BS Mathematics Course Contents Spring 2026

Semester II

MAT-3201	Calculus-II	3(3-0)
MAT-3202	Discrete Mathematics	3(3-0)
GEN-3203	Quantitative Reasoning-II	3(3-0)
GEN-3204	Expository Writing	3(3-0)
GEN-3205	Pakistan Studies	2(2-0)
GEN-3206	Introduction to Philosophy	2(2-0)
UOQ-3207	Understanding of the Holy Quran-I	1(0-1)

MAT-3201 Calculus-II Credit Hours: 3 (3-0)

Course Description

This course is a continuation of Calculus I and delves deeper into the theory and application of integration. It covers advanced techniques of integration, various applications of the definite integral, the study of improper integrals, and a comprehensive introduction to infinite sequences and series, including Taylor and Maclaurin series.

Course Learning Outcomes:

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

- Understand the techniques of integration and its applications in calculating areas and volumes.
- Apply integration techniques to solve real-world problems.
- Analyze convergence of improper integrals and infinite series.

Comprehensive Course Contents

Week 1-3: Applications of Integration. Area between curves. Volumes of solids of revolution using the disk, washer, and cylindrical shells methods. Arc length of a plane curve.

Week 4-6: Techniques of Integration. Integration by parts. Trigonometric integrals and trigonometric substitution. Integration of rational functions by partial fractions.

Week 7: Numerical Integration and Improper Integrals. Approximating definite in tegrals (Trapezoidal Rule, Simpson's Rule).

Week 8 : Midterm Examination.

Week 9-10 : Improper integrals with infinite limits of integration and infinite discontinuities. Infinite Sequences and Series.

Week 11-12: Sequences and their convergence. Introduction to infinite series. The integral test, p-series. The comparison tests (Direct and Limit Comparison).

Week13-14: Alternating Series and Convergence Tests. Alternating series test. Absolute and conditional convergence. The ratio and root tests.

Week 15-16: Power Series and Taylor Series. Power series, radius and interval of convergence. Representing functions as power series. Taylor and Maclaurin series and their applications.

Recommended Books

Primary: Stewart, J. (2021). Calculus: Early Transcendentals (9th ed.). Cengage Learning.

Supplementary: Strang, G. (Editor). (2019). Calculus, Volume 2. OpenStax.

Supplementary: Zegarelli, M. (2023). Calculus II For Dummies. For Dummies.

MAT-3202 Discrete Mathematics Credit Hours: 3 (3-0)

Course Description

This course provides an introduction to the fundamental concepts of discrete mathematics, which form the mathematical foundation for computer science and other related fields. Topics include formal logic, proof techniques, set theory, functions, relations, combinatorics, and an introduction to graph theory. The course emphasizes logical reasoning and problem-solving.

Course Learning Outcomes

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

- Understand the principles of combinatorics, set theory, and graph theory.
- Apply discrete mathematical techniques to solve problems in computer science and cryp tography.
- Analyze logical structures and use them in algorithmic problem-solving.

Comprehensive Course Contents

Week 1-3: The Foundations: Logic and Proofs. Propositional logic, logical equivalences. Predicates and quantifiers. Rules of inference and introduction to proofs (direct, contra position, contradiction).

Week 4-5: Basic Structures: Sets, Functions, Sequences, and Sums. Set operations, functions (one-to-one, onto), sequences and summations.

Week 6-7: Integers and Algorithms. The division algorithm, modular arithmetic, primes and greatest common divisors. The Euclidean algorithm. Growth of functions and Big-O notation.

Week 8: Midterm Examination.

Week 9-11: Counting and Combinatorics. The basics of counting (product rule, sum rule). The pigeonhole principle. Permutations and combinations. Binomial coefficients and identities.

Week 12-13: Advanced Counting Techniques. Recurrence relations. Solving linear recurrence relations. Generating functions.

Week 14-15: Relations. Relations and their properties. Equivalence relations and par titions. Partial orderings.

Week 16: Introduction to Graph Theory. Graphs and graph models. Graph terminology and special types of graphs. Representing graphs and graph isomorphism.

Recommended Books

Primary: Rosen, K. H. (2019). Discrete Mathematics and Its Applications (8th ed.). McGraw-Hill. Supplementary: Epp, S. S. (2019). Discrete Mathematics with Applications (5th ed.). Cengage Learning.

Supplementary: Levin, O. (2021). Discrete Mathematics: An Open Introduction (4th ed.). Open Source Textbook.

GEN-3203: Quantitative Reasoning-II Credit Hours: 3 (3-0)

This course content applies only to BS Mathematics

Prerequisites: GEN-3103: Quantitative Reasoning-I

Course Description

This course builds upon the logical foundations of QR-I, focusing on advanced reasoning tech niques and their applications across mathematical disciplines. Students will explore sophisti cated proof methods, advanced combinatorial reasoning, elementary number theory, and an introduction to mathematical modeling. The course integrates concepts from concurrent Cal culus II and Discrete Mathematics courses, developing the analytical maturity required for upper-level mathematics.

Course Learning Outcomes

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

- Apply advanced proof techniques to solve complex mathematical problems
- Analyze combinatorial structures using generating functions and advanced counting methods
- Solve number-theoretic problems using classical results and algorithms
- Develop and analyze elementary mathematical models
- Synthesize concepts from multiple mathematical domains
- Critically evaluate mathematical arguments and proofs

Comprehensive Course Contents

Week 1-4: Advanced Proof Techniques and Set Theory, Proof by minimal counterexample and well-ordering principle, The Pigeonhole Principle: advanced applications, Cardinality of infinite sets: countable and uncountable sets, Cantor's diagonalization argument, Schroder-Bernstein Theorem and its applications

Week 5-7: Advanced Combinatorics, Generating functions: ordinary and exponential, Solving recurrence relations using generating functions, Inclusion-Exclusion Principle: advanced applications, Introduction to Ramsey theory, Combinatorial identities and bijective proofs

Week 8: Midterm Examination

Week 9-10: Elementary Number Theory– Linear Diophantine equations and the Euclidean algorithm– Prime number theorem (statement and consequences)– Chinese Remainder Theorem and applications– Euler's totient function and Euler's theorem– Primitive roots and discrete logarithms

Week 11-13: Introduction to Graph Theory– Graph isomorphism and graph invariants– Planar graphs and Euler's formula– Graph coloring and the four color theorem– Matching theory and Hall's marriage theorem– Introduction to network flows

Week 14-16: Mathematical Modeling and Applications– Modeling with difference equations– Introduction to game theory: combinatorial games– Applications to computer science: coding theory and cryptography– Optimization problems and greedy algorithms– Mathematical problem-solving strategies

Recommended Books

Primary: Engel, A. (1998). Problem-Solving Strategies. Springer.

Primary: Niven, I., Zuckerman, H. S., & Montgomery, H. L. (1991). An Introduction to the Theory of Numbers (5th ed.). Wiley.

Supplementary: van Lint, J. H., & Wilson, R. M. (2001). A Course in Combinatorics (2nd ed.). Cambridge University Press.

Supplementary: West, D. B. (2001). Introduction to Graph Theory (2nd ed.). Prentice Hall. Reference: Lov´asz, L., Pelik´an, J., & Vesztergombi, K. (2003). Discrete Mathematics: Elementary and Beyond. Springer.

GEN-3204: Expository Writing Credit Hours: 3 (3-0)

Course Objectives: The course is developed with the aim to enable the students to meet their real life communication needs by

- Helping them learn and understand basic concepts of communication process
- Practically implementing theoretical aspects in the real life situations

Course Contents:

What is Communication?

