UNIVERSITY OF SARGODHA
Office of the Registrar

No. DCE 4115
Date: 25/11/20

Ref: SU/Acad 979
November 20 /2020

Notification

The Academic Council in its meeting held on 18.06.2020 has approved the following recommendations made by the Board of Faculty of Sciences in its meeting held on 03.06.2020. The Syndicate in its meeting held on 27.07.2020 has also endorsed the decision of Academic Council:

1. Revised scheme of studies of BS Mathematics under Semester / Term System from session 2020 (Annex-'A')
2. Revised scheme of studies of MSc Mathematics under Semester / Term System from session 2020 (Annex-'B')
3. Revised scheme of studies of MPhil Mathematics from session 2020 (Annex-'C')
4. Revised scheme of studies of PhD from session 2020 (Annex-'D')

Muhammad Farooq
Deputy Registrar (Acad)
20/11/2020

Distribution:

- Chairman, Department of Mathematics
- Director, Sub-Campus Bhakkar
- Controller of Examinations
- Principals of all affiliated colleges (concerned)
- Web-Developer *(for uploading on university web-site)*

C.C:

- Focal Person, Faculty of Sciences
- Deputy Registrar (Affiliation)
- Deputy Registrar (Registration)
- Secretary to the Vice-Chancellor
- P.A to Registrar

Same remarks as on the notification of Sociology.

23/11/2021

26/11

DCE(S)

048-9230802 registrar@uos.edu.pk www.uos.edu.pk University of Sargodha, University Road, Sargodha, Pakistan

mathematics 1305

Annexure-I

REVISED SCHEME OF STUDIES

&

CURRICULUM

BS MATHEMATICS

(Semester / Term System)

(2020)

DEPARTMENT OF MATHEMATICS

UNIVERSITY OF SARGODHA

SARGODHA

Curriculum

Scheme of Studies of BS Mathematics

Total Semesters: 08

Duration of each Semester: 18 weeks

No	Course Code	Course Title	Cr. Hours	Page No.
Compulsory Courses				
Semester-I				
1	MATH-5101	Calculus-I	3(3+0)	1
2	MATH-5102	Elements of Set Theory and Mathematical Logic	3(3+0)	2
3	PHYS-5161	Physics-I	4(3+1)	3
4	URCE-5101	Grammar	3(3+0)	4
5	URCP-5106	Pakistan Studies	2(2+0)	5
6	URCI-5109	Introduction to Information and Communication Technologies	3(3+0)	6
Total			18	
Semester-II				
1	MATH-5103	Calculus-II	3(3+0)	7
2	MATH-5104	Statistics	3(3+0)	8
3	PHYS-5162	Physics-II	4(3+1)	9
4	URCE-5102	Language Comprehension & Presentation Skills	3(3+0)	10
5	URCI-5105	Islamic Studies	2(2+0)	11
6	MATH-5105	Programming Languages for Mathematicains	3(2+1)	12
No-Credit Course				
7	URCC-5110	Citizenship Education and Community Engagement	3(1+2)	13
Total			18	
Semester-III				
1	MATH-5106	Calculus-III	3(3+0)	14
2	MATH-5107	Algebra-I	3(3+0)	15
3	PHYS-5163	Physics-III	4(3+1)	16
4	URCE-5103	Academic Writing	3(3+0)	17
5	MATH-5108	Probability Theory	3(3+0)	18
Total			16	
Semester-IV				
1	MATH-5109	Vector Analysis & Mechanics	3(3+0)	19
2	MATH-5110	Linear Algebra	3(3+0)	20
3	PHYS-5164	Physics-IV	4(3+1)	21
4	MATH-5111	Discrete Mathematics	3(3+0)	22
5	MATH-5112 / MATH-5113 / ECON-5118	Spanish/French/Mathematical Economics	3(3+0)	23/24/25
Total			16	

Semester-V				
1	MATH-6112	Topology	3(3+0)	26
2	MATH-6113	Differential Geometry	3(3+0)	27
3	MATH-6114	Ordinary Differential Equations	3(3+0)	28
4	MATH-6115	Real Analysis-I	3(3+0)	29
5	MATH-6116	Algebra-II	3(3+0)	30
Total			15	
Semester-VI				
1	MATH-6117	Classical Mechanics	3(3+0)	31
2	MATH-6118	Mathematical Methods	3(3+0)	32
3	MATH-6119	Complex Analysis	3(3+0)	33
4	MATH-6120	Functional Analysis	3(3+0)	34
5	MATH-6121	Real Analysis-II	3(3+0)	35
Total			15	
Semester-VII				
1	MATH-6122	Numerical Analysis-I	3(3+0)	36
2	MATH-6123	Number Theory	3(3+0)	37
3	MATH-6124	Partial Differential Equations	3(3+0)	38
4	MATH-61xx	Elective-I*	3(3+0)	
5	MATH-61xx	Elective-II*	3(3+0)	
Total			15	
Semester-VIII				
1	MATH-6125	Numerical Analysis-II	3(3+0)	39
2	MATH-6126	Integral Equations	3(3+0)	40
3	MATH-61xx	Project / Course**	3(3+0)	
4	MATH-61xx	Elective-III*	3(3+0)	
5	MATH-61xx	Elective-IV*	3(3+0)	
Total			15	

Total Numbers of Credit Hours=128

* These four courses are optional and can be selected either from list A or B but cannot be mixed from both or any two courses can be selected from list C.

** In lieu of dissertation a course can be selected from list C.

*** Any other language can be added according to availability of resources.

Note

These courses will be offered by the department from the lists of concentration elective courses and free elective courses as per availability of the resources.

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List of Concentration Elective Courses

A student must satisfactorily complete 12 credit hours of any one of the following concentration groups of Elective Courses namely, Pure or Applied Mathematics.

List A

Concentration Elective Courses in Pure Mathematics

Course Code	Course Title	Cr. Hrs.	Page No.
MATH-6127	Advanced Group Theory-I	3(3+0)	41
MATH-6128	Advanced Group Theory-II	3(3+0)	42
MATH-6129	Modern Algebra-I	3(3+0)	43
MATH-6130	Modern Algebra-II	3(3+0)	44
MATH-6131	Algebraic Topology-I	3(3+0)	45
MATH-6132	Algebraic Topology-II	3(3+0)	46
MATH-6133	Advanced Functional Analysis	3(3+0)	47
MATH-6134	Theory of Modules	3(3+0)	48

List B

Concentration Elective Courses in Applied Mathematics

Course Code	Course Title	Cr. Hrs.	Page No.
MATH-6135	Astronomy-I	3(3+0)	49
MATH-6136	Astronomy-II	3(3+0)	50
MATH-6137	Electromagnetism-I	3(3+0)	51
MATH-6138	Electromagnetism-II	3(3+0)	52
MATH-6139	Fluid Mechanics-I	3(3+0)	53
MATH-6140	Fluid Mechanics-II	3(3+0)	54
MATH-6141	Operations Research-I	3(3+0)	55
MATH-6142	Operations Research-II	3(3+0)	56
MATH-6143	Quantum Mechanics-I	3(3+0)	57
MATH-6144	Quantum Mechanics-II	3(3+0)	58
MATH-6145	Analytical Dynamics	3(3+0)	59
MATH-6146	Special Relativity	3(3+0)	60

List C

List of Free Elective Courses

A student must also satisfactorily complete 06 credits of any one of the following free Elective Courses in Applied & Pure Mathematics

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Course Code	Course Title	Cr. Hrs.	Page No.
MATH-6147	Numerical Solution of Partial differential equations	3(3+0)	61
MATH-6148	Elasticity Theory	3(3+0)	62
MATH-6149	History of Mathematics	3(3+0)	63
MATH-6150	Heat Transfer	3(3+0)	64

MATH-6151	Bio-Mathematics	3(3+0)	65
MATH-6152	Theory of Automata	3(3+0)	66
MATH-6153	Measure Theory	3(3+0)	67
MATH-6154	Special Functions	3(3+0)	68
MATH-6155	Theory of Splines-I	3(3+0)	69
MATH-6156	Theory of Splines-II	3(3+0)	70
MATH-6157	Methods of Optimization-I	3(3+0)	71
MATH-6158	Methods of Optimization-II	3(3+0)	72
MATH-6159	Control Theory	3(3+0)	73
MATH-6160	Applied Matrix Theory	3(3+0)	74

Note: Other elective courses can be offered according to availability of resources.

