear motion of particle, rectangular components of velocity and acceleration. Tangential and normal components. Radial and transverse components. Projectile motion.

Kinetics: Work, power, kinetic energy, conservative force fields, conservation of energy, impulse, torque. Conservation of linear and angular momentum. Non-conservative forces.

Simple Harmonic Motion: The simple harmonic oscillator, period, frequency. Resonance and energy. The damped harmonic oscillator, over damped, critically damped and under damped motion, forces and vibrations.

Central Forces and Planetary Motion**:** Central force fields, equations of motion, potential energy, orbits. Kepler's law of planetary motion, Apsides and apsidal angles for nearly circular orbits.

Planer Motion of Rigid Bodies: Introduction to rigid and. elastic bodies, degree of freedom, translations, rotations, instantaneous axis and center of rotation, motion of the center of mass. Euler's theorem and Chasles' theorem. Rotation of a rigid body about a fixed axis, moments and products of inertia. Parallel and perpendicular axis theorem. Motion of Rigid Bodies in Three Dimensions: General motion of rigid bodies in space.

Recommended Books:

1. E. DiBenedetto, Classical Mechanics. “Theory and Mathematical Modeling”, ISBN: 978-0- 8176-4526-7, Birkhauser Boston, 2011.
2. John R. Taylor, “Classical Mechanics”, ISBN: 978-1-891389-22-1, University of Colorado, 2005.
3. H. Goldstein, “Classical Mechanics”, Addison-Wesley Publishing Co., 1980.

4. C. F. Chorlton, “Text Book of Dynamics”, Ellis Norwood, 1983.
5. M. R. Spiegel, “Theoretical Mechanics”, 3rd
6. G. R. Fowles and G. L. Cassiday, “Analytical Mechanics”, 7 Edition, Addison-Wesley Publishing Company, 2004.
7. Q. K. Ghori, “Introduction to mechanics”, revised Ed., Lahore, 1971.

Complex Analysis	**Credit Hours (3)**

Prerequisites: Analysis-I

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

Course Outline:

Introduction: The algebra of complex numbers, Geometric representation of complex numbers. Powers and roots of complex numbers. Functions of Complex Variables: Definition, limit and continuity Branches of functions, Differentiate and analytic functions The Cauchy-Riemann equations, Entire functions, Harmonic functions, Elementary functions: The exponential, Trigonometric, Hyperbolic, Logarithmic and Inverse elementary functions, Open mapping theorem Maximum modulus theorem. Complex Integrals: Contours and contour integrals, Cauchy-Goursat theorem. Cauchy integral formula, Lioville's theorem, Morerea's theorem Series: Power series, Radius of convergence and analyticity, Taylor's and Laurent's series, Integration and differentiation of power series. Singularities, Poles and residues: Zero, singularities. Poles and Residues, Types of singular points, Calculus of residues, contour integration, Cauchy's residue theorem with applications. Mobius transforms, Conformal mappings and transformations

Recommended Books:

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

Numerical Analysis-II	**Credit Hours (3)**

Prerequisites: Numerical Analysis-I

Specific Objective of the Course: This course is designed to teach the students about numerical methods and their theoretical bases.

Course Outline of the Course:

Numerical Differentiation: Forward formulas, Central Difference formulas, Error in Numerical differentiation, Extrapolation to the limit.
Numerical Integration: The rectangular, Trapezoidal and Simpson's One-Third and Three-Eight's, Romberg Integration, Method of undetermined 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-Bashforth- 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:

1. R. L. Burden and J. Douglas Faires, "Numerical Analysis", 2000, Brooks/Cole Publishing Company.
2. C. E. Froberg, "Introduction to Numerical Analysis", 1974, Addison Wesley Co.
3. M. K. Jain, "Numerical Methods for Scientific and Engineering Computation", 1993, Wiley Eastern Limited.
4. Dr. Faiz Ahmad and M. Afzal Rana, "Elements of Numerical Analysis", 1995, National Book Foundation.

Field Experience	**Credit Hours (3)**

Objective:
Field experience is a professional learning experience that offers meaningful and practical work experience related to a student's field of study or career interest. It is an opportunity to apply knowledge gained in the classroom with practice in the field.

BS 8th

Semester-VIII			
MTH-681	Mathematical Methods	03	Major Disciplinary Specific
MTH-682	Functional Analysis	03	Major Disciplinary Specific
MTH-683	Mathematical Statistics	03	Major Disciplinary Specific
MTH-684	E2	03	Major Disciplinary Specific
	Capstone Project	03	Major
Semester Credit Hours		**15**	

Mathematical Methods	**Credit Hours (3)**

Prerequisites: Calculus-III

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

Course Outline:

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

The Laplace transforms. Hankel transforms for the solution of PDEs and their application to boundary value problems.

Green's Functions and Transform Methods: Expansion for Green's functions. Transform methods. Closed form Green's functions.

Perturbation Techniques: Perturbation methods for algebraic equations. Perturbation methods for differential equations.

Variational Methods: Euler-Lagrange equations. Integrand involving one, two, three and n variables. Special cases of Euler-lagrange's equations. Necessary conditions for existence of an extremum of a functional. Constrained maxima and minima.

Recommended Books:

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

Inc.,1999

Functional Analysis	**Credit Hours (3)**

Prerequisites: Real-I

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

Course Outline:

Metric Space: Review of metric spaces, Convergence in metric spaces, Complete metric spaces,Dense sets and separable spaces, No-where dense sets, Baire category theorem.