- Process of communication, effective steps of communication, basic communication skills

Paragraph Writing;

- Practice in writing a good, unified and coherent paragraphs
- Paragraph writing leading towards the writing of five to seven paragraphs long essay
- Stages of writing (brain storming, researching, drafting and editing)
- Methods of writing (cause and effect, problem solutions,

  comparison and contrast)

Essay Writing;

- Basic structure of essay, topic sentence, supporting sentence, concluding sentence, thesis statement
- Unity and Coherence, Introduction and

  Conclusion

CV and Job Application;

- Preparing a Curriculum Vitae
- Writing a formal job

  application

Translation Skills;

- Urdu to English

  (Practice at advanced level)

Study Skills;

- Skimming and scanning, intensive, extensive and speed reading
- Summary and precis writing
- Comprehension (at advanced level)
- (sQ3R and

  SQ4Rmethods)

Academic Writing;

- Letter/ Memo writing, Minutes of Meeting, use of Dictionary, Library and

  Internet

Presentation Skills;

- Personality development (emphasis on content, style and pronunciation)
- Preparation stage, audience analysis, handling and asking questions, managing time, handling non-verbal means, feedback

Academic Writing;

- How to write a research proposal for research paper/term paper?
- How to write a research paper/ term paper?
- (Emphasis on style, content, language, form, clarity , consistency)

Report Writing;

- Technical Report writing
- Progress report writing
- Preparation and planning

E-mail writing;

- Creating e-mail account
- Writing and sending e-mails

Preparing for Interview and Research proposal/ research paper defense

Note: Documentaries to be shown for discussion and review

Recommended Books:

Communication Skills

a) Grammar

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

b) Writing

1.Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).

2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading

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

d) Speaking

1. Ellen, K. 2002. Maximize Your Presentation Skills: How to Speak, Look and Act on Your Way to the Top
2. Hargie, O. (ed.) Hand book of Communications Skills
3. Mandel, S. 2000. Effective Presentation Skills: A Practical Guide Better Speaking
4. Mark, P. 1996. Presenting in English. Language Teaching Publications

GEN-3206 **Pakistan Studies** **Credit Hours: 2(2-0)**

Category: General Education

Course Contents:

1. Introduction to Pakistan: Geographical location and significance. Historicalbackground: Ancient civilizations in the region. •. Factors leading to the creation of Pakistan.
2. Political History of Pakistan: • Formative phase. Military interventions and democratic transitions.
3. Geography of Pakistan: • Physiography: Mountains, plains, plateaus, deserts, valleys and coastal areas. • River systems: Indus River and its tributaries. Climatic regions of Pakistan.
4. Society and Culture of Pakistan: • Socio-cultural diversity. • Languages and literature of Pakistan.
5. Economic Development of Pakistan: • Agriculture and industrial sectors of Pakistan. • Eeonomic challenges of Pakistan.
6. Contemporary Issues: • Foreign relations of Pakistan. Security challenges: terrorism, extremism, and regional conflicts. Environmental problems and sustainable development (SDGs). Media and social change.

Recommended Books:

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

GEN-3206 Introduction to Philosophy Credit Hours: 2 (2-0)

Course Description

This course provides a broad introduction to a discipline within the Arts and Humanities. The specific course offered may vary by institution. A suggested course is Introduction to Philosophy, which introduces students to the fundamental problems and methods of philosophical inquiry. It explores core branches such as metaphysics, epistemology, and ethics through the works of major historical and contemporary thinkers.

Course Learning Outcomes

- Identify the principal branches of philosophy (metaphysics, epistemology, and ethics).
- Articulate the diverse philosophical views of multiple historical and contemporary figures.
- Interpret and reconstruct the arguments in challenging philosophical texts.

Comprehensive Course Contents

Week 1-3: What is Philosophy? The value of philosophy. Introduction to logic and argumentation. Identifying premises and conclusions.

Week 4-6: Epistemology (Theory of Knowledge). Skepticism and the problem of the external world. Rationalism (Descartes) and Empiricism (Hume).

Week 7: Philosophy of Religion. Arguments for the existence of God (ontological, cosmological, design).

Week 8: Midterm Examination.

Week 9-11: The problem of evil. Metaphysics. The mind-body problem (dualism, materialism). Free will and determinism.

Week 12-14: Ethics (Moral Philosophy). Introduction to major ethical theories: Utili tarianism (Mill) and Deontology (Kant). Introduction to applied ethics.

Week 15-16: The Meaning of Life. Exploring different philosophical perspectives on the purpose and value of human existence.

Recommended Books

Primary: Perry, J., Bratman, M., & Fischer, J. M. (Eds.). (2018). Introduction to Philosophy: Classical and Contemporary Readings (8th ed.). Oxford University Press.

Supplementary: Solomon, R. C., & Higgins, K. M. (2015). The Big Questions: A Short Introduction to Philosophy (10th ed.). Cengage Learning.

Supplementary: Nagel, T. (1987). What Does It All Mean? A Very Short Introduction to Philosophy. Oxford University Press

UOQ-3207: Understanding of the Holy Quran-I **Credit Hours: 1 (0-1)**

Week	Lecturer (1.5hours)	Units	Lesson	Assignments/home Task	Linguistic Rules
1	1	1	1-6	پڑھے گئے اسباق کے قرآنی الفاظ کا معنٰی لکھیں	معرفہ، مذکر مؤنث
	2	1	9-14	پڑھے گئے اسباق کے قرآنی الفاظ کا معنٰی لکھیں	جمع کی دو اقسام ، نکرہ اور و معنی
2	3	1	15-17	پڑھے گئے ابساق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	هذا، هذه ذالک ، تلک
	4	1	18-19 and revision of unit 1	پڑھے گئے ابساق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	لام تاکید ، اسم تفضیل
3	5	2	1-3	پڑھے گئے ابساق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	ان ، لام کئی اور فی کی بحث
	6	2	4-6	پڑھے گئے ابساق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	حروف جا ر علی ، من ، الی

4	7	2	7-9	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	حروف جار "ب"، لام نافیہ لام نفی جنس ، ما نافیہ اور الا
	8	2	10-13 and Revision of Unit 2 Assignment #1	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	ان ، کان ، حروف النداء
5	9	Unit 3	1-2	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	صفت ، موصوف
	10	3	3-5	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	مضاف ، مضاف الیہ
6	11	3	6-7	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	مضاف ، مضاف الیہ
	12	3	8-10 And revision of Unit 3 Quiz #1	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	اسم فاعل ، اسم مفعول اور مثنی
7	13	Unit 4	1-2	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	ضمیر ھو منفصل ، ہٗ ضمیر متصل
	14	4	3-4	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	حروف جار، ضمیر متصل
	15	4	5-8	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	ضمیر منفصل انت ، ضمیر متصل "ک" مرکب اضافی اور ضمیر متصل
	16	4			
8	**Mid- Term Exam**				
9	17	4	9-12	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	ضمیر منفصل ھی ، ضمیر متصل ھا
	18	4	13-16 Assignment #2	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	ضمیر منفصل انا ، ضمیر متصل ی
10	19	4	17 and revision of unit 4	پڑھے گئے اسباق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	حال

	20	Unit 5	1-2	پڑھے گئے ابساق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	جمع مذکر سالم ، جمع مذکر سالم المسبوق بحرف الجر
11	21	5	3-4	پڑھے گئے ابساق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	جمع مذکر سالم المسبوق بالاضافۃ
	22	5	5-6 Quiz #2	پڑھے گئے ابساق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	ضمر ھم منفصل و متصل
12	23	5	7-8	پڑھے گئے ابساق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	اضافت اور حروف جار
	24	5	9-11	پڑھے گئے ابساق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	ضمیر منفصل انتم اور متصل کم
13	25	5	12-14	پڑھے گئے ابساق کے قرآنی الفاظ ، قطعے اور جملوں کا ترجمہ لکھیں	ضمیر منفصل نحن ، متصل نا
	26	5	15-16	پڑھے گئے ابساق کے جملوں اور آیات کا ترجمہ لکھیں	حروف جار کو اضافت کے ساتھ ملانا
14	27	5	17-18	پڑھے گئے ابساق کے جملوں اور آیات کا ترجمہ لکھیں	اسما اشارہ ھؤلاء، اولئک
	28	5	19-23	پڑھے گئے ابساق کے جملوں اور آیات کا ترجمہ لکھیں	ما/الا، ان /الا، انما، لیس ، ما ، کان ، (الا، الیس ، الیوم ،
15					یومئذ، سبحان ، مابینھما ، قل ، اذن ، بئس ، نعم ، کلا ، ما ادراک، حسب اعلم ، مصیر ، دینا(تمییز)
	29	5	Revision unit 5 Quiz		
16	30	6	1-3	پڑھے گئے ابساق کے جملوں اور آیات کا ترجمہ لکھیں	فعل مضارع، جملہ فعلیہ ، فعل مضارع، صیغہ مفرد
	31	6	4-5	پڑھے گئے ابساق کے جملوں اور آیات کا ترجمہ لکھیں	فعل مضارع ، صیغہ مفرد یعلم