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MATH-5101 **Calculus-I** **3 (3+0)**

Calculus is the mathematical study of continuous change. If quantities are continually changing, we need calculus to study what is going on. Calculus is concerned with comparing quantities which vary in a non-linear way. It is used extensively in science and engineering, since many of the things we are studying (like velocity, acceleration, current in a circuit) do not behave in a simple, linear fashion. Calculus has two major branches, differential calculus (Calculus – I) and integral calculus (Calculus – II); the former concerns instantaneous rates of change, and the slopes of curves, while integral calculus concerns accumulation of quantities, and areas under or between curves. This is the first course of the sequence, Calculus-I, II and III, serving as the foundation of advanced subjects in all areas of mathematics. The sequence, equally, emphasizes basic concepts and skills needed for mathematical manipulation. It focus on the study of functions of a single variable. Calculus-I is an introduction to differential and integral calculus: the study of change.

Contents

1. Functions and their graphs, Rates of change and tangents to curves
2. Limit of a function and limit laws, the precise definition of a limit
3. One-sided limits, continuity, Limits involving infinity; asymptotes of graphs
4. Differentiation: tangents and derivative at a point, the derivative as a function
5. Differentiation rules, the derivative as a rate of change
6. Derivatives of trigonometric functions, Chain rule, implicit differentiation
7. Related rates, linearization and differentials, higher derivatives
8. Applications of derivatives: extreme values of functions
9. Rolls' theorem, the mean value theorem, Monotonic functions and the first derivative test
10. Convexity, point of inflection and second derivative test, Concavity and curve sketching
11. Applied optimization, Antiderivatives, integration: area and estimating with finite sums
12. Sigma notation and limits of finite sums, definite integral, the fundamental theorem of calculus
13. Indefinite integrals and the substitution method, Substitution and area between curves
14. Applications of definite integrals: volumes using cross-sections
15. Volumes using cylindrical shells, arc length, Areas of surfaces of revolution
16. Transcendental functions: inverse functions and their derivatives
17. Natural logarithms, exponential functions, Indeterminate forms and L' Hôpital's rule
18. Inverse trigonometric functions, hyperbolic functions

Recommended Texts

1. Thomas, G. B., Weir, M. D. and Hass J. R. (2014). *Thomas' Calculus: single variable* (13th ed.). London: Pearson plc.
2. Stewart, J. (2015). *Calculus* (8th ed.). Boston: Cengage Learning.

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Suggested Readings

1. Anton, H., Bivens I. C. and Davis, S. (2016). *Calculus* (11th ed.). New York: Wiley.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I. and Asmar, N. H. (2017). *Calculus & its applications* (14th ed.). London: Pearson.
3. Larson, R. and Edwards, B. H. (2013). *Calculus* (10th ed.). New York: Brooks Cole.

MATH-5102 Elements of Set Theory and Mathematical Logic 3 (3+0)

The main aim of this course is the study of set theory and the concept of mathematical logic. 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 foundational role of set theory and its mathematical development have raised many philosophical questions that have been debated since its inception in the late nineteenth century. In particular, mathematicians have shown that virtually all mathematical concepts and results can be formalized within the theory of sets. The course aims at familiarizing the students with cardinals, ordinal numbers, relations, functions, Boolean algebra and fundamentals of propositional and predicate logics.

Contents

1 Set theory: sets, subsets
2 Operations with sets: union, intersection
3 Difference, symmetric difference
4 Cartesian product and disjoint union
5 Functions: graph of a function
6 Composition; injections, surjections, bijections, inverse function
7 Computing cardinals: Cardinality of Cartesian product, union
8 Cardinality of all functions from a set to another set
9 Cardinality of all injective, surjective and bijective functions from a set to another set
10 Infinite sets, finite sets
11 Countable sets, properties and examples
12 Operations with cardinal numbers. Cantor-Bernstein theorem
13 Relations: equivalence relations
14 Partitions, quotient set; examples
15 Parallelism, similarity of triangles
16 Order relations, min, max, inf, sup; linear order
17 Examples: N, Z, R, P(A). Well ordered sets and induction
18 Inductively ordered sets and Zorn's lemma
19 Mathematical logic: propositional calculus. truth tables
20 Predicate calculus

Recommended Texts

1. Halmos, P.R (2019). Native set theory. New York: Bow Wow Press.
2. Lipschuts, S. (1998). Schaum's outline of set theory and related topics (2nd ed.). New York: McGraw-Hill Education.

Suggested Readings

1. Pinter, C. C. (2014). *A book of set theory*. New York: Dover Publication.
2. O'Leary, M. L. (2015). *A first course in mathematical logic and set theory* (1st ed.). New York: Wiley.
3. Smith, D. Eggen, M. & Andre, R.S. (2014). *A transition to advanced mathematics* (8th ed.). New York: Brooks/Cole.

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PHYS- 5161 **Physics-I** 4(3+1)

First part of a two-semester sequence directed primarily towards students working towards a B.Sc. in science, with an emphasis on the life sciences. Kinematics; Newton's laws; gravitation; simple harmonic motion; mechanical waves; fluids; ideal gas law; heat and the first and second laws of thermodynamics. This course has a laboratory component.

Contents

1 Vector Analysis
2 Particle Dynamics
3 System of Particles
4 Circular Motions
5 Rotational Dynamics
6 Angular Momentum
7 Collisions
8 Work Power and Energy
9 Gravitation
10 Fluid Mechanics
11 Bulk Properties of Matters
12 Waves and Oscillations
13 Harmonic Oscillations
14 Waves in Physical Media, Sound Waves
15 Light, Interference
16 Diffraction, Polarization

Lab-I

1 Modulus of rigidity by static and dynamic method (Maxwell's needle, Barton's
2 Apparatus)
3 Determination of moment of inertia of a solid/hollow cylinder and a sphere etc.
4 To study the conservation of energy (Hook's Law)
5 To determine the surface tension of water by capillary tube method
6 To determine the value of 'g' by a compound pendulum
7 To study the laws of vibration of stretched string-using sonometer

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Recommended Texts

1. Raymond, A., Jewett, Jr., J.W. (2011). *Physics for scientists and engineers with modern physics* (8th ed.). Boston: Cengage Learning.
2. Halliday, Resnick and Walker, (2008). *Fundamental of physics, extended.* (8th ed.). New York: John Wiley.

Suggested Readings

1. Beiser. A. (1987). *Concepts of modern physics.* (4th ed.). New York: McGraw-Hill Book Co.
2. Young, H.D., Freedman, R.A. (2008). *University physics with modern physics* (14th ed.). London: Pearson.

URCE-5101 **Grammar** **3(3+0)**

The course introduces the students to the underlying rules to acquire and use language in academic context. The course aims at developing grammatical competence of the learners to use grammatical structures in context in order to make the experience of learning English more meaningful enabling the students to meet their real life communication needs. The objectives of the course are to, reinforce the basics of grammar, understand the basic meaningful units of language, and introduce the functional aspects of grammatical categories and to comprehend language use by practically working on the grammatical aspects of language in academic settings. After studying the course, students would be able to use the language efficiently in academic and real life situations and integrate the basic language skills in speaking and writing. The students would be able to work in a competitive environment at higher education level to cater with the long term learners' needs.

Contents

1 Parts of speech
2 Noun and its types
3 Pronoun and its types
4 Adjective and its types
5 Verb and its types
6 Adverb and its types
7 Prepositions and its types
8 Conjunction and its types
9 Phrases and its different types
10 Clauses and its different types
11 Sentence, parts of sentence and types of sentence
12 Synthesis of sentence
13 Conditional sentences
14 Voices
15 Narration
16 Punctuation
17 Common grammatical errors and their corrections

Recommended Texts

1. Eastwood, J. (2011). *A basic English grammar*. Oxford: Oxford University Press.
2. Swan, M. (2018). *Practical English usage* (8th ed.). Oxford: Oxford University Press.

Suggested Readings

1. Thomson, A. J., & Martinet, A. V. (1986). *A practical English grammar*. Oxford: Oxford University Press
2. Biber, D., Johansson, S., Leech, G., Conrad, S., Finegan, E., & Quirk, R. (1999). *Longman grammar of spoken and written English*. Harlow Essex: MIT Press.
3. Hunston, S., & Francis, G. (2000). *Pattern grammar: A corpus-driven approach to the lexical grammar of English*. Amsterdam: John Benjamins.

URCP-5106 **Pakistan Studies** 2(2+0)

The course is designed to acquaint the students of BS Programs with the rationale of the creation of Pakistan. The students would be apprised of the emergence, growth and development of Muslim nationalism in South Asia and the struggle for freedom, which eventually led to the establishment of Pakistan. While highlighting the main objectives of national life, the course explains further the socio-economic, political and cultural aspects of Pakistan's endeavours to develop and progress in the contemporary world. For this purpose, the foreign policy objectives and Pakistan's foreign relations with neighbouring and other countries are also included. This curriculum has been developed to help students analyse the socio-political problems of Pakistan while highlighting various phases of its history before and after the partition and to develop a vision in them to become knowledgeable citizens of their homeland.