Normed Spaces: Normed linear spaces, Banach spaces, Equivalent norms, Linear operator, Finite dimensional normed spaces, Continuous and bounded linear operators, Dual spaces.

Inner Product Spaces: Definition and examples, Orthonorrnal sets and bases, Annihilators, projections, Linear functionals on Hilbert spaces. Reflexivity of Hilbert spaces.

Recommended Books:

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

Mathematical Statistics	**Credit Hours (3)**

Prerequisites: Real-I

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

Course Outline:

Statistical inference. Maximum likelihood estimators. Properties of maximum likelihood estimators.

Sufficient statistics. Jointly sufficient statistics. Minimal sufficient statistics. The sampling distribution of a statistic. The chi square distribution. Joint distribution of the sample mean and sample variance. That distribution. Confidence intervals. Unbiased estimators. Fisher information. Testing simple hypotheses. Uniformly most powerful tests. The t test. The F distribution. Comparing the means of two normal distributions. Tests of goodness of fit. Contingency tables. Equivalence of confidence sets and tests. Kolmogorov- Smirnov tests. The Wilcoxon Signed-ranks test. The Wilcoxon-Mann-Whitney Ranks test.

Recommended Books:

1. Mood, A.M., Graybill, F.A., Boes, D.C., Introduction to the Theory of Statistics, 2nd edition, McGraw-Hill Book Company New York 1986.
2. Degroot, M. H., Probability and Statistics, 2nd edition, Addison-Wesley Publishing Company, USA 1986.
3. Hogg, R. V., McKean, J., & Craig, A. T. Introduction to mathematical statistics. Pearson Education, 2005.

Capstone Project	**Credit Hours (3)**

Objective:
The project will be in semester 8th. At the end of 8th semester thesis must be submitted and will be graded from an external examiner.

BS ELECTIVE COURSES

Rings and Fields	**Credit Hours (3)**

Specific Objectives of Course:
This course introduces the basic concepts of modern algebra such as rings.
The philosophy of this course is that modern algebraic notions play a fundamental role in mathematics itself and in applications to areas such as physics, computer science, economics and engineering. This course emphasizes the application of techniques.

Course Outline:

Rings and fields, Ideals, Quotient rings, Homomorphism of rings. Operations on ideals, Isomorphism, Integral domains and fields, Embedability of an integral domain in a field, Field of quotients, Maximal, Prime and primary ideals and their properties, Divisibility theory in integral Domains, Polynomial rings, Division Algorithm, Remainder theorem. R(X) as a unique factorization Domain, Irreducible Polynomials, Primitive polynomials, Gauss's Lemma, Simple algebraic Extensions, Transcendental extensions, Finite extensions of fields and related theorems, Splitting field extensions.

Recommended Books:

1. J.B.Fraleigh, A First Course in Abstract Algebra, Addison Wesley Company, 1976.
2. 1. I.N.Herstein, Topics in Algebra, Addison Wesley Company, 1980.
3. P.M.Cohn, Algebra Vol. I-II, John Wiley & Sons, 1982
4. . M. Burton, A First Course in Rings & Ideals, Addison Wesley Company, 1970.
5. J.Lambek, Lectures on Rings & Modules, American Mathematical Society, 2009.
6. T.S. Blyth & E.F. Robertson, Essential Student Algebra, Vol. I-V, Chapman & Hall, 1986.
7. T.S. Blyth & E.F. Robertson, Algebra through Practice, Book I-VI, Cambridge University Press, 1984.

Fluid Mechanics

Prerequisites: Knowledge of Calculus-I & II , Ordinary and Partial differential equations.
Specific Objectives of Course: Develop an understanding of fluid mechanics and its importance in mathematics and its applications in aerospace and technology. Learn to use control volume analysisto develop basic equations and to solve problems. Understand and use differential equations to determine pressure and velocity variations in internal and external flows. Understand the concept ofviscosity and where viscosity is important in real flows. To model the governing equations of a flowpast or inside a body of a specific geometry. Students will be able to classify fluids and will also become familiar of the laminar to turbulence transition of flows.

Course outline:

Introduction: Dimensions, units and physical quantities, gases and liquids, pressure and temperature, properties of fluids, thermodynamics properties and relationship. Pressure variation.

Fluid statics: pressure variation, forces on plane and curved surfaces.
Fluids in motion: Lagrangian and Eulerian description, pathlines, streaklines and steamlines, acceleration, angular velocity and vorticity, classification of fluid flows, Bernoulli's equation.
Navier Stokes equations: The integral and differential forms of the conservation of mass, momentumand energy.

Viscous flow: Incompressible viscous flow using Navier-Stokes equations, pipe flow, boundarylayers, separation, introduction to turbulence.

Recommended books:

1. *D. F. Young, "A Brief Introduction to Fluid Mechanics"*, 5th Edition, Wiley, 2010.
2. H. Schlichting, "Boundary layer theory", 7th Edition, Mc Graw Hill. 1979.
3. F. M. White, "Viscous fluid flow", 3rd Edition, 2006.
4. M. Pottert & D. Wiggert, "Fluid Mechanics", Shaums Outlines series, MC Graw Hill, 2008

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Algebraic Topology

Pre-requisite: Set Topology and Linear Algebra

Objective of the Course: This course is designed for undergraduate students to be taught in one semester. This course is intended to the introduction of the machinery of algebraic topology. Specifically, we will focus on singular homology and the dual theory of singular co-homology.