	32	6	6	پڑھے گئے ابساق کے جملوں اور آیات کا ترجمہ لکھیں	فعل مضارع صیغہ جمع یعملون
			Terminal		

Course book: معلم القرآن از ڈاکٹر عبید الرحمن بشیر (جلد 1 تا 3)

Semester-IV

GEN-4401	Introduction to Sociology	2(2-0)
GEN-4402	Ideology and Constitution of Pakistan	2(2-0)
GEN-4403	Entrepreneurship	2(2-0)
MATH-4404	Ordinary Differential Equations	3(3-0)
MATH-4405	Mathematical Computing	3(3-0)
PHY-4406	Modern Physics and Electronics	3(3-0)
PHY-4407	Physics Lab-IV	1(0-1)

GEN-4401 **Introduction To Sociology** **Credit Hrs 2(2-0)**

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

Course Contents

Unit I: Introduction

a. Definition, Scope, and Subject Matter
b. Sociology as a Science
c. Historical back ground of Sociology

Unit II: Basic Concepts

a. Group, Community, Society
b. Associations
    i. Non-Voluntary
    ii. Voluntary
c. Organization
    i. Informal
    ii. Formal
d. Social Interaction
    i. Levels of Social Interaction

ii. Process of Social Interaction
    1. Cooperation
    2. Competition
    3. Conflict
    4. Accommodation
    5. Acculturation and diffusion
    6. Assimilation
    7. Amalgamation

Unit III: Social Groups

a. Definition & Functions

b. Types of social groups
    i. In and out groups
    ii. Primary and Secondary group
    iii. Reference groups
    iv. Informal and Formal groups
    v. Pressure groups

Unit IV: Culture

a. Definition, aspects and characteristics of Culture
    i. Material and non-material culture
    ii. Ideal and real culture

b. Elements of culture
    i. Beliefs
    ii. Values
    iii. Norms and social sanctions

c. Organizations of culture
    i. Traits
    ii. Complexes
    iii. Patterns
    iv. Ethos
    v. Theme

d. Other related concepts
    i. Cultural Relativism
    ii. Sub Cultures
    iii. Ethnocentrism and Xenocentrism
    iv. Cultural lag

Unit V: Socialization & Personality

a) Personality, Factors in Personality Formation
b) Socialization, Agencies of Socialization
c) Role & Status

Unit VI: Deviance and Social Control

a) Deviance and its types
b) Social control and its need
c) Forms of Social control
d) Methods & Agencies of Social control

Unit VII: Collective Behavior

a) Collective behavior, its types
b) Crowd behavior
c) Public opinion

d) Propaganda
e) Social movements
f) Leadership

Recommended Books:

1. Anderson, Margaret and Howard F. Taylor. 2001. *Sociology the Essentials*. Australia: Wadsworth.
2. Brown, Ken 2004. *Sociology*. UK: Polity Press
3. Gidden, Anthony 2002. *Introduction to Sociology*. UK: Polity Press.
4. Macionis, John J. 2006. 10th Edition *Sociology* New Jersey: Prentice-Hall
5. Tischler, Henry L. 2002. *Introduction to Sociology* 7th ed. New York: The Harcourt Press.
6. Frank N Magill. 2003. *International Encyclopedia of Sociology*. U.S.A: Fitzroy Dearborn Publishers
7. Macionis, John J. 2005. *Sociology* 10th ed. South Asia: Pearson Education
8. Kerbo, Harold R. 1989. *Sociology: Social Structure and Social Conflict.* New York: Macmillan Publishing Company.
9. Koening Samuel. 1957. *Sociology: An Introduction to the Science of Society*. New York: Barnes and Nobel..
10. Lee, Alfred Mclung and Lee, Elizabeth Briant 1961. *Marriage and The family.* New York: Barnes and Noble, Inc.
11. Leslie, Gerald et al. 1973. *Order and Change: Introductory Sociology* Toronto: Oxford University Press.
12. Lenski, Gevbard and Lenski, Jeam. 1982. *Human Societies*. 4th edition New York: McGraw-Hill Book Company.
13. James M. Henslin. 2004. *Sociology: A Down to Earth Approach*. Toronto: Allen and Bacon.

GEN-4402: Ideology and Constitution of Pakistan Credit Hrs. 2(2-0)

Course Objectives

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

1. Demonstrate enhanced knowledge of the basis of the ideology of Pakistan with special reference to the contributions of the founding father of Pakistan.
2. Demonstrate fundamental knowledge about the Constitution of Pakistan 1973 and its evolution with special reference to state structure.
3. Explain about the guiding principles on rights and responsibilities of Pakistan citizens as enshrined in the Constitution of Pakistan 1973.

Course Contents

1. **Introduction to the Ideology of Pakistan:**
   - Definition and significance of ideology.
   - Historical contest of the creation of Pakistan (with emphasis on socio-political religious and cultural dynamics of British India between 1857 till 1947).
   - Contributions of founding fathers of Pakistan of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal, Muhammad Ali Jinnah., etc.
   - Contributions of women and students in the freedom movement for separate homeland

for Muslims of British India.

2. **Two-Nation Theory:**
   - Evolution of the Two-Nation Theory (Urdu-Hindi controversy, Partition of Bengal, Simla Deputation 1906, Allama Iqbal's Presidential Address 1930, Congress Ministries 1937 Lahore Resolution 1940).
3. **Introduction to the Constitution of Pakistan:**
   - Definition and importance of a constitution.
   - Ideological factors that shaped the Constitution(s) of Pakistan (Objectives Resolution 1949).
4. **Constitution and State Structure:**
   - Structure of Government (executive, legislature, and judiciary).
   - Distribution of powers between federal and provincial governments.
   - 18th Amendment and its impact on federalism.
5. **Fundamental Right, Principles of Policy and Responsibilities:**
   - Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles 8-28).
   - Overview of Principles of Policy (Articles 29-40).
   - Responsibilities of the Pakistan citizens (Article 5).
6. **Constitutional Amendments:**
   - Procedures for amending the Constitution.
   - Notable Constitutional amendments and their implications

Recommended Books

1. "The Idea of Pakistan" by Stephen P. Cohen.
2. "Ideology of Pakistan" by Javed Iqbal.
3. "The Struggle for Pakistan" by I.H. Qureshi.
4. "Pakistan the Formative Phase" by Khalid Bin Sayeed.
5. "Pakistan: Political Roots and Development" by Safdar Mahmood.
6. "Ideology of Pakistan" by Sharif-ul-Mujahid.
7. "The Struggle for Pakistan: A Muslim Homeland and Global Politics" by Ayesha Jala.
8. "Jinnah, Pakistan and Islamic Identity: The Search for Saladin" by Akbar S. Ahmed.
9. "The Making of Pakistan: A Study in Nationalism" by K.K. Aziz.
10. "Pakistan: A New History" by Lan Talbot.
11. "Pakistan in the Twentieth Century: A Political History" by Lawrence Ziring.
12. "The Constitution of Pakistan 1973". Original.
13. "Constitutional and Political Development of Pakistan" by Hamid Khan.
14. "The Parliament of Pakistan" by Mahboob Hussain.
15. "Constitutional Development in Pakistan" by G.W. Choudhury.
16. "Constitution-Making in Pakistan: The Dynamics of Political Order" by G.W. Choudhury.

GEN-4402 ENTREPRENEURSHIP Credit Hrs. 2(2-0)

Objective:

By the end of this course, students shall have:

1. Knowledge of fundamental entrepreneurial concepts, skills and process.
2. Understanding on different personal, social and financial aspects associated with entrepreneurial activities.