Contents

1. Contextualizing Pakistan Studies
2. Geography of Pakistan: Geo-Strategic Importance of Pakistan
3. Freedom Movement (1857-1947)
4. Pakistan Movement (1940-47)
5. Muslim Nationalism in South Asia
6. Two Nations Theory
7. Ideology of Pakistan
8. Initial Problems of Pakistan
9. Political and Constitutional Developments in Pakistan
10. Economy of Pakistan: Problems and Prospects
11. Society and Culture of Pakistan
12. Foreign Policy Objectives of Pakistan and Diplomatic Relations
13. Current and Contemporary Issues of Pakistan
14. Human Rights: Issues of Human Rights in Pakistan

Recommended Texts

1. Kazimi, M. R. (2007). *Pakistan studies*. Karachi: Oxford University Press.
2. Sheikh, J. A. (2004). *Pakistan's political economic and diplomatic dynamics*. Lahore: Kitabistan Paper Products.

Suggested Readings

1. Hayat. S. (2016). *Aspects of Pakistan movement*. Islamabad: National Institute of Historical and Cultural Research.
2. Kazimi, M. R (2009). *A concise history of Pakistan*. Karachi: Oxford University Press.
3. Talbot, I. (1998). *Pakistan: A modern history*. London: Hurst and Company.

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URCI-5109 Introduction to Information & Communication Technologies 3 (2+1)

The course introduces students to information and communication technologies and their current applications in their respective areas. Objectives include basic understanding of computer software, hardware, and associated technologies. They can make use of technology to get maximum benefit related to their study domain. Students can learn how the Information and Communications systems can improve their work ability and productivity. How Internet technologies, E-Commerce applications and Mobile Computing can influence the businesses and workplace. At the end of semester, students will get basic understanding of Computer Systems, Storage Devices, Operating systems, E-commerce , Data Networks, Databases, and associated technologies. They will also learn Microsoft Office tools that includes Word, Power Point, Excel. They will also learn Open office being used on other operating systems and platforms. Specific software's related to specialization areas are also part of course.. Course will also cover Computer Ethics and related Social media norms and cyber laws.

Contents

1 Introduction, Overview and its types.
2 Hardware: Computer Systems & Components, Storage Devices and Cloud Computing.
3 Software: Operating Systems, Programming and Application Software.
4 Introduction to Programming Language
5 Databases and Information Systems Networks
6 The Hierarchy of Data and Maintaining Data.
7 File Processing Versus Database Management Systems
8 Data Communication and Networks.
9 Physical Transmission Media & Wireless Transmission Media
10 Applications of smart phone and usage
11 The Internet, Browsers and Search Engines.
12 Websites Concepts, Mobile Computing and their applications.
13 Collaborative Computing and Social Networking
14 E-Commerce & Applications.
15 IT Security and other issues
16 Cyber Laws and Ethics of using Social media
17 Use of Microsoft Office tools (Word, Power Point, Excel), mobile apps or other similar tool depending on the operating system.
18 Other IT tools/software specific to field of study of the students if any

Recommended Texts

1. Vermaat. M. E. (2018). *Discovering computers: digital technology, data and devices.* Boston: Course Technology Press.

Suggested Readings

1. Timothy J. O'Leary & Linda I. (2017). *Computing essentials.* (26th ed.). San Francisco: McGraw Hill Higher Education.
2. Schneider. G. M., & Gersting. J. (2018). *Invitation to computer science.* Boston: Cengage Learning.

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MATH-5103 **Calculus-II** 3(3+0)

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

Contents

1. Techniques of integration: Using Basic Integration Formulas
2. Integration by Parts
3. Trigonometric Integrals
4. Trigonometric Substitutions
5. Integration of Rational Functions by Partial Fractions
6. Integral Tables and Computer Algebra Systems
7. Numerical Integration
8. Improper Integrals
9. Sequences and Infinite Series
10. The Integral Test, Comparison Tests
11. Absolute Convergence
12. The Ratio and Root Tests
13. Alternating Series and Conditional Convergence
14. Power Series, Taylor and Maclaurin Series
15. Convergence of Taylor Series
16. The Binomial Series and Applications of Taylor Series
17. Parametrizations of Plane Curves
18. Calculus with Parametric Curves
19. Polar Coordinates
20. Graphing Polar Coordinate Equations
21. Areas and Lengths in Polar Coordinates
22. Conic Sections
23. Conics in Polar Coordinates

Pre-requisite: Calculus-I

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Recommended Texts

1. Thomas, G. B., Weir, M. D. and Hass J. R. (2014). *Thomas' Calculus: single variable* (13th ed.). London: Pearson.
2. Stewart, J. (2012). *Calculus*, (8th ed.). New York: Cengage Learning.

Suggested Readings

1. Anton, H., Bivens I. C. and Davis, S. (2016). *Calculus*. (11th ed.). New York: Wiley.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I. and Asmar, N. H. (2017). *Calculus & Its Applications* (14th ed.). London: Pearson.
3. Larson, R. and Edwards, B. H. (2013). *Calculus* (10th ed.). New York: Brooks Cole.

MATH-5104 **Statistics** **3(3+0)**

Mathematics and statistics open doors in engineering, business, finance, computing, data sciences, health sciences, environmental sciences and public policy. They are also fascinating in their own right. Recent discoveries in the mathematical sciences have played an essential role in internet search algorithms, disease control, communications technology, climate modelling and much more. Mathematics and Statistics are among the most important disciplines in today's complex world, in part because they serve as the common language of science. The main aim of this course is the study of statistical distributions like beta, gamma, binomial, exponential, Poisson, hypergeometric and normal distributions. Furthermore, the decision theory and sampling theory is also discussed.

Contents

1. Mathematical Expectation: Moments
2. Moment generating functions
3. Cummulants, cumulative functions
4. Continuous Probability distributions
5. Beta, gamma and binomial distributions
6. Exponential, Poisson, hypergeometric and normal distributions.
7. Sampling distributions
8. Sampling procedures
9. Estimation of parameters
10. Estimation of mean
11. Variance
12. Confidence intervals
13. Hypothesis testing and decision making
14. Types of errors in tests, quality control
15. Control charts for mean
16. Standard deviation
17. Variance, range
18. Goodness of fit
19. Chi-square test

Recommended Texts

1. Chaudhry, S. M. and Kamal. S. (2008). *Introduction to statistical theory. Part I, II.* (8th ed.). Lahore: Ilmi Kitab Khana.
2. DeGroot, M. H., and Schervish. M. J. (2002). *Probability and statistics* (3rd ed.). Boston: Addison- Wesley.

Suggested Readings

1. Johnson, R. (1994). *Probability and statistics for Engineers* (1st ed.). New Jersey: Prentice-Hall.
2. Papoulis, A. (1991). *Probability, random variables, and stochastic processes.* (3rd ed.). New York: McGraw Hill.
3. Sincich. T. (1990). *Statistics by examples* (3rd ed.). San Francisco: Dellen Publication Company.

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PHYS- 5162 **Physics-II** 4(3+1)

This course presents the basic concepts of electricity and magnetism, and certain aspects of electronics. The course objectives are to enable students about the ideas of electric field, electric potential, capacitor, resistance, magnetic field, and some concepts of basic electronics. The course objectives are to enable students about the ideas of electric field, electric potential, capacitor, resistance, magnetic field, and some concepts of basic electronics. Students are encouraged to share their thinking with teachers and peers and to examine different problem-solving strategies, in the said field.

Contents

1. Electric Field, Gauss's Law
2. Electric Potential, Current and Resistances
3. Direct Current and Circuits, Capacitors and Dielectrics
4. Inductance, Alternating Current and Circuits Basic Electronics
5. Magnetic Field Effects
6. Magnetic Properties of Matter
7. Electro-Magnetic Waves (Maxwell's Equations)

Lab-II

1. Conversion of a galvanometer into Voltmeter & an Ammeter,
2. To determine the frequency of A.C mains by using a sonometer,
3. To determine the frequency of A.C by Meld's experiment,
4. Resonance frequency of an acceptor circuit,
5. Resonance frequency of a rejector circuit,
6. To set up and study various logic gates (OR,AND, NOT, NAND etc.) using diode and to develop their truth table,
7. Study the characteristics of a transistor.

Pre-requisite: Physics-I

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Recommended Texts:

1. Raymond, A., Jewett, Jr., J. W. (2011). *Physics for scientists and engineers with modern physics* (8th ed.). New York: Cengage Learning.
2. Halliday, Resnick and Walker, (2008). *Fundamental of physics, extended* (8th ed.). New York: John Wiley.