Course Contents:

CW-complexes, delta-complexes, simplicial homology, exact sequences, diagram chasing, Singular homology, homotopies and chain homotopies, categories and functors, Eilenberg-Steenrod axioms, Excision, computations for spheres, equivalence of simplicial and singular homology, Cellular homology, Mayer-Vietoris sequences, the Mayer-Vietoris argument, homology with coefficients,Tensor products, Tor, universal coefficient theorem for homology, products of simplices, The Eilenberg-Zilber shuffle "product" map, diagonal approximations, the Alexander-Whitney map, method of acyclic models, Kunneth formula, Duality, cohomology, Ext, universal coefficients for cohomology, Projective spaces and Grassmannians, cup products, relative cup products, Dual Kunneth formula, field coefficients, cup products in cohomology of projective spaces, Manifolds,local orientations, global orientations, Cap products and choices of appropriate sign conventions, statement of Poincare duality, limits, Compactly supported cohomology, proof of Poincare duality, Finish proof of Poincare duality, Intersection pairing and cup product, Lefschetz fixed point theorem, Finish proof of Lefschetz theorem.

Recommended Books:

1. Hatcher, Allen. "*Algebraic Topology"*. Cambridge, UK: Cambridge University Press, 2002.
2. Massey, William S. "*A Basic Course in Algebraic Topology"*. New York, NY: Springer-Verlag, 1997.
3. Rotman, Joseph J. "*An Introduction to Algebraic Topology"*. New York, NY: Springer-

Verlag, 1998.
4. Munkres, James R. "*Elements of Algebraic Topology"*. Boulder, CO: Westview Press, 1993

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Galois Theory

Pre-requisites: Linear Algebra, Algebra-II, Rings and Fields.

Course Objectives: The course will discuss the problem of solutions of polynomial equations both in explicit terms and in terms of abstract algebraic structures. The course demonstrates the tools of abstract algebra (linear algebra, group theory, rings and ideals) as applied to a meaningful problem.

Course Outlines:

Integral domains and Fields, Homorphisms and ideals, Quotient Rings, Polynomialrings in one indeterminate over Fields, Prime ideals and Maximal ideals, irreducible Polynomials. Algebraic and transcendental field extensions, Simple Extensions, Composite Extensions, SplittingFields, The Degree of and Extension, Ruler and Compass Constructions. Normality and Separability. Circle Division, The Galois Group, Toots of Unity, Solvability by Radicals, Galois Extensions, TheFundamental Theorem of Galois Theory, Galois's Great Theorem, Algebraically Closed Fields.

RECOMMENDED BOOKS:

1. Joseph Rotman, "Galois Theory", Springer-Veriog, New York, Inc. , 2005
2. Lan Steward, "Galois Theory", Chapman & Hall, New York , 2004

Electromagnetism

Prerequisites: Basic of Physics

Course Outline:

Equations of electrostatic and magnelostatic boundary conditions, Boundary value problems and methods of solution, Electrostatics and magnetostatics of macroscopic medium. Dipolesand Multipole. Dielectrics. Steady currents and their interaction. Varying Currents. Electromagnetic induction. Maxwell;s equations.Energy, momentum (polynting) vectors and stress tensor of electromagnetic fields. Wave propagation, Waves in a conducting medium, reflection and dispersion. Lorentz formula. Wave3 guide and cavity resonators. Spherical waves. Field of a uniformly moving charged particle. Field of an oscillating dipole. Diffraction of electromagnetic waves.

Recommended Books:

1. *V.C.A. Ferraro, "Electromagnetic Theory", ELBS London, 1950*
2. *Lorrain & Corson,Electromagnetic Fields and Waves, Toppan Company Ltd. 1970*

3. *C.A.Coulson, Electricity, Liver & Boyd Edinburgh. 1951*
4. *A.S. Ramsey, Electricity & Magnetism, Cambridge University Press. 1952*
5. *J.R. Reitz, F.J. Milford & Christy, "Foundation of Electromagnetic Theory". London, 2008*

Modeling and Simulations

Prerequisite(s): Partial-Differential Equations

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

Course Outlines:

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; Application to biological systems; Modeling with periodic or impulse forcing functions; Modeling with systems of first order differential equations; Competitive hunter model; Predator prey model.

Recommended Books:

1. Giordano FR, Weir MD, "*Differential Equations: A Modeling Approach"*, Addison- Wesley,Reading, Ma, USA (suggested text), 19994.
2. Jerri AJ, "*Introduction to Integral Equations with Applications"*, Marcel Dekker, New York,1985.
3. Myint UT, Debnath L, "*Partial Differential Equations for Scientists and Engineers",* 3rd edition,North Holland, Amsterdam, 1987

Measure Theory

Prerequisites: Real Analysis

Course Outline:

Lebesgue measure, Outer measure. Measurable set and Lebesgue measure, A non-measurable set, measurable function. The Lebesgue Integral: The Lebesgue integral of a bounded function. The general Lebesgue integral. Lebesgue integral and its relation to Riemann integral. Convergence in measure.Measure space, Measurable functions. Integration, General convergencetheorems. Signed measures. The Radon-Nikodym theorem. The L_p-spaces, Outer measure and measurability, the extension theorem, The Lebesgue Stieltjes integral, product measure. Inner Measure.

Recommended Books:

1. *H.L.Royden; "Real analysis", The McMillian Company, 1968.*
2. *D de Barra; "Measure Theory & Integration", Eillis Horwood Ltd, 1981.*
3. *P.R. Halmos., "Measure theory", Von Nostrand NY, 1950.*
4. *A Mukherjca; "Real and Functional Analysis", Plenum and K.Pothoven Press, 1978.*
5. *Seymour Lipschutz, "Set Theory and Related Topics", McGraw-Hill Publishing C,1998.*

Projective Geometry

Pre-requisite: Differential Geometry

Specific Objective of Course:

This course is designed to introduce the students with basic notions and intuitions on projective geometry. Projective geometry has interesting visual computing domains, especially in computer graphics. It provides a mathematical formalism that enables us to manipulate 2D projections of 3D objects. Projective geometry has a fundamental aspect that objects at infinity can be represented andmanipulated which is not possible in the Euclidean geometry.