3. Basic understanding of regulatory requirements to set up an enterprise in Pakistan, with special emphasis on export businesses;
4. Ability to apply knowledge, skills and competencies acquired in the course to develop a feasible business plan.

Course Contents:

1. **Introduction to Entrepreneurship:**
   - Definition and concept of entrepreneurship.
   - Why to become an entrepreneur?
   - Entrepreneurial process.
   - Role of entrepreneurship in economic development.

2. **Entrepreneurial Skills:**
   - Characteristics and qualities of successful entrepreneurs (including stories of successes and failures).
   - Areas of essential entrepreneurial skill and ability such as creative and critical thinking, innovation and risk taking abilities etc.
3. **Opportunity Recognition** and **Idea Generation:**
   - Opportunity identification, evaluation and exploitation;
   - Innovative idea generation techniques for entrepreneurial ventures.
4. **Marketing and Sales**
   - Target market identification and segmentation;
   - Four P's of Marketing.
   - Developing a marketing strategy.
   - Branding.
5. **Financial Literacy:**
   - Basic concepts of income, savings and investments.
   - Basic concepts of assets, liabilities and equity.
   - Basic concepts of revenue and expenses.
   - Overview of cash-flows.
   - Overview of banl‹ing products including Islamic modes of financing.
   - Sources of funding for startups (angel financing, debt financing, equity financing etc.).
6. **Team Building for Startups:**
   - Characteristics and features of effective teams.
   - Team building and effective leadership for startups

7. **Regulatory Requirements to Establish Enterprises in Pakistan:**
   - Types of enterprises (e.g., sole proprietorship; partnership; private limited companies etc.).
   - Intellectual property rights and protection.
   - Regulatory requirements to register an enterprise in Pakistan, with special emphasis on export firms.
   - Taxation and financial reporting obligation.

Suggested Reading

1. "Entrepreneurship: Successfully Launching New Ventures" by Bruce R. Barringer and R. Duane Ireland.
2. "Entrepreneurship: Theory, Process, and Practice" by Donald F. Kuratko.
3. "New Venture Creation: Entrepreneurship for the 21st Century" by Jeffry A. Timmons, Stephen Spinelli Jr., and Rob Adams.
4. "Entrepreneurship: A Real-World Approach" by Rhonda Abrams.

5. "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries.
6. Effectual Entrepreneurship" by Stuart Read, Saras Sarasvathy, Nick Dew, Robert Wiltbank, and Anne-Valerie Ohlsson.

MATH-4404 Ordinary Differential Equations Credit Hrs. 3(3-0)

Course Objectives:

1. Understand physical systems that can be described by differential equations
2. Understand the practical importance of solving differential equations
3. Understand the differences between initial value and boundary value problems (IVPs and BVPs)
4. Appreciate the importance of establishing the existence and uniqueness of solutions
5. Recognize an appropriate solution method for a given problem
6. Classify differential equations.
7. Real-life applications of differential equations.

Course Contents:

First Order Differential Equations: Linear Equations, Method of Integrating Factors, Separable Equations, Modeling with First Order Equations, Differences between Linear and Nonlinear Equations, Autonomous Equations and Population Dynamics, Exact Equations and Integrating Factors, The Existence and Uniqueness Theorem. Second Order Linear Equations: Homogeneous Equations with Constant Coefficients, Solutions of Linear Homogeneous Equations, The Wronskian, Complex Roots of the Characteristic Equation, Repeated Roots, Reduction of Order, Nonhomogeneous Equations, Method of Undetermined Coefficients, Variation of Parameters. Higher Order Linear Equations: General Theory of nth Order Linear Equations, Homogeneous Equations with Constant Coefficients, The Method of Undetermined Coefficients, The Method of Variation of Parameters. Series Solutions of Second Order Linear Equations: Solutions About Ordinary Points, Solutions About Singular Points, Special Functions, Bessel's Equation, Legendre's Equation.

Recommended Books:

1. Elementary Differential Equations and Boundary Value Problems" by William E. Boyce and Richard C. DiPrima
2. Differential Equations with Boundary-Value Problems" by Dennis G. Zill

MATH-4405 Mathematical Computing Credit Hrs. 3(3-0)

Course Objectives:

This course introduces students to mathematical computing using software tools, with a focus on Mathematica. Students will learn how to use computational techniques to solve mathematical problems and visualize mathematical concepts.

Course Contents:

1. **Introduction to Mathematical Computing**
    - Overview of computational tools in mathematics
    - Introduction to Mathematica interface and basic functionalities
2. **Symbolic Manipulation**
    - Performing algebraic manipulations using Mathematica
    - Simplification, expansion, and factorization of expressions
    - Solving equations symbolically
3. **Numerical Methods and Approximations**
    - Numeric evaluation of mathematical expressions
    - Solving equations numerically using iterative methods
    - Approximation techniques: Taylor series, truncation, and rounding errors
4. **Plotting and Visualization**
    - Creating 2D and 3D plots of functions and data
    - Customizing plot appearance and labels
    - Visualizing mathematical concepts and relationships
5. **Calculus with Mathematica**
    - Computing derivatives and integrals symbolically
    - Applications of calculus: optimization, area, and volume
6. **Linear Algebra and Matrix Computations**
    - Manipulating matrices and vectors using Mathematica
    - Solving systems of linear equations
    - Eigenvalues and eigenvectors
7. **Differential Equations**

- Solving ordinary differential equations (ODEs) symbolically and numerically
- Systems of ODEs and initial value problems

8. **Programming in Mathematica**
    - Introduction to programming concepts in Mathematica
    - Defining functions, loops, and conditional statements
    - Creating custom computational tools
9. **Mathematica Applications in Various Mathematical Fields**
    - Exploring applications in calculus, linear algebra, discrete mathematics, and more
    - Symbolic and numerical solutions to real-world mathematical problems

Recommended books:

1. A Beginner's Guide to Mathematica" by David McMahon and Daniel M. Topa
2. The Student's Introduction to Mathematica" by Bruce Torrence and Eve A. Torrence
3. Hands-on Start to Wolfram Mathematica and Programming with the Wolfram Language" by Cliff Hastings, Kelvin Mischo, and Michael Morrison

PHY-4406: Modern Physics and Electronics Credit Hrs. 3(3-0)

Course Objectives:

1. To give the concept of modern physics
2. To know the nuclear structure and radioactivity
3. To know some nuclear reactions and the production of nuclear energy
4. To give a basic understanding of Plasma and LASER

Course Contents

Electronics:

Basic crystal structure, free electron model, energy band in solid and energy gaps, p-type, n-type semiconductor materials, p-n junction diode, its structure. Characteristics and application as rectifiers. Transistor, its basic structure and operation, transistor biasing for amplifiers, characteristics of common base, common emitter, common collector, load line, operating point, hybrid parameters (common emitter), Transistor as an amplifier (common emitter mode), Positive & and negative feed-back R.C. Oscillators, Monostable multi-vibrator (basic), Logic gates OR, AND, NOT, NAND, NOR and their basic applications.

Origin of Quantum Theory:

Black body radiation, Stefan Boltzmann, Wien's, and Planck's law, consequences, the quantization of energy, photoelectric and Compton Effect, Line spectra, explanation using quantum theory.

Wave Nature of Matter:

Wave behavior of particle **(**wave function etc.), its definition and relation to the probability of particle, de Broglie hypothesis and its testing, Davisson-Germer Experiment and J.P. Thomson Experiment, Wave packets, and particles, localizing a wave in space and time.

Atomic Physics:

Bohr's theory (review), Frank-Hertz experiment, energy levels of electrons, Atomic spectrum, Angular momentum of electrons, Vector atom model, Orbital angular momentum. Spin quantization, Bohr's Magnetron. X-ray spectrum (continuous and discrete) Moseley's law, Pauli's exclusion principle, and its use in developing the periodic table.