Suggested Readings

1. Reitz, John R., Fredrick, M. J. (1970). *Foundations to electromagnetic theory,* (2nd ed.). Boston: Addison-Wesley Publishing Co.
2. Young, H. D., Freedman, R. A. (2008). *University physics with modern physics* (14th ed.). London: Pearson.
3. Grobe. (1993). *Basic electronics* (7th ed.). New York: McGraw Hill Book Co.

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URCE-5102 **Language Comprehension & Presentation Skills** **3(3+0)**

The course aims at developing linguistic competence by focusing on basic language skills in integration to make the use of language in context. It also aims at developing students' skills in reading and reading comprehension of written texts in various contexts. The course also provides assistance in developing students' vocabulary building skills as well as their critical thinking skills. The contents of the course are designed on the basis of these language skills: listening skills, pronunciation skills, comprehension skills and presentation skills. The course provides practice in accurate pronunciation, stress and intonation patterns and critical listening skills for different contexts. The students require a grasp of English language to comprehend texts as organic whole, to interact with reasonable ease in structured situations, and to comprehend and construct academic discourse. The course objectives are to enhance students' language skill management capacity, to comprehend text(s) in context, to respond to language in context, and to write structured response(s).

Contents

1 Listening skills
2 Listening to isolated sentences and speech extracts
3 Managing listening and overcoming barriers to listening
4 Expressing opinions (debating current events) and oral synthesis of thoughts and ideas
5 Pronunciation skills
6 Recognizing phonemes, phonemic symbols and syllables, pronouncing words correctly
7 Understanding and practicing stress patterns and intonation patterns in simple sentences
8 Comprehension skills
9 Reading strategies, summarizing, sequencing, inferencing, comparing and contrasting
10 Drawing conclusions, self-questioning, problem-solving, relating background knowledge
11 Distinguishing between fact and opinion, finding the main idea, and supporting details
12 Text organizational patterns, investigating implied ideas, purpose and tone of the text
13 Critical reading, SQ3R method
14 Presentation skills, features of good presentations, different types of presentations
15 Different patterns of introducing a presentation, organizing arguments in a presentation
16 Tactics of maintaining interest of the audience, dealing with the questions of audience
17 Concluding a presentation, giving suggestions and recommendations

Recommended Texts

1. Mikulecky, B. S., & Jeffries, L. (2007). *Advanced reading power: Extensive reading, vocabulary building, comprehension skills, reading faster*. New York: Pearson.
2. Helgesen, M., & Brown, S. (2004). *Active listening: Building skills for understanding*. Cambridge: Cambridge University Press.

Suggested Readings

1. Roach, C. A., & Wyatt, N. (1988). *Successful listening*. New York: Harper & Row.
2. Horowitz, R., & Samuels, S. J. (1987). *Comprehending oral and written language*. San Diego: Academic Press.

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URCI-5105 **Islamic Studies** 2(2+0)

Islamic Studies engages in the study of Islam as a textual tradition inscribed in the fundamental sources of Islam; Qur'an and Hadith, history and particular cultural contexts. The area seeks to provide an introduction to and a specialization in Islam through a large variety of expressions (literary, poetic, social, and political) and through a variety of methods (literary criticism, hermeneutics, history, sociology, and anthropology). It offers opportunities to get fully introductory foundational bases of Islam in fields that include Qur'anic studies, Hadith and Seerah of Prophet Muhammad (PBUH), Islamic philosophy, and Islamic law, culture and theology through the textual study of Qur'an and Sunnah..

Islamic Studies is the academic study of Islam and Islamic culture. It majorly comprises of the importance of life and that after death. It is one of the best systems of education, which makes an ethical groomed person with the qualities which he/she should have as a human being. The basic sources of the Islamic Studies are the Holy Qur'an and Sunnah or Hadith of the Holy Prophet Muhammadﷺ. The learning of the Qur'an and Sunnah guides the Muslims to live peacefully.

Contents

1. Study of the Qur'an (Introduction to the Qur'an, Selected verses from *Surah Al-Baqarah, Al-Furqan, Al-Ahzab, Al-Mu'minoon, Al-An'am, Al-Hujurat, Al-Saff*)
2. Study of the Hadith (Introduction to Hadith literature, Selected Ahadith (Text and Translation)
3. Introduction to Qur'anic Studies
4. Basic Concepts of Qur'an
5. History of Quran, Basic Concepts of Hadith
6. History of Hadith
7. Kinds of Hadith
8. Uloom –ul-Hadith
9. Sunnah & Hadith
10. Seerat ul-Nabi (PBUH), necessity and importance of Seerat, role of Seerah in the development of personality, Pact of Madinah, Khutbah Hajjat al-Wada' and ethical teachings of Prophet (PBUH).
11. Legal Position of Sunnah
12. Islamic Culture & Civilization
13. Characteristics of Islamic Culture & Civilization
14. Historical Development of Islamic Culture & Civilization
15. Comparative Religions and Contemporary Issues
16. Impact of Islamic civilization

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Recommended Books

1. Hassan. A. (1990). *Principles of Islamic jurisprudence*. New Dehli: Adam Publishers.
2. Zia-ul-Haq, M. (2001). *Introduction to al-Sharia al-Islamia*. Lahore: Aziz Publication.

Suggested Readings

1. Hameedullah, M. (1957). *Introduction to Islam*. Lahore: Sh M Ashraf Publisher.
2. Hameedullah, M. (1980). *Emergence of Islam*. New Dehli: Adam Publishers.
3. Hameedullah, M. (1942). *Muslim conduct of state*. Lahore: Sh M Ashraf Publisher.

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MATH-5105 **Programming Languages for Mathematicians** **3(2+1)**

Programming Languages plays an important role in Mathematics. A number of computer software available to deal with mathematical computing and simulation. This course provide a practical introduction to most widely used Mathematical computing software's namely, MATHEMATICA or MAPLE. After this course students will be able to develop computer programs in these software according to their requirements in mathematical computing.

Contents

Mathematica

1 Introduction to the basic environment of MATHMATICA and its syntax
2 Running MATHEMATICA
3 Numerical/Algebraic Calculations
4 Vectors, Matrices, Sets, Lists, Tables, arrays
5 Symbolic Mathematics in MATHEMATICA
6 Functions and functional programming
7 Procedural programming
8 Do, for and while loops
9 Flow controls
10 Graphics, Plots of 2D and 3D functions
11 Packages within MATHEMATICA

Maple

1. Introductory Demonstration of Maple
2. Symbolic computations in MAPLE
3. Vectors, Matrices, Sets, Lists, Tables, arrays and Arrays
4. Toolbars and Palettes
5. Operators, Constant, Elementary Functions, Procedures
6. If clauses, selection and conditional execution
7. Looping, for and while loop, looping commands
8. Recursion
9. Plots of 2D and 3D functions, Packages within MAPLE

Recommended Texts

1. Wellin P., Kamin S. Gaylord R. (2011). *An introduction to programming with mathematica*. (3rd ed.). Cambridge : Cambridge university press.
2. Monagan M. B. Geddes K. O. (2005). *Maple introductory programming guide*. Waterloo: Maplesoft, a division of Waterloo Maple Inc.

Suggested Readings

1. Aladjev, V. Z., Bogdivicus M. A. (2006). *Maple: Programming, physical and engineering Problems*. London: Fultus Publishing.
2. Maeder, R. E. (1997). *Programming in mathematica* (3rd ed.). Boston: Addision-Weseley.
3. Hoste, J. (2009). *Mathematica demystified*. New York: McGraw Hill.

URCC-5110 **Citizenship Education and Community Engagement** 3 (1+2)

In recent years, community engagement has become a central dimension of governance as well as policy development and service delivery. However, efforts to directly involve citizens in policy processes have been bedeviled by crude understandings of the issues involved, and by poor selection of techniques for engaging citizens. This course will provide a critical interrogation of the central conceptual issues as well as an examination of how to design a program of effective community engagement. This course begins by asking: Why involve citizens in planning and policymaking? This leads to an examination of the politics of planning, conceptualizations of "community" and, to the tension between local and professional knowledge in policy making. This course will also analyze different types of citizen engagement and examine how to design a program of public participation for policy making. Approaches to evaluating community engagement programs will also be a component of the course. Moreover, in order to secure the future of a society, citizens must train younger generations in civic engagement and participation. Citizenship education is education that provides the background knowledge necessary to create an ongoing stream of new citizens participating and engaging with the creation of a civilized society.