Course Outline:

Projective Spaces-Definition, Properties, the hyper plane at infinity, The projective line-Projective transformation of P1, The cross-ratio, The Projective Plane-points and lines, line at infinity, homographies, conics, Affine, Euclidean transformations, Particular transformation, Transformationhierarchy.

Recommended Books:

1. J.G. Semple and G.T. Kneebone, "*Algebraic projective geometry",* Clarendon Press, Oxford , 1952
2. R. Hartley and A. Zisserman, "*Multiple View Geometry"*, Cambridge University Press , 2000.
3. O. Faugeras and Q-T. Luong, "*The Geometry of Multiple Images"*, MIT Press, 2001.
4. D. Forsyth and J. Ponce, "*Computer Vision: A Modern Approach",* Prentice Hall, 2003.

Riemannian Geometry

Prerequisites: Algebra-I, Calculus-I, Set Topology

Specific Objectives of the Course: Riemannian Geometry provide an important tool in modern mathematics, impacting on diverse areas from the pure to the applied. The main aim of this course is to give a thorough introduction to the theory of abstract manifolds, which are the fundamental objects in Riemannian Geometry, in particular the notion of geodesics and curvature. We will be able to analyze manifolds with constant curvature, with a focus on the sphere and hyperbolic space.

Course Outlines:

Definition and examples of manifolds; Submanifolds; smooth maps; Tangents; Coordinate vector fields; Tangent spaces; Dual spaces; Algebra of tensors; Vector fields; Tensor fields; Integral curves; Affine connections and Christoffel symbols; Covariant differentiation of tensor fields; Geodesics equations; Curve on manifold; Parallel transport; Lie transport; Lie derivatives and Lie Brackets; Geodesic deviation; Differential forms; Introduction to integration theory on manifolds; Riemannian Curvature tensor;. Geodesics, exponential map, curvature and examples. Completeness and Hopf-Rinow Theorem; Manifolds with constant curvature, sphere, geometry of hyperbolic space.

Recommended Books:

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

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General Relativity

Pre-requisite: Special Relativity

Objective of the Course:

After the birth of Einstein's special theory of relativity, Minkowski reformulated it geometrically. This reformulation brought a revolution in the history of physics. To check the consistency of new theories, experiments were designed which in turn developed our scientific technology. This course is designed to introduce the students with theories presented in general relativity and explain the predictions it made. Both physical and mathematical aspects of general relativity are discussed in a systematic way.

Course Contents:

Vectors, One forms and the Metric, Manifolds, Parameterized curves, Tangent vectors, Vectors

in curved space, The metric tensor and covariant differentiation, The curvature, Ricci and Weyl tensors, Curves in manifolds; parallel transport, Geodesics, Bianchi identity, Lie derivative and Isometries. Energy momentum tensor, Killing vectors, Brief literature review of symmetries in general relativity.

Recommended Books:

1. Robert M. Wald, "*General Relativity",* The University of Chicago Press, 1984.
2. David McMahon, "*Rrelativity Demystified",* Tata McGraw-Hill, New Delhi 2006.
3. G. S. Hall, "*Symmetries and curvature structure in general relativity",* World Scientific,2004.

Mathematical Modeling

Prerequisites: Partial Differential equations, vector analysis, Programming in MATLAB
Specific Objectives of the Course: At the end of the course, students will be able to model problems from everyday life and diverse applications in science.

Course Outline:

Concept 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; application to biological systems; modeling with period or impulse forcing functions. Modeling with systems of first order differential equations; competitive hunter model; predator prey model
Partial-Differential Equations: Methodology of mathematical modeling; objective, background, approximation and idealization, model validation, compounding. Modeling wave phenomena (wave equation); shallow water waves, uniform transmission line, traffic flow, RC circuits. Modeling the heat equation and some application to heat conduction problems in rods, lamina, cylinders etc. modeling the potential equation (Laplace equation), application in fluid mechanics, gravitational problems. Equation of continuity.

Recommended Books:

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

Axiomatic Set Theory

Prerequisites: Some knowledge of first order logic will be an advantage, knowledge of basic set theory.

Specific Objective of the Course:

After studying this course the students will be able to be familiar with the axiomatic basis of the theory of the universe of sets of mathematical discourse. Be able to understand the notion of an "inner model" of set theory. Be able to understand how such models enable consistency statements. Have a working knowledge of theconstructability hierarchy. Be able to understand Zermelo-Fraenkel axiom system ZFCfor set theory with the axiom of choice and with how ZFC may serve as a formalization of mathematics. Be able to understand the equivalence of the well ordering principle. Have a knowledge of the axiom of choice and Zorn's lemma.

Course Outlines:.

Basics: Classes and Sets, Special Classes. Boolean algebra of Classes: Boolean Class Operators, Boolean Algebra, Order, Singletons and ClassPairs, Infinite Boolean Operators, Power Class Building. Sets, Relations and Functions: Sets, Ordered Pair, Cartesian Product, Relations, Relation Algebra,quivalence Relations, Maps and Functions, Natural Numbers: Foundation and Infinity, Definition and Basic Properties, Induction, Sequences andNormal Functions. Recursion: Axiom of Choice, Well-Ordering, Applications of the Axiom of Choice. The Axioms of ZFC: Tentative Axioms, The Axioms of Zermelo-Fraenkel Set Theory with Choice, Class terms, relativisations to models, Absoluteness and reflection theorems, Introduction to Consistency proofs, Closed and unbounded sets, stationary sets, Regular and singular cardinals, cofinality; inaccessible cardinals, Goedel's Def function and the definition of the constructible hierarchy L, The Consistency of AC and GCH with ZFC.