Recommended Books:

1. Robert M Eisberg, Fundamentals of Modern Physics, John Wiley & Sons 1961
2. Sanjiv Puri, Modern Physics, Narosa Publishing House, 2004.
3. Paul A. Tipler and Ralph A. Llewellyn, Modern Physics 3rd edition, W H Freeman and Company 2000.
4. Arthur Beiser, Concepts of Modern Physics (fifth edition) McGraw-Hill 1995.
5. Robert M. Eisberg and Robert Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, 2nd edition, John Wiley & Sons, 2002.
6. D. Halliday, R. Resnick, K. S. Krane, *Physics,* John Willey & Sons, Inc.

PHY-4407 Physics Lab-IV Credit Hrs. 1(0-1)

List of Experiments:

1. To develop an understanding and uses of electronic devices, including GATS, Transistors.
2. Determination of ionization potential of mercury.
3. Characteristics of a semiconductor diode (Compare Si with Ge diode)
4. Setting up of half and full wave rectifier & and study of following factors
    i. Smoothing effect of a capacitor
    ii. Ripple factor & its variation with the load.
    iii. Study of regulation of output voltage with load.
5. To set up a single-stage amplifier & and measure its voltage gain and bandwidth.
6. To set up a transistor oscillator circuit and measure its frequency with an oscilloscope.
7. To set up and study various logic gates (AND, OR, NAND, etc.) using diode and to develop their truth table.
8. To set up an electronic switching circuit using transistor LDR and demonstrate its use as a NOT Gate.
9. Characteristics of a transistor.

10. Use of computers in the learning of knowledge of GATE and other experiments.

Recommended Books

G L Squires, Practical Physics 3rd Edition, Cambridge University Press

Semester-VI

MATH-5201: Real Analysis-II Credit Hrs. 3(3-0)

Course Contents:

Dabroux upper and lower sums and integrals; Dabroux integrability; Riemann sums and the Riemann integral; Riemann integration in R^2 ; Change of order of variables of integration; Riemann-Steiltjes integration; Functions of bounded variation; Sequences and Series of Functions: Discussion of Main Problem, Point wise convergence, Uniform Convergence, Uniform Convergence and Continuity, Uniform Convergence and Integration, Uniform Convergence and Differentiation, Stone-Weierstrass Theorem. Improper integrals, Some Special Functions: The Gamma Function, The Beta function. Functions of Several Variables: Linear Transformations, Differentiation, The Rank Theorem, Determinants, Derivatives of Higher Order, Differentiation of Integrals.

Recommended Textbooks:

[1] "Principles of Mathematical Analysis" by Walter Rudin
[2] "Understanding Analysis" by Stephen Abbott
[3] "Real Analysis" by H. L. Royden and P. M. Fitzpatrick.

MATH-5202: Complex Analysis Credit Hrs. 3(3-0)

Course Description: This course introduces students to the basic concepts of complex analysis, including complex numbers, analytic functions, elementary complex mappings, series representation of functions, and conformal mappings.

Course Contents:

Complex Numbers and the Complex Plane: Complex Numbers and Their Properties, Complex Plane, Polar Form of Complex Numbers, Powers and Roots, Sets of Points in the Complex Plane. Complex Functions and Mappings: Complex Functions, Complex Functions as Mappings, Linear Mappings, Special Power Functions, Reciprocal Function, Limits and Continuity, Limits, Continuity. Analytic Functions: Differentiability and Analyticity, Cauchy-Riemann Equations, Harmonic Functions. Elementary Functions: Exponential and Logarithmic Functions, Complex Exponential Function, Complex Logarithmic Function, Complex Powers, Trigonometric and Hyperbolic Functions, Complex Trigonometric Functions, Complex Hyperbolic Functions, Inverse Trigonometric and Hyperbolic Functions. Integration in the Complex Plane, Complex Integrals, Cauchy-Goursat Theorem, Independence of Path, Cauchy's Integral Formulas and Their

Consequences, Cauchy's Two Integral Formulas, Some Consequences of the Integral Formulas. Series and Residues: Sequences and Series, Taylor Series, Laurent Series, Zeros and Poles, Residues and Residue Theorem, Some Consequences of the Residue Theorem, Conformal Mappings.

Recommended Textbooks:

[1] "A First Course in Complex Analysis with Applications" by Dennis G. Zill, Patrick D. Shanahan
[2] "Complex Variables and Applications" by Ruel V. Churchill
[3] "Introductory Complex Analysis" by Richard A. Silverman
[4] "Complex Analysis" by Lars Ahlfors
[5] "Complex Analysis" by Ian Stewart and David Tall
[6] "Visual Complex Analysis" by Tristan Needham
[7] "An Introduction to Complex Function Theory" by Bruce P. Palka
[8] "Complex Analysis" by Elias M. Stein and Rami Shakarchi
[9] "Basic Complex Analysis" by Jerrold E. Marsden and Michael J. Hoffman.

MATH-5203 Algebra-II Credit Hrs. 3(3-0)

Course Contents:

Rings: Sub Rings, Characteristic of a Ring, Ideals, Sum of Ideals, Product of Ideals, Quotient Rings, Homomorphism, Imbedding of Rings, More on Ideals, Maximal Ideals, Euclidean Domains, Prime and Irreducible Elements, Polynomial Rings, Unique Factorization Domain, Review of elementary concepts of vector spaces, Linear dependence and independence of vectors. Vector spaces and subspaces, Quotient Spaces, Direct sum of spaces, Linear transformation, Rank and Nullity of linear transformations, Algebra of linear transformation and representation of linear transformation of matrices, Change of bases, Linear functionals, Dual spaces and Annihilators, Eigenvectors and eigenvalues and Cayley-Hamilton Theorem, Diagonalization of matrices, Inner product spaces, Matrices for point group operations.

Recommended Textbooks:

[1] "Abstract Algebra" by David S. Dummit and Richard M. Foote
[2] “A First Course in Abstract Algebra” by John B. Fraleig
[3] “Topics in Algebra” by I.N. Herstein
[4] “A Course in Abstract Algebra” by Vijay K. Khanna and S. K. Bhambri

MATH-5204: Functional Analysis Credit Hrs. 3(3-0)

Course Description: This course introduces students to the fundamental concepts of functional analysis, focusing on normed vector spaces, inner product spaces, and basic properties of linear operators.

Course Contents:

Normed Spaces: Vector Space, Normed Space, Banach Space, Further Properties of Normed Spaces, Finite Dimensional Normed Spaces and Subspaces, Compactness and Finite Dimension, Linear Operators, Bounded and Continuous Linear Operators, Linear Functionals, Linear Operators and Functionals on Finite Dimensional Spaces, Normed Spaces of Operators, Dual Space. Inner Product Space: Hilbert Space, Further Properties of Inner Product Spaces, Orthogonal Complements and Direct Sums, Orthonormal Sets and Sequences, Series Related to Orthonormal Sequences and Sets, Total Orthonormal Sets and Sequences, Legendre, Hermite and Laguerre Polynomials, Representation of Functionals on Hilbert Spaces, Hilbert-Adjoint Operator, Self-Adjoint, Unitary and Normal Operators. Fundamental Theorems for Normed and Banach Spaces: Zorn's Lemma, Hahn-Banach Theorem, Hahn-Banach Theorem for Complex Vector Spaces and Normed Spaces, Adjoint Operator, Reflexive Spaces, Category Theorem, Uniform Boundedness Theorem, Strong and Weak Convergence, Convergence of Sequences of Operators and Functionals, Open Mapping Theorem, Closed Linear Operators, Closed Graph Theorem.