Contents

1 Introduction to Citizenship Education and Community Engagement: Orientation
2 Introduction to Active Citizenship: Overview of the ideas, Concepts, Philosophy and Skills
3 Identity, Culture and Social Harmony: Concepts and Development of Identity
4 Components of Culture and Social Harmony, Cultural & Religious Diversity
5 Multi-cultural society and inter-cultural dialogue: bridging the differences, promoting harmony
6 Significance of diversity and its impact, Importance and domains of inter-cultural harmony
7 Active Citizen: Locally active, Globally connected
8 Importance of active citizenship at national and global level, understanding community
9 Identification of resources (human, natural and others), Human rights, Universalism vs relativism
10 Constitutionalism and citizens' responsibilities: Introduction to human rights
11 Human rights in constitution of Pakistan, Public duties and responsibilities
12 Social Issues in Pakistan: Introduction to the concept of social problem, Causes and solutions
13 Social Issues in Pakistan (Poverty, Equal and Equitable access of resources, unemployment)
14 Social Issues in Pakistan (Agricultural problems, terrorism & militancy, governance issues)
15 Social action and project: Introduction and planning of social action project
16 Identification of problem, Ethical considerations related to project, Assessment of existing resources

Recommended Books

1 Kennedy, J. K. Brunold, A. (2016). *Regional context and citizenship education in Asia and Europe*. New York: Routledge Falmer.
2 Macionis, J. J. Gerber, M. L. (2010). *Sociology*. New York: Pearson Education

Suggested Books

1 British, Council. (2017). *Active citizen's social action projects guide*. Scotland: British Council
2 Larsen, K. A. (2013). *Participation in community work: international perspectives*. Vishanthie Sewpaul, Grete Oline Hole.

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MATH-5106 **Calculus-III** 3(3+0)

This is the third course of the basic sequence Calculus-I, II and III, serving as the foundation of advanced subjects in all areas of mathematics. Its focus on the study of functions of a multivariable. The main focus of the course is to the study of multiple integrals in different coordinate systems and their applications. Moreover, a brief introduction to vector calculus will also be presented.

Contents

1 Vectors and analytic geometry in space: Three-dimensional Coordinate System
2 Vectors, lines and planes in space
3 The dot product, the cross product
4 Cylinder and Quadric surfaces, vector-valued functions
5 Vector functions and space curve
6 Derivatives and integrals of vector functions
7 Arc length and Curvature
8 Motion in space, Velocity and Acceleration
9 Tangential and Normal Components of Acceleration
10 Velocity and Acceleration in Polar Coordinates
11 Functions of several variables, limits, Continuity and partial derivatives
12 Chain rule, directional derivatives and the gradient vector
13 Maximum and minimum values, optimization problems, Lagrange Multipliers
14 Multiple integrals: Double integrals over rectangles and iterated integrals
15 Double integrals over general regions
16 Double integrals in polar coordinates
17 Triple integrals in rectangular, cylindrical and spherical coordinates
18 Applications of double and triple integrals, Change of variables in multiple integrals
19 Vector calculus: Vector fields, line integrals, The fundamental theorem of Line Integrals
20 Green's theorem, Curl and divergence
21 Surface integrals over scalar and vector fields
22 Divergence theorem, Stokes' theorem

Pre-requisite: *Calculus-II*

Recommended Texts

1. Thomas, G. B., Weir, M. D. and Hass J. R. (2014). *Thomas' Calculus: multivariable* (13th ed.). London: Pearson.
2. Stewart, J. (2015). *Calculus* (8th ed.). New York: Cengage Learning.

Suggested Readings

1. Anton, H., Bivens I. C. and Davis, S. (2016). *Calculus* (11th ed.). New York: Wiley.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I. and Asmar, N. H. (2017). *Calculus & its applications* (14th ed.). London: Pearson.
3. Larson, R. and Edwards, B. H. (2013). *Calculus* (10th ed.). New York: Brooks Cole.

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MATH-5107 **Algebra-I** 3(3+0)

Group theory is the study of groups. Groups are sets equipped with an operation (like multiplication, addition, or composition) that satisfies certain basic properties. As the building blocks of abstract algebra, groups are so general and fundamental that they arise in nearly every branch of mathematics and the sciences. This course aims to provide a first approach to the subject of algebra, which is one of the basic pillars of modern mathematics. The focus of the course will be the study of groups, their types and applications.

Contents

1 Groups, definition and examples of groups, elementary properties of groups
2 Finite and Infinite Groups
3 Order of element of a group and related results
4 Subgroups, examples of subgroup, subgroup tests, subgroup generated by set
5 Cyclic groups, properties of cyclic groups
6 Classification of subgroups of cyclic groups
7 Cosets decomposition of a group, properties of cosets
8 Lagrange's theorem and its consequences
9 Conjugate elements and conjugacy classes
10 Centralizer of a subset of a group, normalizer of a subset of a group
11 Center of group definition and examples
12 Normal Subgroups, factor groups, application of factor groups
13 Permutations and Permutation groups, definition and examples
14 Homomorphism of groups, properties of Homomorphisms
15 Fundamental theorem of homomorphism
16 Isomorphism theorems, properties of Isomorphisms and Cayley's theorem
17 Endomorphism and automorphisms of groups
18 Commutator subgroups
19 External and Internal direct products, definition and examples

Recommended Texts

1. Gallian, J.A. (2017). *Contemporary abstract algebra* (9th ed.). New York: Brooks/Cole.
2. Malik, D. S., Mordeson J. N. and Sen, M. K. (1997). *Fundamentals of abstract algebra.* New York: WCB/McGraw-Hill.

Suggested Readings

1. Roman, S. (2012). *Fundamentals of group theory* (1st ed.). Basel: Birkhäuser.
2. Rose, H. E. (2006). *A Course on finite groups* (1st ed.). London: Springer-Verlag.
3. Rotman, J. J. (1999). *An introduction to the theory of groups* (4th ed.). London: Springer.
4. Fraleigh, J. B. (2003). A *First Course in Abstract Algebra* (7th ed.). Boston: Addison-Wesley Publishing Company.

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PHYS-5163 **Physics-III** 4(3+1)

This course aims to introduce students with Newtonian's Mechanics as well as Waves and Oscillations. This course wills also describe the basic concepts of Vectors, Power and Energy. This course will also cover the three phenomenon's of diffraction, interference and polarization. In addition in the laboratory they will also familiar with Modulus of rigidity by static and dynamic method (Maxwell's needle, Bartons Apparatus), Determination of moment of inertia of a solid/hollow cylinder and a sphere etc. and with study the conservtion of energy (Hook's Law).

Contents

1 Kinetic theory of gases, The Van der Waals equation
2 Temperature, Thermodynamics and Thermodynamic equilibrium
3 Maxwell distribution of molecular speeds and Energies
4 Laws of Thermodynamics
5 Heat engine , Carnot cycle and efficiency measurements, Concept of entropy
6 Entropy measurements for reversible and irreversible process
7 Low temperature Physics
8 Thermodynamic relations
9 Thermoelectricity
10 Basic principles of Statistical Mechanics
11 Microscopic and macroscopic states, Phase space
12 Partition function, Relations of partition
13 Function with thermo dynamical variables

Lab-III

1 Measurement of resistance using a Neon flash bulb and condenser,
2 Determination of ionization potential of mercury,
3 To determine the stopping potential by photo cell,
4 Measurement of low resistance of a wire by using Carey Foster Bridge,
5 Calibration of a thermocouple by potentiometer,
6 Determination of temperature coefficient of resistance of a given wire.

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Pre-requisite: Physics-II

Recommended Texts:

1. Garg, S. C., Bansal, R. M., Ghosh, C. K. (2013). *Thermal physics kinetic theory, thermodynamics and statistical mechanics* (2nd ed.). New York: McGraw-Hill Education Private Limited.
2. Raymond, A., Jewett, J. W. (2011). *Physics for scientists and engineers with modern physics* (8th ed.). New York: Cengage Learning.

Suggested Readings

1. Young, H. D., Freedman, R. A. (2008). *University physics with modern physics* (14th ed.). London: Pearson.
2. Beiser, A. (1987). *Concepts of modern physics* (4th ed.). new York: McGraw-Hill Book Co.

URCE-5103 **Academic Writing** **3 (3+0)**

Academic writing is a formal, structured and sophisticated writing to fulfill the requirements for a particular field of study. The course aims at providing understanding of writer's goal of writing (i.e. clear, organized and effective content)and to use that understanding and awareness for academic reading and writing. The objectives of the course are to make the students acquire and master the academic writing skills. The course would enable the students to develop argumentative writing techniques. The students would be able to the content logically to add specific details on the topics such as facts, examples and statistical or numerical values. The course will also provide insight to convey the knowledge and ideas in objective and persuasive manner. Furthermore, the course will also enhance the students' understanding of ethical considerations in writing academic assignments and topics including citation, plagiarism, formatting and referencing the sources as well as the technical aspects involved in referencing.