Recommended Books:

1. P. Suppes, "*Axiomatic Set Theory"*, Dover Publication, United States", 1960.
2. Dana S. Scott, Thomas J. Jech, "*Axiomatic Set Theory",* American Mathematical Society,Providence, Rhodes Island, 1967.
3. P. Burnays. "*Axiomatic Set Theory",* Dover Publication, United States, 2003.
4. J. L. Krivine, "*Introduction to Axiomatic Set Theory",* Springer, Netherlands, 1973

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Dynamical Systems

Prerequisite: Linear Algebra and Calculus

Course Outlines:

One Dimensional Dynamics: Elementary definitions of dynamical systems**,** hyperbolicity**,** the quadratic family**,** symbolic dynamics, structure stability**,** chaos**,** bifurcation theory
Higher Dimensional Dynamics: The dynamics of linear maps, attractors**,** the stable and unstablemanifold theorems**,** global results and Hyperbolic sets, Periodic points.

Recommended books:

1) Robert L. Devaney, "*Chaotic Dynamical Systems* (second edittion)", Westview Press, 1992.
2) A. N. Michel, Ling Hou, Derong Liu, "*Stability of Dynamical Systems"*, Birkhauser, 2008.
3) Morries, W. Hirich, Stephen smale, Robert L. Devaney, "*Differential Equations, Dynamicalsystems and Introductio to Chaos",* (Third edition), Elsevier inc, 2012.

Computational Fluid Dynamics

Prerequisites: Knowledge of Calculus-I & II , Ordinary and Partial differential equations, Fluid Mechanics, Numerical Analysis, Mat Lab or Fortran or C.

Specific objectives of course:

At the end of this course students will be able to apply numerical techniques of finite difference method to solve partial differential equations related to fluid dynamics. Finite difference techniques will be studied in detail with examples. Students will also be able to built computer programmes for numerical solutions of partial differential equations related to flow phenomena. Students will be ableto sketch and analyze various solutions based on the output of the computer programmes. Laminar flow equations for flow due to a rotating disk will be modelled and solved numerically with programmes in Mat Lab or any other language.

Course outline:

A brief review of Navier Stokes equations. Numerical Methods for modeling parabolic and elliptic equations: Model equations, discretization of derivatives with finite differences, finite difference method for parabolic equations, explicit method with various boundary conditions, implicit methods, Crank Nicolson and Keller Box schemes with examples and programming. Finite difference methods for hyperbolic partial differential equations with examples and computerprogrammes. The laminar boundary layer flow over rotating disk with programming and visualizations.

Recommended books:

1. T. Cebbeci, J. Shao, F. Kafayeke, E. Laurendeau, "Computational Fluid Dynamics for engineers", Horizons publishing, 2005.
2. H. Schlichting, "Boundary layer theory", 7th Edition, Mc Graw Hill. 1979
3. F. M. White," Viscous fluid flow", 3rd Edition, 2006.
4. S. Iengar, D. Jain, "Numerical Methods", New age international (P) Ltd. 2009

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History of Mathematics

Course prerequisite: The prerequisite for this course is an intense interest in mathematics. There are no other prerequisites for it other than a familiarity with plane geometry and algebra.

Specific Objective of Course objectives:

After studying this course the students will be able to describe the development of various areas

of mathematics within and across various civilizations describe the changing character of mathematics over time and recognize the distinction between formal and intuitive mathematics give examples of significant applications of mathematics to commerce, science, and general life, past and present understand that history includes the interpretion the past, not just facts better research historical questions and present your conclusions to others

Course Outline:

Early Number Systems and Symbols: Primitive Counting, Number Recording of the Egyptians and Greeks, Number Recording of the Babylonians.

Mathematics in Early Civilizations: The Rhind Papyrus, Egyptian Arithmetic, Four Problems from theRhind Papyrus, Egyptian Geometry, Babylonian Mathematics, Plimpton 322.

The Beginnings of Greek Mathematics: The Geometrical Discoveries of Thales, Pythagorean Mathematics, The Pythagorean Problem, Three Construction Problems of Antiquity, The Quadratrixof Hippias.

The Alexandrian School, Euclid: Euclid and the Elements, Euclidean Geometry, Euclid's Number Theory, Eratosthenes, the Wise Man of Alexandria, Archimedes.

The Twilight of Greek Mathematics, Diophantus: The Decline of Alexandrian Mathematics, The Arithmetica, Diophantine Equations in Greece, India, and China, The Later Commentators, Mathematics in the Near and Far East.

The First Awakening: Fibonacci: The Decline and Revival of Learning, The *Liber Abaci* and *Liber Quadratorum*, The Fibonacci sequence, Fibonacci and the Pythagorean Problem.

The Renaissance of Mathematics: Cardan and Tartaglia**:** Europe in the Fourteenth and Fifteenth Centuries, The Battle of the Scholars, Cardan's *Ars* Magna, Ferrari's Solution of the Quartic Equation.

The Mechanical World: Descartes and Newton: The Dawn of Modern Mathematics, Descartes: The Discours de la Methode, Newton: The *Principia Mathematica*, Gottfried Leibniz: The CalculusControversy.