Recommended Textbooks:

[1] "Introductory Functional Analysis with Applications" by Erwin Kreyszig
[2] "Functional Analysis" by Peter D. Lax
[3] “Functional Analysis: An Introductory Course” by Sergei Ovchinnikov

MATH-5205: Topology Credit Hrs. 3(3-0)

Course Contents:

- **Introduction to Metric Spaces**
    - Definition of metric spaces
    - Examples of metric spaces
    - Distance between sets and diameter of sets
    - Open sets and interior points
    - Closed sets and closure of sets

- **Sequences and Convergence**
    - Convergence of sequences in metric spaces
    - Limit points and Cauchy sequences
    - Completeness of metric spaces
    - Cantor intersection theorem
- **Continuity in Metric Spaces**
    - Continuous functions between metric spaces
    - Properties of continuous functions
    - Homeomorphisms and equivalent metrics
    - Uniform continuity

- **Introduction to Topology**
    - Overview of topology and its applications
    - Set theory basics and notation
    - Topological spaces and open sets
- **Topological Properties**
    - Closed sets and limit points
    - Interior, closure, and boundary of sets
    - Basis for a topology
- **Continuity and Homeomorphisms**
    - Continuous functions between topological spaces
    - Homeomorphisms and topological equivalences
    - Examples of continuous functions

- **Compactness**
    - Open covers and finite subcovers
    - Compact subspaces of Hausdorff spaces
- **Connectedness**
    - Connected sets and components
    - Constructions with connected spaces
- **Separation Axioms**
    - T0, T1, T2 (Hausdorff), T3, T4 (normal) spaces

Recommended Textbooks:

[1] ”Metric Spaces Including Fixed Point Theory and Set-valued Maps” by Qamrul Hasan Ansari
[2] "Topology" by James R. Munkres
[3] “Introduction to Metric and Topological Spaces” by W.A. Sutherland
[4] “An Introduction to Point-Set Topology” by Andrew Pease

VIII Semester

MAT-6401	**Numerical Analysis-II**	**3(3-0)**
MAT-6402	**Differential Geometry-II**	**3(3-0)**
MAT-6403	**Mathematical Physics**	**3(3-0)**
MAT-6404	**Fluid Mechanics-II**	**3(3-0)**
MAT-6405	**Quantum Mechanics**	**3(3-0)**
MAT-6406	**Integral Equations**	**3(3-0)**
MAT-6407	**An Introduction to Convex Analysis**	**3(3-0)**
MAT-6408	**Calculus of Variation & Optimal Control**	**3(3-0)**
MAT-6409	**Dynamical Systems**	**3(3-0)**
MAT-6410	**Computer Language C/C^{++}**	**3(3-0)**
MAT-6411	**Electromagnetism**	**3(3-0)**
MAT-6412	**Special Theory of Relativity**	**3(3-0)**
MAT-6413	**Topology-II**	**3(3-0)**
MAT-6414	**Theory of Elasticity**	**3(3-0)**
MAT-6415	**Decomposition of Modules**	**3(3-0)**

MAT-6401 Numerical Analysis-II 3(3-0) Prerequisite(s): Numerical Analysis-I

Specific Objectives of the Course:

The most phenomena in our World are essentially non-linear or desire by non-linear equations may be PDE and ODE since that appearance of high performance digit computers it becomes easier to solve the problem .However, Generally Spacing it is still difficult to obtained or get an analytical approximations then a numerical one of a given non-Linear problem. The numerical techniques generally can be applied to non-linear problems in complicated computational domain. This is obvious of advantage on numerical methods over analytical one that often handle non-linear problem in simple domain. Numerical method gives discontinuous points of a curve. Thus it is often costly or time consuming to get a complete of those results. Besides from numerical results it is hard to have whole and essential understanding of non-linear problems. A number of software package has been developed to produce symbolic mathematical computations such as Mathematica and Matlab.

Course Outline:

Osculating polynomials; Differentiation and integration in multidimensional; Predicator methods; Modified Euler's Method; Truncation error and stability; The Taylor Series method; Runge-Kutta methods; Differential equations of higher order system of differential equations; Runge-Kutta methods; Shooting methods; Finite difference methods; Elliptic, hyperbolic and parabolic equations; Explicit and implicit finite difference methods; Stability; Convergence and consistency analysis; The method of characteristic; Estimation of eigenvalues and corresponding error bounds; Gerschgorin's theorem and its applications; Power method; Shift of origin; Deflation method for the subdominant eigenvalues.

Recommended Books:

[1] Conte SD, De Boor, Elementary Numerical Analysis, 1972, McGraw-Hill. [2] Gerald CF, Applied Numerical Analysis, 2006, Addison Wesley.
[3] Froberg CE, Introduction to Numerical Analysis, 1972, Addison Wesley.

[4] Gourlay AR, Watson GA, Computational Methods of Matrix Eigen Problems, 1973, John Wiley & Sons.

[5] Smith GD, Numerical Solution of Partial Differential Equations, 1986, Oxford University Press.

[6] Mitchel AR, Griffith DE, The Finite Difference Methods in Partial Differential Equations, 1980, John Wiley & Sons.

MAT-6402 Differential Geometry-II 3(3-0) Prerequisite(s): Differential Geometry-I

Specific Objectives of the Course:

Differential geometry is a main branch of analysis and geometry. It is impossible to solve any problem of physical life without clear understanding of basic ideas of differential geometry. Particularly, modern physics is written in the language of differential geometry. This course aims to introduce this language.

Course Outline:

Extension of analytical geometry to n-dimensional flat space, Cartesian tensors, Curved space and manifolds, Tangent and cotangent spaces, Vector fields and their flows, Lie derivatives of vector fields and dual vector fields, Metric connection, Tensors on manifolds and their Lie and covariant differentials, Killing vector fields, Curvature tensor and the Bianchi identities, Geodesics and the exponential map, Heuristic to integration on manifolds.

Recommended Books:

[1] Laugwitz D, Differential and Riemannian Geometry, 1970, Academic Press.

[2] Livelock D, Rund H, Tensors: Differential forms and Variational Principles, 1975, John Wiley.

[3] Eisenhart LP, Riemannian Geometry, 1964, Princeton University Press.

[4] Eisenhart LP, An Introduction to Differential Geometry with use of the Tensor Calculus, 1947, Princeton University Press.

MAT-6403 Mathematical Physics 3(3-0) Prerequisite(s): Partial Differential Equations

Specific Objectives of the Course:

There are several distinct branches of mathematical physics; these roughly correspond to particular historical periods. In this course we shell study the Lap lace transform, Fourier transform and variational techniques. Laplace transform reduces the solution of an ordinary differential equation to an algebraic equation. In fact this method has a particular advantage in finding the general solution and the using for evaluating the arbitrary constant with appropriate initial conditions without finding the general solution and then using initial conditions for evaluating the arbitrary constants. Also when the Laplace transform technique is applied to partial differential equations, it reduces the number of independent variables by one. Fourier transform techniques have been widely used to solve problems involving semi-infinite or totally infinite range of variables or unbounded regions. The one of most

interesting method used in mathematical physics is the calculus of variations. The theory of partial differential equations, the related areas of variational calculus and Fourier analysis are closely related with mathematical physics.

Course Outline:

Definitions and properties of Laplace transforms with proofs, The inversion problems, Convolution and inversion theorem with illustrative examples. Applications of Laplace transforms to ordinary and partial differential equations, Definition and basic properties of Fourier Transforms with proofs, Fourier integrals, Convolution theorem. Persaval's theorems, Fourier sine and cosine transforms with illustrative examples, Fourier sine and cosine transforms of derivatives, Applications of Fourier transforms to boundary value problems.

Recommended Books:

[1] Butkov EL, Mathematical physics, Addison-Wesley.

[2] Sagan H, Boundary and Eigen value Problems in Mathematical Physics. [3] Arfken G, Mathematical Methods for Physics, Academic press.

MAT-6404 Fluid Mechanics-II 3(3-0) Prerequisite(s): Fluid Mechanics-I

Specific Objectives of the Course:

Fluid mechanics is an exciting and fascinating subject with unlimited practical applications ranging from microscopic biological systems to modern technological developments in engineering and industry. Fluid mechanic has historically been one of the most challenging subjects for Graduate/Undergraduate students. Fluid mechanics is a very broad filed. A small library of books would be required to cover all of the topics that could be included in it. In this course we shall be interested mainly in flows of interest to daily life science/engineering problems but even that is very broad area so we shall classify the types of problems that may be encountered. The original aims of this course to develop the basic ideas/concepts, fundamental laws, equations (Constitutive) for viscous / Newtonian fluids. After presenting the basic concepts of fluid mechanics we than discuss how mathematical models for physical/engineering problems are prepare and how to interpret the result obtain from the analysis of such models than a systematic problem-solving techniques/ method that can be used to solve those problems in detail.