Contents

1 Academic vocabulary
2 Quoting, summarizing and paraphrasing texts
3 Process of academic writing
4 Developing argument
5 Rhetoric: persuasion and identification
6 Elements of rhetoric: Text, author, audience, purposes, setting
7 Sentence structure: Accuracy, variation, appropriateness, and conciseness
8 Appropriate use of active and passive voice
9 Paragraph and essay writing
10 Organization and structure of paragraph and essay
11 Logical reasoning
12 Transitional devices (word, phrase and expressions)
13 Development of ideas in writing
14 Styles of documentation (MLA and APA)
15 In-text citations
16 Plagiarism and strategies for avoiding it

Recommended Texts

1. Swales, J. M., & Feak, C. B. (2012). *Academic writing for graduate students: Essential tasks and skills* (3rd ed.). Ann Arbor: The University of Michigan Press.
2. Bailey, S. (2011). *Academic writing: A handbook for international students* (3rd ed.). New York: Routledge.

Suggested Readings

1. Craswell, G. (2004). *Writing for academic success*. London: SAGE.
2. Johnson-Sheehan, R. (2019). *Writing today*. Don Mills: Pearson.
3. Silvia, P. J. (2019). *How to write a lot: A practical guide to productive academic writing*. Washington: American Psychological Association.

MATH-5108 **Probability Theory** **3(3+0)**

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.

Contents

1 Finite probability spaces
2 Basic concept
3 probability and related frequency
4 Combination of events
5 Some examples of Combination of events
6 Independence
7 random variables
8 Expected value
9 Standard deviation
10 Chebyshev's inequality
11 Independence of random variables
12 Multiplicatively of the expected value
13 Additivity of the variance
14 Discrete probability distribution
15 Probability as a continuous set function
16 Sigma-algebras, examples
17 Continuous random variables
18 Expectation and variance
19 Normal random variables and continuous probability distribution
20 Applications: De Moivre-Laplace limit theorem
21 Weak and strong law of large numbers
22 The central limit theorem
23 Markov chains and continuous Markov process

Recommended Texts

1. Capinski, M. and Kopp, E. (1998). *Measure, integral and probability*. London: Springer-Verlag.
2. Dudley, R. M. (2004). *Real Analysis and probability*. Cambridge: Cambridge University Press.

Suggested Readings

1. Resnick, S. I. (1999). *A probability path*, Basel: Birkhauser.
2. Ross, S. (1998). *A first course in probability theory* (5th ed.). New Jersey: Prentice Hall.
3. Ash, R. B. (2008). *Basic probability theory*. New York: Dover Books.

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MATH-5109 **Vector Analysis and Mechanics** 3(3+0)

This course shall assume background in calculus. It covers basic principles of vector analysis, which are used in mechanics. This course introduces the fundamental principles in mechanics. Structural design applications of a variety of problems are developed throughout the course using examples that elucidate the theory of mechanics. It emphasize on the laws of friction, equilibrium, center of gravity and harmonic and orbital motion.

Contents

1 Vector Analysis: Scalar and vector triple product
2 Differentiation and integration of vector functions
3 Gradient, divergence
4 Curl of vector point functions
5 Mechanics: Composition and resolution of co-planar forces
6 Moments
7 Couples and conditions of equilibrium under the action of co-planar forces
8 Frictional forces
9 Laws of friction
10 Equilibrium of bodies on rough surfaces
11 Principle of virtual work and related problems
12 Center of gravity
13 Center of mass of various bodies
14 Kinematics of a particle in Cartesian and polar co-ordinates
15 Linear and angular velocity
16 Rectilinear motion with uniform and variable acceleration
17 Simple harmonic motion
18 Projectile motion
19 Motion along horizontal and vertical circles
20 Orbital motion, planetary motion and keplar laws, conservative forces
21 Damped forces

Recommended Texts

1. Munawar, H., Saeed, S. M. Ahmed, C. B. (2016). *Elementary vector analysis*. Lahore: The Caravan Book House.
2. Ghori, Q. K. (2015). *Mechanics*. Lahore: West Pakistan Publishing Company.

Suggested Readings

1. Spiegel, M. R., Lipschutz, S. and Spellman, D. (2009). *Schaum's outline vector analysis* (2nd ed.). New York: McGraw-Hill Education.
2. Brand, L. (2006). *Vector analysis*, New York: Dover Publications.
3. Yousuf, S. M., *Vector analysis*, (latest ed.). Lahore: Ilmi Ketab Khana.
4. Mir, K. L., *Mechanics*, (latest ed.). Lahore: Ilmi Ketab Khana.

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MATH-5110 **Linear Algebra** **3(3+0)**

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

Contents

1 Representation of linear equations in matrix form
2 Solution of linear system, Gauss-Jordan and Gaussian elimination method
3 Vector space, definition, examples and properties
4 Subspaces
5 Linear combination and spanning set
6 Linearly Dependent and Linearly Independent sets
7 Bases and dimension of a vector space
8 Intersections, sums and direct sums of subspaces
9 Quotient Spaces
10 Change of basis
11 Linear transformation
12 Rank and Nullity of linear transformation
13 Matrix of linear transformations
14 Eigen values and eigen vectors
15 Dual spaces
16 Inner product Spaces with properties
17 Projection
18 Cauchy inequality
19 Orthogonal and orthonormal basis
20 Gram Schmidt process and diagonalization

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Pre-requisite: Algebra-I

Recommended Texts

1. Dar, K. H. (2007). *Linear algebra* (1st ed.). Karachi: The Carwan Book House.
2. Kolman, B. and Hill, D. R. (2005). *Introductory linear algebra* (8th ed.). London: Pearson/Prentice-Hall.

Suggested Readings

1. Cherney, D., Denton, T., Thomas, R. and Waldron, A. (2013). *Linear algebra* (1st ed.). California: Davis.
2. Anton, H. and Rorres, C. (2014). *Elementary linear algebra: applications version* (11th ed.). New York: John Wiley & Sons.
3. Grossman, S. I. (2004). *Elementary linear algebra* (5th ed.). New York: Cengage Learning.

PHYS- 5164 **Physics-IV** 4(3+1)

This course presents the basic concepts of relativistic mechanics and Quantum theory along with its mechanics. The course objectives are to enable students about the ideas of atomic Physics, structure of nuclear and brief introduction to Cosmology. Students are encouraged to share their thinking with teachers and peers and to examine different problem-solving strategies, in the said field.

Contents

1 Relativistic mechanics, Origin of Quantum Theory
2 Wave nature of matter, Quantum Mechanics
3 Introduction to Quantum Optics (Laser) and Plasma Physics
4 Atomic Physics, bonding in solids, band theory of solids
5 Fundamental forces in nature
6 Nuclear structure, fundamental particles
7 Nuclear transmutation (Alpha-Beta and Gamma decays)
8 Radioactivity, Half life and Mean life
9 Fission and Fusion reactions, Introduction to Cosmology

Lab-IV

1 Determination of e/m of an electron,
2 Characteristics of a semiconductor diode,
3 Setting up of half & full wave rectifier & study of following factors
4 Smoothing effect of a capacitor
5 Ripple factor & its variation with load
6 Study of regulation of output voltage with load,
7 Study of the parameter of wave i.e. amplitude, phase and time period of a complex signal by CRO, to determine Horizontal/Vertical distance by Sextant,
8 The determination of wavelength of Sodium D lines by Newton's ring.
9 The determination of wavelength of light/laser by diffraction grating.

Pre-requisite: Physics-III

Recommended Texts

1. Halliday, Resnick and Walker, (2008). *Fundamental of physics* (8th ed.). New York: John Wiley.
2. Raymond, A., Jewett, J. W. (2011). *Physics for scientists and engineers with modern physics*, (8th ed.). New York: Cengage Learning.

Suggested Readings

1. Reitz, John R., Fredrick, M. J. (1970). *Foundations to electromagnetic theory* (2nd ed.). Boston. Addison-Wesley Publishing Co.
2. Young, H.D., Freedman, R.A. (2008). *University physics with modern physics* (14th ed.). London: Pearson.
3. Krane, K. S. (1987). *Introductory nuclear physics* (3rd ed.). New York: Wiley.
4. Alonso, M., Finn, E. J. (1999). *Physics*. Boston: Addison-Wesley.

MATH-5111 **Discrete Mathematics** 3(3+0)

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. It is the study of mathematical structures that are fundamentally discrete rather than continuous. In contrast to real numbers that have the property of varying "smoothly", the objects studied in discrete mathematics, such as integers, graphs, and statements in logic. 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

Contents

1 Counting methods: Basic methods: product
2 inclusion-exclusion formulae
3 Permutations and combinations
4 Recurrence relations and their solutions
5 Generating functions
6 Double counting and its pplications
7 Pigeonhole principle and its applications
8 Relations: Binary relations
9 n-ary Relations
10 Closures of relations
11 Composition of relations
12 Inverse relation
13 Graphs: Graph terminology
14 Representation of graphs
15 Graphs isomorphism
16 Algebraic methods: the incidence matrix
17 Connectivity
18 Eulerian and Hamiltonian paths
19 Shortest path problem
20 Trees and spanning trees
21 Complete graphs and bivalent graphs

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Recommended Texts

1. Rosen, H. H. (2012). *Discrete mathematics and its applications*. New York: The McGraw-Hill Companies, Inc.
2. Chartrand, G. and Zhang, P. (2012). *A first course in graph theory*. New York: Dover Publications, Inc.