The Development of Probability Theory: Pascal, Bernoulli, and Laplace**:** The Origins of Probability Theory, Pascal's Arithmetic Triangle, The Bernoullis and Laplace.

The Revival of Number Theory: Fermat, Euler, and Gauss**:** Marin Mersenne and the Search for Perfect Numbers, From Fermat to Euler, The Prince of Mathematicians: Carl Friedrich.

Nineteenth−Century Contributions: Lobachevsky to Hilbert: Attempts to Prove the Parallel Postulate, The Founders of Non-Euclidean Geometry, The Age of Rigor, Arithmetic Generalized.

Transition to the Twentieth Century: Cantor and Kronecker**:** The Emergence of American Mathematics, Counting the Infinite, The Paradoxes of Set Theory.

Extensions and Generalizations: Hardy, Hausdorff, and Noether: Hardy and Ramanujan, The Beginnings of Point-Set Topology, Some Twentieth-Century Developments.

Recommended Books:

1. *D. M. Burton, "The History of Mathematics", An Introduction, 6th Edition, McGraw-Hill Primis, 2010.*
2. *J. R. Durbin, "Mathematics: Its Spirit and Evolution". Boston: Allyn and Bacon, 1973.*
3. *R. Cook, "The History of Mathematics: A Brief Course. 2nd edition", New York: Wiley.*
4. *R. Courant and H. Robbins, "What is Mathematics? An Elementary Approach to Ideas andMethods", 2nd edition, Revised by Ian Stewart.*

Oxford: Oxford University Press, 1996.

Pointless Topology

Prerequisites: Knowledge of Topology.

Specific Objectives of Course:

Topological spaces have points and open sets, but many definitions and theorems can be stated purely in terms of the behavior of open sets, without reference to points. This leads to a formulation of topological ideas in more abstract spaces, called locales that may not have any points.

Course Outline:

Introduction: Spaces and Lattices of open Sets, Sober spaces, the axiom TD: another case of spaces easy to reconstruct, Aside: several technical properties of TD-spaces.

Frames and Locales Spectra: Frames, Locales and locales maps, Points, Spectra, The unit σ and spatiality, The unit λ and sobriety.

Sublocales: Extremal monomorphisms in Loc, Sub locales, The co-frame of sub locales, Images and preimages, Alternative representations of sub locales, Open and closed sub locales, Open and closed localic maps, Closure, Preimage as a homomorphism, Other special sub locales, one-point sub locales and Boolean ones , Sub locales as a quotients.

Separation Axioms: Instead of T_1: subfit and fit, Mimicking the Hausdorff axiom , I-Hausdorff frames and regular monomorphisms, Aside: Raney identity , Quite like the classical case: Regular, completely regular and normal.

Compactness and Local Compactness: Compactness and separation, Compactification, Continuous completely regular frames, Hofmann-Lawson duality.

Metric Frames: Diameters and metric diameters, Metric spectrum, Uniform Metrization Theorem, Metrization theorems for plain frames, Categories of metric frames.

Connectedness: A few observations about sub locales, Connected and disconnected locales, Locally connected locales.

Recommended Books:

(1) *B. Banaschewski, "The Real numbers in Pointfree topology", Textos de Matematicavol. 12, Coimbra, 1997.*

(2) *Jorge Picado and Ales Pultr , "Topology without points", Springer Basel.*

(3) *B. Banaschewski, "Uniform completion in Pointfree topology", vol. 20, Kluwer AcademicPublishers, Boston, Dordrecht, London, 2003.*

Quantum Mechanics

Prerequisites: Mechanics

Course Outline:

Inadequacy of Classical Mechanics. Black body rediation. Photoelectric Effect, Comption Effect, Bohr's theory of atomic structure, Wave-Particle duality, De-Broglies postulate. The Uncertainty Principle.Uncertainty of position and momentum, statement and proof of the uncertainty principle, Energy-time uncertainty. Eigenvalues and Eigenfunctions, Operators and Eigenfunctions, Linear Operators, Operators formulism in Quantium Mechanics, Orthonormal system,Hermitian operators and their properties, Simultaneous Eigen-functions, Parity operators. Postulate of quantium mechanics, Schroedinger Wave. Equation. Motion in One Dimension. Step Potential, Potential Barrier, Potential Well, harmonic Oscillator. Motion in Three Dimensions, Angular Momentum, Pauli Exclusion Principle, Hydrogen atom. Heisenberg equationsw of motion and equivalence of Schrodinger and Heisenberg physical pictures. Scattering theory. Born approximation. Partial wave analysis. Optical theorem. Time dependent & time independent perturbation theory. Selection rules. Klein-Gordon equation. Dirac's equation. Spin angular momentum.

Recommended Books:

1. *R.L. White, Basic Quantum Mechanics, McGraw Hill Book Co. N.Y, 1966.*
2. *L.I. Schiff, Quantum Mechanics, McGraw Hill Kogakusha Ltd.,1955*
3. *P.T. Mathews, Introduction to Quantum Mechanics, McGraw Hill Book Co. 1956*
4. *Dicke & Wittike, Introduction to Quantum Mechanics, Addison Wesley PublishingCompany Inc.,1966.*
5. *F.Mandl, Quantum Mechanics, Butterworth, 1966, London. 7th Impression.*
6. *P.M. Mathews, K.V.Venkatesan, A Text Book of quantum Mechanics 8th Reprint, TataMcGraw Hill Publishing Company Limited, New Delhi, 1984*
7. *P.A.M.Dirac, Introduction to Quantum Mechanics.*
8. *Riazuddin and Fayyazuddin, Introduction to Quantum Mechanics, World Scientific, 1990.*

Lie Groups and Lie algebras

Pre-requisite: Fundamental concepts of group theory and Differential geometry

Specific Objectives of the Course: Representation theory is a powerful tool because it reduces problems in abstract algebra to problems in linear algebra, a subject that is well understood. Furthermore, the vector space on which a group (for example) is represented can be infinite-dimensional and by allowing it to be, for instance, a Hilbert space, methods of analysis can be appliedto the theory of groups. Representation theory is also important in physics because, for example, it describes how the symmetry group of a physical system affects the solutions of equations describing that system. This course covers the structure of Lie groups, Lie algebras and their (complex) representations.