Course Outline:

Constitutive equations, Navier-Strokes equations, Exact solutions of Navier-Strokes equations, Steady unidirectional flow, Poiseuille flow, Couette flow , Unsteady unidirectional flow , Sudden motion of a plane boundary in a fluid at rest , Flow due to an oscillatory boundary , Equations of motion relative to a rotating system, Ekman flow , Dynamical similarity and the Reynold's number, Flow over a flat plate (Blasius solution). Reynold 's equations of turbulent motion.

Recommended Books:

[1] Landau LD, Lifshitz EM, Fluid Mechanics, 1966, Pergamon Press.

[2] Batchelor GK, An introduction to Fluid Dynamics, 1969, Cambridge University Press. [3] Jaunzemies W, Continuum Mechanics, 1967, Macmillan Company.

[4] Milne Thomson, Theoretical Hydrodynamics, 1967, Macmillan Company. [5] Schlichting H, Boundary Layer Theory, 1979, McGraw Hill.
[6] Streeter, Hand Book of Fluid Dynamics, McGraw Hill.

[7] Charlton F, Textbook of fluid Dynamics, 1967, D. Van Nostrand Co. Ltd.

MAT-6405 Quantum Mechanics 3(3-0) Prerequisite(s): Classical Mechanics

Specific Objectives of the Course:

The mathematical formulation of quantum mechanics is abstract and its implications are often non-intuitive. The centerpiece of this mathematical system is the wave function. The wave function is a mathematical function of time and space that can provide information about the position and momentum of a particle, but only as probabilities, as dictated by the constraints imposed by the uncertainty principle. Mathematical manipulations of the wave function usually involve the bracket notation, which requires an understanding of complex numbers and linear functional. Many of the results of Quantum Mechanics can only be expressed mathematically and do not have models that are as easy to visualize as those of classical mechanics. For instance, the ground state in quantum mechanical model is a non-zero energy state that is the lowest permitted energy state of a system, rather than a more traditional system that is thought of as simple being at rest with zero kinetic energy.

Course Outline:

Basic postulates of quantum mechanics, State vectors, Formal Properties of quantum mechanical operators. Eigenvalues and Eigen-states, Simple harmonic oscillator, Schordinger representation, Heisenberg equation of motions, Schrodinger equation, Potential step, Potential barrier, Potential well, Orbital angular momentum motion in a centrally symmetric field, Hydrogen atom, Matrix
representation of angular momentum and spin, Time independent perturbation theory, Degeneracy, The stark effect, Introduction to relativistic quantum mechanics.

Recommended Books:

[1] Fayyazuddin, Riazuddin, Quantum Mechanics, 1990, World Scientific. [2] Merzebacher E, Quantum Mechanics, 1970, John Wiley.
[3] Liboff RL, Introduction Quantum Mechanics, 1991, Addison-Wesley. [4] Dirac PMA, Principles of Quantum Mechanics, 1985, Oxford University Press.

MAT-6406 Integral Equations 3(3-0) Prerequisite(s): Ordinary Differential Equations

Specific Objectives of the Course:

Many physical problems which are usually solved by differential equation methods can be solved more effectively by integral equation method. Indeed, the latter have been appearing in current literature with increasing frequency and have provided solutions to problems heretofore not solvable by standard methods of differential equations, and the type of solutions explored in this course will be useful particularly in applied mathematics, theoretical mechanics, and mathematical physics. If the kernel is separable, the problem of solving an integral equation of second kind reduces to that of solving an algebraic system of equations. Unfortunately, integral equations with degenerate kernel do not occur frequently in practice. But they are easily treated, and furthermore, the results derived in this course for such questions lead to better understanding of integral equations of more general type,

it is worthwhile to study them. When an integral equation cannot be solved in closed form, then recourse has to be taken to approximate methods can be applied with confidence only if the existence of the solution is assured in advance. The Fredholm theory included in this course provides such an assurance. We shall study the Hilbert Schmidt theory, the Wiener-Hopf technique which is very useful in solving problems in science and engineering.

Course Outline:

Integral equation formulation of boundary value problems, Classification of integral equations, Method of successive approximation, Hilbert-Schmidt theory, Schmidt's solution of non homogeneous integral equations, Fredholm theory, Care of multiple roots of characteristic equation, Degenerate kernels, Introduction to Wiener-Hopf technique.

Recommended Books:

[1] Lovitt WV, Linear Integral Equations, 1950, Dover Publication.

[2] Smith F, Integral Equations, 2003, Cambridge University Press.

[3] Tricomi FG, Integral Equations, 1957, Interscience.

[4] Noble B, Methods Based on the Wiener-Hopf Technique, 1958, Pergamon Press.

[5] Abdul JJ, Introduction to Integral Equations with Applications, 1985, Marcel Dekker Inc. New York.

MAT-6407 An Introduction to Convex Analysis 3(3-0) Prerequisite(s): Functional Analysis-I

Specific Objectives of the Course:

The main purpose of this course is to introduce the convexity. The prerequisites are mainly linear algebra and linear programming (LP) including the duality theorem and the simplex algorithm.
The second, and final, part of the course is to go into convexity. The plenty of material in convexity is presented in this course.

Course Outline:

The basic concepts, Convex hulls and Caratheodory's theorem, Projection and separation, Representation of convex sets, Convex functions, Nonlinear and convex optimization.

Recommended Books:

[1] Jean-Baptiste Hiriart-Urruty, *Fundamentals of Convex Analysis*, 2003, Springer.

[2] Magaril-Ilyaev GG, Tikhomirov VM, *Convex Analysis*: Theory and Applications, 2003, AMS.

MAT-6408 Calculus of Variation & Optimal Control 3(3-0) Prerequisite(s): Optimization Theory

Specific Objectives of the Course:

A huge amount of problems in the calculus of variations have their origin in physics where one has to minimize the energy associated to the problem under consideration. Nowadays many problems come from economics. Here is the main point that the resources are restricted. There is no economy without restricted resources. The calculus of variations is concerned with the construction of optimal

shapes, states, or processes where the optimality criterion is given in the form of an integral involving an unknown function. The task of the calculus of variations then to demonstrate the existence and to deduce the properties of some function that realizes the optimal value for this integral. Such problems occur in many-fold applications, in particular physics, engineering, economics and variational integral may represents some action, energy, or cost functional. The calculus of variations also has deep and important connections with other fields of mathematics. For instance, in geometrically defined classes of objects, a variational principle often permits the selection of a unique optimal representative and the properties of can frequently be used to much advantage to deduce additional information about its class. For these reasons, the calculus of variations is a rich mathematical subject.

Course Outline:

Variation of the functionals, Euler-Lagrange equation and its particular cases, Lagrange problem with free end points, Lagrange problem with more than one functionals, Variational problems with constraints,from Calculus of Variations to Optimal Control, The Maximum Principle, The Hamilton-Jacobi-Bellman equation, The Linear Quadratic Regulator.

Recommended Books:

[1] Moser J, *Selected Chapters in the Calculus of Variations*, 2003, Birkhauser-Verlag, Switzerland.

[2] Liberzon D, *Calculus of Variations & Optimal Control Theory*, 2012, Princeton University Press.

MAT-6409 Dynamical Systems 3(3-0) Prerequisite(s): Ordinary Differential Equations, Linear Algebra

Specific Objectives of the Course:

After taking this course it is expected that the students will learn about the linear and nonlinear dynamical systems. They will be able to construct and analyze the models of real time-dependent systems in several different areas of study. Moreover, this course will be helpful to use Mathematica for the investigation of different properties of dynamical systems.

Course Outline:

Introduction: Preliminary ideas, Autonomous equations, Autonomous systems in plane, Linear systems: Linear changes of variables, Similarity types for 2×2 real matrices, Phase portraits for canonical systems in the plane, Classification of simple linear phase portraits in the plane. Nonlinear systems in the plane: Local and global behavior, Linearization at a fixed point, The linearization theorem, Non-simple fixed points, Stability of fixed points, Ordinary points and global behavior. Applications: Linear models, Nonlinear models, Relaxation oscillation, Piecewise modeling. Dynamical systems with Mathematica: Differential equations, Planar systems, Interacting species.