Suggested Readings

1. Tucker, A. (2002). *Applied combinatorics*. New York: John Wiley and Sons.
2. Diestel, R. (2010). *Graph theory* (4th ed.). New York: Springer- Verlag
3. Brigs, N. L. (2003). *Discrete mathematics*. Oxford : Oxford University Press.

MATH-5112 **Spanish Language** 3(3+0)

Spanish is a Romance language that originated in the Iberian Peninsula and today is a global language with more than 483 million native speakers, mainly in Spain and the Americas. It is the world's second-most spoken native language, after Mandarin Chinese and the world's fourth-most spoken language, after English, Mandarin Chinese and Hindi. Spanish is a part of the Ibero-Romance group of languages, which evolved from several dialects of Vulgar Latin in Iberia after the collapse of the Western Roman Empire in the 5th century. The oldest Latin texts with traces of Spanish come from mid-northern Iberia in the 9th century, and the first systematic written use of the language happened in Toledo, a prominent city of the Kingdom of Castile, in the 13th century. Beginning in 1492, the Spanish language was taken to the viceroyalties of the Spanish Empire, most notably to the Americas, as well as territories in Africa, Oceania and the Philippines. Spanish course develops the ability to communicate directly and effectively with people from Spanish culture. The focus of the curriculum is the progressive development of the skills of listening, speaking, reading and writing in the Spanish language. This course will be fruitful for the students who are seeking opportunities for higher studies in Spanish countries.

Contents

1 Identify Spanish alpha batiks sounds
2 Identify numbers
3 Listening
4 Speaking
5 Reading
6 Writing
7 Understanding description about daily life
8 Basic Grammar Rules
9 Total Physical Response
10 Storytelling materials
11 Novels
12 Newspapers (Spanish)
13 Media
14 Classes discussion
15 Magazines

Recommended Texts

1. Vargas, D. C. (2008). *The big red Book of Spanish*. New York: McGRAW Hill.
2. Bregstein, B. (2015). *Easy Spanish step by step*. Seattle: Amazon Publisher.

Suggested Readings

1. Sanchez, C. (2017). *Spanish short stories for beginners*. (Kindle Ed.). Seattle: Amazon Publisher.
2. Bregstein, B. (2015). *Easy Spanish step by step*. Seattle: Amazon Publisher.

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MATH-5113 **French Language** **3(3+0)**

In modern times, French is still a significant diplomatic language: it is an official language of the United Nations, the Olympic Games, and the European Union. It is also the official language of 29 countries. The objective for complete beginners is to reach next level. At this stage the student will be able to understand very simple phrases about daily life if someone speaks to him slowly and clearly. The student will know how to introduce himself, to describe his work, to talk about his tastes and his hobbies and to describe his past. He will be able to respond to simple and practical questions.

Contents

Actes De Communication

1 Saluer et prendrecongé
2 Demander et donnerl'identitéd'unepersonne
3 Faire comprendrequ'onn'a pas compris
4 Se présenter de façoninformelle
5 Épeler, Téléphoner, Aborderquelqu'un, Situer et se situerdansl'espace et dans le temps
6 Fixer des rendez-vous, Donner un emploi du temps, Inviter, accepter et refuserune invitation Offrir et remercier, Décrire un lodgement
MORPHOSYNTAXE:
6 Les articles définis, indéfinis, contractés et partitifs
7 Conjugaison à l'indicatifprésent des verbes du 1er et du 2ème groupes
8 Conjugaison à l'indicatifprésent des auxiliaires et de quelquesirréguliers : faire, venir, aller, prendre, partir, sortir, dormir, servir, sentir, suivre, savoir, devoir, vouloir et pouvoir
9 Les pronomspersonnelssujets 1ère et 2ème formes (atones et toniques)
10 Les formes interrogative et négative, Le genre et le nombre des noms et adjectifs
11 Le passé composé, Le futurproche, Les principalesprépositions et adverbes de lieu

Phonetique

12 Les phonèmes du français, L'intonationdans les phrases affirmative
13 Négative et interrogative, Les accents et groupesrythmiques
14 Distinction entre les différents sons vocaliques

Lexique

15 Les nombres et l'heure, Les nationalités, Les professions, Les transports
16 L'alimentation, La famille
17 Le calendrier, L'habitation

Recommended Texts

1. Cossard, M. and Salazar, R. (1980). *French basic course.* USA: Foriegn service Institute.
2. Boulares, M. and Frerot, J. L. (1999). *Grammaire progressive du français.* Cleveland: CLE Internationale.

Suggested Readings

1. Studio 100, niveau I, méthode de français.
2. Boulares, M. and Frerot, J. L. *Grammaire progressive du français.* Cleveland: CLE Internationale.

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ECON-5118 Mathematical Economics 3(3+0)

The course is intended for students who are wishing to obtain knowledge of mathematical techniques suitable for economic analysis. It assumes very little prerequisite knowledge. The approach is informal and aims to show students how to do and apply the mathematics practically. Economic applications are considered although this course aims to teach the mathematics rather than the economics. Topics include basic algebra, simple finance, calculus and matrix algebra.

Contents

1 Economic Applications of Graphs and Equations: Isocost Lines, Supply and Demand Analysis
2 Income Determination Models, IS-LM Analysis
3 Uses of the Derivative in Mathematics and Economics: Increasing and Decreasing Functions
4 Concavity and Convexity
5 Relative Extrema, Inflection Points, Optimization of Functions
6 Successive-Derivative Test for Optimization, Marginal Concepts
7 Optimizing Economic Functions, Relationship among Total
8 Marginal, and Average Concepts
9 Calculus of Multivariable Functions in Economics: Marginal Productivity
10 Income Determination, Multipliers and Comparative Statics
11 Income and Cross Price Elasticities of Demand, Differentials and Incremental Changes
12 Optimization of Multivariable Functions in Economics
13 Constrained Optimization of Multivariable Functions in Economics
14 Homogeneous Production Functions, Returns to Scale
15 Optimization of Cobb-Douglas Production Functions
16 Optimization of Constant Elasticity of Substitution Production Functions
17 Exponential and Logarithmic Functions in Economics: Interest Compounding, Effective vs. Nominal Rates of Interest, Discounting
18 Converting Exponential to Natural Exponential Functions, Estimating Growth Rates from Data Points
19 Special Determinants and Matrices and Their Use in Economics: The Jacobian, the Hessian
20. The Discriminant, Higher-Order Hessians
21 The Bordered Hessian for Constrained Optimization
22 Input-Output Analysis, Characteristic Roots and Vectors (Eigenvalues, Eigenvectors)

Recommended Texts

1. Dowling, E.T. (2001). *Introduction to mathematical economists, Schaum's Outline Series* (3rd ed.). New York: McGraw Hill Publishing Company.
2. Weber, E.J. (1976). *Mathematical analysis, business and economic application* (latest ed.). New York: Harper and Row Publishers.

Suggested Readings

1. Chiang, A.C. and Wainwright, K. (2005). *Fundamental methods of mathematical economics* (4th ed.). New York: McGraw Hill Publishing Company.
2. Frank, B.N. (1993). *Applied mathematics for business, economics and social sciences* (4th ed.). New York: McGraw Hill Publishing Company.

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MATH-6112 Topology 3(3+0)

Topology studies continuity in its broadest context. We begin by analyzing the notion of continuity familiar from calculus, showing that it depends on being able to measure distance in Euclidean space. This leads to the more general notion of a metric space. A brief investigation of metric spaces shows that they do not provide the most suitable context for studying continuity. A deeper analysis of continuity in metric spaces shows that only the open sets matter, which leads to the notion of a topological spaces. We easily see that this is the right setting for studying continuity. The central concepts of topology, compactness, connectedness and separation axioms are introduced. Applications of topology to number theory, algebraic geometry, algebra and functional analysis are featured. Since many important applications of topology use metric spaces, we investigate topological concepts applied to them and introduce the notion of completeness. In addition, this course provides the basis for studying differential geometry, functional analysis, classical and quantum mechanics, dynamical systems, algebraic and differential topology.