Course outlines:

Definition of Lie group and Lie algebra, The exponential mapping, Matrix Lie groups, Complex Lie groups, Infinite dimensional Lie groups, Cartan's theorem on closed subgroups, The adjoint

representation, Universal covering groups, The universal enveloping algebra, Compact Lie groups, Representation of Lie groups on finite dimensional vector space and on Hilbert space, Lie Subgroups, Properties of Lie algebra, Lie subalgebra, Actions of Lie groups and Lie algebras,Structure constants, Direct sums, Lie algebra of matrix Lie groups, Universal Enveloping Algebras,

Recommended books:

1. Gilmore, R. : Lie Groups, Lie Algebras and Some of Their Applications ,Dover Publication, 2006.
2. Erdmann, K. and Mark, W. Introduction to Lie Algebras , Springer, 2006.
3. Iachello, F. Lie Algebras and Applications , Springer, 2006.
4. Hall, B. Lie groups, Lie algebras and representations ,Springer, 2003.

Introduction to Econometrics

Prerequisites: Statistics, Calculus, MATLAB

Specific Objectives of course: This course focuses on techniques for estimating regression models, on problems commonly encountered in estimating such models, and on interpreting the estimates from such models. The goal of the course is to teach the basics of the theory and practice of econometrics and to give an experience in estimating econometric models with actual data. This course will help the students, taking their research areas in applications of mathematics in economics and social sciences.

Course Outline:

Simple linear regression; Multiple linear regression-estimation; Multiple linear regression-inference; Multiple regression-OLS asymptotic; Multiple regression-further issues; Multiple regression-qualitative variables; Heteroskedasticity; Data problems; Simple panel data methods; Causality.

Recommended Books:

1. Jeffrey Wooldridge, *Introductory Econometrics*, 4th edition [WR], 2009.
2. Acock, Alan, "*A Gentle Introduction to Stata"*, 3rd edition, College Station: Stata Press,2010.

Module Theory

Prerequisite: Algebra-I

Course Objectives: In abstract algebra, the concept of a module over a ring is a generalization of the notion of vector space over a field, where the corresponding scalars are the elements of an arbitrary ring. Modules also generalize the notion of abelian groups, which are modules over the ring of integers. Much of the modern development of commutative algebra emphasizes modules.

Both ideals of a ring R and R-algebras are special cases of R-modules, so module theory encompasses bothideal theory and the theory of ring extensions. This course focuses the basic concepts and results of Module Theory.

Course outlines:

Modules, submodules, operations on submodules, generation of modules, finitely generated modules, direct sum of modules, cyclic modules, free modules, quotient modules, homomorphisms of modules, isomorphism theorems of modules, short exact sequences of modules, group of module homomorphisms, simple modules, modules over PID's, Artinian Modules, Noetherian Modules, modules of finite length, Artinian rings, Noetherian rings.

Recommended Books:

1. Adamson, J.,1976. Rings and modules 1st ed. NY: Chelsea.
2. Blyth, T.S., 1977. Module Theory. 1st ed. Oxford University Press.
3. Hartley, B. and Hawkes, T.O. Rings, Modules and Linear algebra. 1st ed. Chapman and Hall,1980.
4. David S Dummit, Richard M. Foote, Abstract Algebra, (third edition), John Wiley & Sons.ThomasW, 2004.
5. Hungerford, Algebra, Springer-Verlag, New York Inc. 1974.

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Graph Theory

Pre-requisites: Set Theory, Mathematical Logic, Discrete Mathematics.

Course Objectives: The objective of this course is to introduce students to some of the most important notions of graph theory and develop their skill in solving basic exercises. Students should also become able to identify graph theory problems in a natural way even when they appear in a different setting.

Course Outlines:

Basic definitions, isomorphisms, walks, cycles and bipartite graphs, Components, cut-edges, Eulerian graphs, vertex degrees and degree sequences, directed graphs, Eulerian digraphs, trees and distance, Counting spanning trees and the matrix tree theorem, minimal spanning trees and shortest paths, Matchings, Hall's theorem and coverings, maximum matchings, factors, Cuts and connectivity, Network flow problems, max-flow min-cut theorem, Vertex colorings, bounds on chromatic numbers and Mycielski's construction, Chromatic polynomials, chordal graphs, planar graphs, Euler's formula and Kuratowski's theorem, five and four color theorems.

Recommended Books:

1. Introduction to Graph Theory by Douglas B. West, Second edition, 2000.
2. G. Chartland, P. Zhang, “A first course in graph theory”, Dover Books, 2012.