Recommended Books:

[1] Lynch S, Dynamical systems with Applications using Mathematica, 2007, Birkhauser Boston.

[2] Alligood TK, Sauer DT, Yorke AJ, Chaos: An Introduction to Dynamical Systems, 1996, Springer.

[3] Arrowsmith KD, Place MC, Dynamical Systems, Differential Equations, Maps and Chaotic Behavior, 1992, Chapman & Hall.

MAT-6410 Computer Language C/C++ 3(3-0) Prerequisite(s): Programming Languages for Mathematicians

Specific Objectives of the Course:

The main objectives of this course are:

To present the material one simple step at a time, so the students can easily digest each concept before moving on. To explore the issues of when and how to use in lines, references, operator overloading, inheritance and dynamic objects. To introduce advanced topics such as the proper use of templates, exceptions and multiple inheritance.

Course Outline:

Introduction to objects, Making & using objects, The C in C++, Data abstraction, Hiding the implementation, Initialization & cleanup, Function overloading & default arguments, Constants, Inline functions, Name control, References & the copy-constructor, Operator overloading, Dynamic object creation, Inheritance & composition, Polymorphism & virtual functions, Introduction to templates.

Recommended Books:

[1] Ackel B, Thinking in C++, 2000, Prentice Hall.

[2] Anderson, C++ Programming & Fundamental Concepts, Prentice Hall. [3] Lam, A Jump Start Course in C++ Programming, Wiley.

MAT-6411 Electromagnetism 3(3-0) Prerequisite(s): Fluid Mechanics-I

Specific Objectives of the Course:

Electromagnetism is the branch of science concerned with the forces that occur between electrically charged particles. In electromagnetic theory these forces are explained using electromagnetic fields. Electromagnetic force is one of the four fundamental interactions in nature, the other three being the strong, the weak interaction and gravitation. Electromagnetism is the interaction responsible for practically all the phenomena encountered in daily life, with the exception of gravity. Ordinary matters takes its form as a result of intermolecular forces between individual molecules in matter. Electromagnetism manifests as both electric fields magnetic fields. Both fields are simply different aspects of electromagnetism and hence intrinsically related. Thus, a charging electric field generates a magnetic field; conversely a charging magnetic field generates an electric field. This effect is called electromagnetic induction, and is the basis of operations for electrical generators, induction motors and transformers.

Course Outline:

Electrostatics and the solution of problems in vacuum and in media, Electrostatic energy, Electric currents, The magnetic fields of steady currents, Magnetic properties of matter and its Applications, Magnetic energy, Electromagnetic induction, Maxwell's Equations and Applications, Boundary value potential problems in two dimensions and Applications, Electromagnetic waves, Radiation, Motion of electric charges and their Applications.

Recommended Books:

[1] Reitz JR, Milford FJ, Foundation of Electromagnetic Theory, 1969, Addison-Wesley. [2] Panofsky KH, Philips M, Classical Electricity and Magnetism, 1962, Addison-Wesley. [3] Corson D, Lerrain P, Introduction to Electromagnetic Fields and Waves, 1962, Freeman. [4] Ferraro VCA, Electromagnetic Theory, 1968, The Athlone Press.

MAT-6412 Special Theory of Relativity 3(3-0) Prerequisite(s): Classical Mechanics

Specific Objectives of the Course:

General relativity or the general theory of relativity is the geometric theory of gravitation published by Albert Einstein in 1915. It is the current description of gravitation in modern physics. It unifies special relativity and Newton's law of universal gravitation, and describes gravity as a geometric property of space and time. In particular, the curvature of space and time is directly related to the four-momentum (mass-energy and linear momentum) of whatever matter and radiation are present. The relation is specified by the Einstein field equations, a system of partial differential equations. To learn general relativity which differ significantly from those of classical physics, especially concerning the passage of time, the geometry of space, the motion of bodies in free fall, and the propagation of light.

Course Outline:

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

Recommended Books:

[1] Qadir A, Relativity: An Introduction to the Special Theory, 1989, World Scientific. [2] Goldstein H, Classical Mechanics, 1962, Addison-Wesley, New York. [3] Jackson JD, Classical Electrodynamics, 1962, John Wiley, New York. [4] Rindler W, Essential Relativity, 1977, Springer-Verlag.

MAT-6413 Topology-II 3(3-0) Prerequisite(s): Topology-I

Specific Objectives of the Course:

This is a continuation of the study of topology and how it extends the ideas of geometry, place, location and analysis, as well as some of the newer applications of topology.

Course Outline:

Compactness in metric spaces, Limit point compactness, Sequential compactness and their various characterization, Equivalence of different notions of compactness. Connectedness with examples, Various characterizations of connectedness and its Application, Connectedness and T_2-spaces, Local connectedness, Path-connectedness, Components and its Application. Homotopic maps with

examples, Homotopic paths, Loop spaces and its Application, Fundamental groups, Covering spaces, The chain complexes, Notion of homology.

Recommended Books:

[1] Greenberg MJ, Algebraic Topology, A First Course, 1967, The Benjamin/Commings publishing Company.

[2] Wallace AH, Algebraic Topology, Homology and Cohomology, 1968, New York. [3] Gemignani MC, Elementary Topology, 1972, Addison-Wesley Publishing Company. [4] Ahmad B, Introduction to General Topology, 2004, Ideal Publishers.

MAT-6414 Theory of Elasticity 3(3-0) Prerequisite(s): Classical Mechanics

Specific Objectives of the Course:

Linear elasticity is the mathematical study of how solid objects deforms and become intemally stressed due to prescribed condition. It relies upon the continuum hypothesis and in applicable at macroscopic (and sometime microscopic) length seals. It is a branch of continuum mechanics. The fundamental (linearizing) assumptions of linear elasticity are infinitesimal strain or small deformations and linear relationship between stress & rate of strain. In addition linear elasticity is only valid for stress state, that do not produce yielding. These assumptions are reasonable for many engineering materials. Linear elasticity in therefore used extensively in structural analysis and engineering design. We hope that at the end of the course the student will understand the concepts / basic of elasticity and have a working knowledge as well as creative thinking.

Course Outline:

Cartesian tensors, Analysis of stress and strain, Generalized Hooke's law, Crystalline structure, Point groups of crystals, Reduction in the number of elastic moduli due to crystal symmetry, Equations of equilibrium, Boundary conditions, Compatibility equation, plane stress and plane strain problems, Two dimensional problem in rectangular and polar co-ordinates, Torsion of rods and beams.

Recommended Books:

[1] Sokolinikoff, Mathematical Theory of Elasticity, McGraw-Hill, New York. [2] Dieulesaint E, Royer D, Elastic Waves in Solids, 1980, John Wiley and Sons, New York. [3] Funk YC, Foundations of Solid Mechanics, 1965, Prentice-Hall, Englewood Cliffs.

MAT-6415 Decomposition of Modules 3(3-0) Prerequisite(s): Ring Theory

Specific Objectives of the Course:

In graph theory, the modular decomposition is a decomposition of an undirected graph into subsets of vertices called modules. A module is a generalization of connected component of a graph. Unlike connected components, however, one module can be proper subset of another. Modules therefore lead to a recursive (hierarchical) decomposition of graph, instead of just a partition. For each undirected graph, this decomposition is unique. At the end of the course we expect that the students understand the concepts of Decomposition of Modules.

Course Outline:

Rings and modules with examples, decomposition of modules and their Applications, Decomposition theorem, The primary Decomposition theorem, The primary Decomposition, Abelian groups as z-modules, Abelian groups, Sylow's theorem, Linear transformation and
matrices, Invariants and the Jordan canonical form, The rational canonical form theorem (linear transformation version), The Jordan canonical form theorem, Conjugacy classes in general linear groups.

Recommended Books:

[1] Blyth T, Modules theory, 1977, O.U.P., Oxford.

[2] Hartley B, Hawkes T, Rings, Modules and linear Algebra, Chapman G. Lecture Notes on Modules, Michigan University Press.