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Special Relativity

Pre-requisite: Electricity and Magnetism

Specific Objective of the Course:

Newton, Faraday and Maxwell made remarkable contributions in the development of Physics. There was still disagreement on ether theory and interpretation was needed to explain some physical laws. Meanwhile, in 1905 Einstein published two papers, one on quantum of radiation and other on electrodynamics of moving bodies. His later paper on electrodynamics of moving bodies proved to be a base for special theory of relativity. In this theory Einstein gave explanation to different phenomenon by using simple kinematics for frames of constant velocity. In this course we will learn special theory in a way that will lead us easily to the generalization of the theory.

Course Contents:

Development of the Pre-Newtonian and Newtonian theories of motion. Einstein's special theory of relativity: length contraction, time dilation and simultaneity; velocity addition for 1-d motion. The extension of special relativity to 3-dimensions. Invariant quantities and tensors. Coordinate transformations. The 4-vector formulation of special relativity; its geometric and group aspects. Physical applications of special relativity: Doppler effect; Compton effect; particle scattering; particle production, decay and binding energy. Use of 4-vector formulation for electromagnetism and its consequences gauge transformations and gauge groups. Special relativity with small accelerations andits geometrical implications.

Recommended Books:

1. Asghar Qadir, *"Relativity: An Introduction to the Special Theory"*, World Scientific, 1989.
2. M. Born, *"Einstein's Theory of Relativity"* , (Revised Edition), Dover Publications, 1962.
3. Vidwan Singh Soni, *"Mechanics and Relativity",* Asoke K, Ghosh Publishing New Delhi 2009.

Optimization Theory

Prerequisites: Calculus-I, Numerical Analysis-I

Specific Objectives of the Course: At the end of the course, students will be able to solve practical problems of optimization.

Course Outline:

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

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

Recommended Books:

1. *Gill, P.E., Murray E & Wright, H.H. "Practical Optimization", Academic Press, 1981.*
2. *Fletcher, R. "Practical Methods of Optimization", Vol.I & II, john Wiley and Sons, 1980.*
3. *David G.Luenberger, " Optimization by Vector Space Methods", John Wiley & Sons, 1986*
4. *Gotfreid BS, Weisan J, "Introduction to Optimization Theory", Prentice Hall, Englewood Cliffs,NJ, USA, 1973.*
5. *S.S. Rao., "Optimization Theory and Application", Wiley Eastern Ltd, 1984.*
6. *Bazaraa, M.S. and Shetty, C.M., "Nonlinear Programming", Theory and Algorithms, John Wiley& Sons, 1979,*

Category Theory

Pre-requisites: Basic knowledge of Group theory, Ring Theory, Modulus Theory, Linear algebraand Functional analysis.

Specific object of the course: To know about basic structure of categories Theory.

Course Outline: Basic Concepts of categories: Categories of Metric spaces, Co-Equalizers and Equalizers , Constructions in categories of metric spaces, Definition of category, Epimorphism andMonomorphism , Limit and Co-Limit. Product and Co- product, Vector space and Posets.

Recommended Books:

1. *Michael A. Arbib and Ernest G. Manes, "Arrows, structures and functions", academic press, 1975.*
2. *T.S. Blyth, "Categories", Longman Sc & Tech,* 1986.

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Convex Analysis

Prerequisite: Calculus-I

Course Objectives: Convex analysis deals with the study of convex sets and convex functions. There is main connection between convex functions and convex sets, namely the domain of convex functions must be a convex set. Convex functions play an important role in many fields of mathematics such as optimization, control theory, operations research, geometry, differential equations, functional analysis etc. as well as in applied sciences e.g. in economics and finance. They have a lot of interesting and fruitful properties, e.g. continuity and differentiability properties or the fact that a local minimum turns out to be a global minimum etc. They even allow to establish a proper and general theory of convex functions. In this course we will learn

some basic theory of convex functions and convex sets and some related results.

Course Outlines:

Convex set, J- Convex function, convex and log- convex function, continuity and differentiability of convex function, epigraph of convex function, relation between convex and J-convex functions, Characterizations, Differences of convex functions, Affine function, sub differential of convex function, support line of convex functions, Conjugate convex functions, affine sets, convex and affine hull.

Recommended Books:

(1) *A. W. Roberts and D. E., "Varberg, Convex functions", Academic Press, New York, 1973.*
(2) *C. P. Niculescu and L. E. Persson, "Convex functions and their applications", CMS Books inMathematics, Springer-Verlage, New York, 2006.*
(3) *R. T. Rockafellar, Convex Analysis, "New Jersey Princeton University", 1972.*
(4) *Simon, Barry. Convexity: An Analytic Viewpoint. N.p., Cambridge University Press, 2011.*

Advanced Group Theory

Course Objective:

The aim of this course is to provided students the advance concepts in groups theory. For example, Direct product of groups, Subnormal series of groups and Sylow groups etc.

Course Outline:

Direct product of groups and its properties, Cauchy's Theorem for abelian and and non-abelian groups, Sylow groups and Sylow theorems, Zassenhaus' Butterfly Lemma, Normal Series, Schreier's Refinement theorem and its properties, Composition series, Jordan Holder theorem and its properties, Solvable groups and its properties. Nilpotent groups and its properties, Free groups and finitely generated abelian groups.

Recommended Books :

1. J.B.Fraleigh, A First Course in Abstract Algebra, Addison Wesley Company, 1976.
2. I. N. Herstein, Topics in Algebra, Second Edition, John Wiley & Sons, 1975.
3. P.M.Cohn, Algebra Vol. I-II, John Wiley & Sons, 1982.
4. T.S. Blyth & E.F. Robertson, Essential Student Algebra, Vol. I-V, Chapman & Hall, 1986.
5. T.S. Blyth & E.F. Robertson, Algebra through Practice, Book I-VI, Cambridge University Press, 1984.

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