Contents

1 Topological spaces
2 Bases and sub-bases
3 First and second axiom of countability
4 Separability
5 Continuous functions and homeomorphism
6 Finite product space
7 Separation axioms (T_0)
8 Separation axioms (T_1)
9 Separation axioms (T_2)
10 Techonoff spaces
11 Regular spaces
12 Completely regular spaces
13 Normal spaces
14 Product spaces
15 Compactness
16 Connectedness

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Recommended Texts

1. Sheldon, W. D. (2005). *Topology* (1st ed.). New York: McGraw Hill.
2. Willard, S. (2004). *General topology* (1st ed.). New York: Dover Publications.

Suggested Readings

1. Lipschutz, S. (2011). *General topology , Schaum's outline series* (1st ed.). New York: McGraw Hill.
2. Armstrong, M.A. (1979). *Basic topology*. (1st ed.). New York: McGraw Hill.
3. Mendelson, B. (2009). *Introduction to topology*. (3rd ed.). New York: Dover Publications.

MATH-6113 **Differential Geometry** 3(3+0)

Differential geometry is the study of geometric properties of curves, surfaces, and their higher dimensional analogues using the methods of calculus. It has a long and rich history, and, in addition to its intrinsic mathematical value and important connections with various other branches of mathematics, it has many applications in various physical sciences, e.g., solid mechanics, computer tomography, or general relativity. Differential geometry is a vast subject. This course covers many of the basic concepts of differential geometry in the simpler context of curves and surfaces in ordinary 3-dimensional Euclidean space. The aim is to build both a solid mathematical understanding of the fundamental notions of differential geometry and enough visual and geometric intuition of the subject. This course is of interest to students from a variety of math, science and engineering backgrounds, and that after completing this course, the students will ready to study more advanced topics such as global properties of curves and surfaces, geometry of abstract manifolds, tensor analysis, and general relativity.

Contents

1. Space Curves
2. Arc length, tangent
3. Normal and binormal
4. Curvature and torsion of a curve
5. Tangent planes
6. The Frenet-Serret apparatus
7. Fundamental existence theorem of plane curves
8. Four vertex theorem, Isoperimetric inequality
9. Surfaces
10. First fundamental form
11. Isometry and conformal mappings
12. Curves on Surfaces, surface Area
13. Second fundamental form
14. Normal and Principle curvatures
15. Gaussian and Mean curvatures
16. Geodesics

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Recommended Texts

1. Somasundaran, D. (2005). *Differential geometry* (1st ed.). New Delhi: Narosa Publishing House.
2. Pressley, A. (2001). *Elementary differential geometry* (1st ed.). New York: Springer-Verlag.

Suggested Readings

1. Wilmore, T. J. (1959). *An introduction to differential geometry*, (1st ed.). Oxford Calarendon Press.
2. Weatherburn, C. E. (2016). *Differential geometry of three dimensions*. (Revised ed.). Cambridge University Press.
3. Millman. R. S., Parker, G. D. (1977). *Elements of differential geometry*. Englewood Cliffs: Prentice Hall.

MATH-6114 **Ordinary Differential Equations** 3(3+0)

This course introduces the theory, solution, and application of ordinary differential equations. Topics discussed in the course include methods of solving first-order differential equations, existence and uniqueness theorems, second-order linear equations, power series solutions, higher-order linear equations, systems of equations, non-linear equations, Sturm-Liouville theory, and applications. The relationship between differential equations and linear algebra is emphasized in this course. An introduction to numerical solutions is also provided. Applications of differential equations in physics, engineering, biology, and economics are presented. The goal of this course is to provide the student with an understanding of the solutions and applications of ordinary differential equations. The course serves as an introduction to both nonlinear differential equations and provides a prerequisite for further study in those areas.

Contents

1 Introduction to differential equations: Preliminaries and classification of differential equations
2 Verification of solution, existence of unique solutions, introduction to initial value problems
3 Basic concepts, formation and solution of first order ordinary differential equations
4 Separable equations, linear equations, integrating factors, Exact Equations
5 Solution of nonlinear first order differential equations by substitution, Homogeneous Equations,
6 Bernoulli equation, Ricaati's equation and Clairaut equation
7 Modeling with first-order ODEs: Linear models, Nonlinear models
8 Higher order differential equations: Initial value and boundary value problems
9 Homogeneous and non-homogeneous linear higher order ODEs and their solutions, Wronskian,
10 Reduction of order, homogeneous equations with constant coefficients,
11 Nonhomogeneous equations, undetermined coefficients method, Superposition principle
12 Annihilator approach, variation of parameters, Cauchy-Euler equation,
13 Solving system of linear differential equations by elimination
14 Solution of nonlinear differential equations
15 Power series, ordinary and singular points and their types, existence of power series solutions
16 Frobenius theorem, existence of Frobenius series solutions
17 The Bessel, Modified Bessel, Legendre and Hermite equations and their solutions
18 Sturm-Liouville problems: Introduction to eigen value problem, adjoint and self-adjoint operators,
19 Self-adjoint differential equations, eigen values and eigen functions
20 Sturm-Liouville (S-L) boundary value problems, regular and singular S-L problems

Recommended Texts

1 Boyce, W. E., Diprima, R. C. (2012). *Elementary differential equations and boundary value problems* (10th ed.) USA: John Wiley & Sons.
2 Zill, D.G., Michael, R. (2009) *Differential equations with boundary-value problems* (5th ed.) New York: Brooks/Cole.

Suggested Readings

1 Arnold, V. I. (1991). *Ordinary differential equations* (3rd ed.). New York: Springer
2 Apostol, T. (1969). *Multi variable calculus and linear algebra* (2nd ed.). New York: John Wiley and sons.

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MATH-6115 **Real Analysis –I** **3(3+0)**

This is the first part of a two-semester course. This course covers the fundamentals of mathematical analysis: convergence of sequences and series, continuity, differentiability, Riemann integral, sequences and series of functions, uniformity, and the interchange of limit operations. It shows the utility of abstract concepts and teaches an understanding and construction of proofs. It develops the fundamental ideas of analysis and is aimed at developing the student's ability to describe the real line as a complete, ordered field, to use the definitions of convergence as they apply to sequences, series, and functions, to determine the continuity, differentiability and integrability of functions defined on subsets of the real line, to write solutions to problems and proofs of theorems that meet rigorous standards based on content, organization and coherence, argument and support, and style and mechanics, to determine the Riemann integrability of a bounded function and prove a selection of theorems concerning integration, to recognize the difference between pointwise and uniform convergence of a sequence of functions and to illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability, and integrability.

Contents

1 Number Systems: Ordered fields
2 rational, real and complex numbers
3 Archimedean property
4 supremum, infimum and completeness
5 Topology of real numbers
6 Convergence, completeness, completion of real numbers
7 Heine Borel theorem
8 Sequences and Series of Real Numbers
9 Limits of sequences, algebra of limits
10 Bolzano Weierstrass theorem, Cauchy sequences, liminf, limsup
11 limits of series, convergences tests, absolute and conditional convergence, power series
12 Continuity: Functions, continuity and compactness, existence of minimizers and maximizers
13 uniform continuity, continuity and connectedness, intermediate mean value theorem
14 monotone functions and discontinuities
15 Differentiation: Mean value theorem, L'Hopital's Rule, Taylor's theorem

Recommended Texts

1. Bartle, R. G., Sherbert, D. R. (2011). *Introduction to real analysis* (4th ed.) New York: John Wiley & Sons.
2. Trench, W. F. (2013). *Introduction to real analysis,* (2nd ed.). New Jersey: Prentice Hall.

Suggested Readings

1 Folland, G.B. (1999). *Real analysis* (2nd ed.). New York: John Wiley and Sons.
2 Rudin, W. (1976). *Principles of mathematical analysis* (3rd ed.) New York: McGraw-Hill. (1976).
3 Royden, H., Fitzpatrick, P. (2010). *Real analysis* (4th ed.). New Jersey: Pearson Hall.

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MATH-6116 Algebra-II 3(3+0)

This is a course in advanced abstract algebra, which builds on the concepts learnt in Algebra I. The objectives of the course are to introduce students to the basic ideas and methods of modern algebra and enable them to understand the idea of a ring and an integral domain, and be aware of examples of these structures in mathematics; appreciate and be able to prove the basic results of ring theory; The topics covered include ideals, quotient rings, ring homomorphism, the Euclidean algorithm and the principal ideal domains.

Contents

1 Rings: Definition, examples. Quadratic integer rings
2 Examples of non-commutative rings
3 The Hamilton quaternions
4 Polynomial rings
5 Matrix rings. Units, zero-divisors
6 Nilpotents, idempotents. Subrings, Ideals
7 Maximal and prime Ideals. Left, right and two-sided ideals; Operations with ideals
8 The ideal generated by a set. Quotient rings. Ring homomorphism
9 The isomorphism theorems, applications
10 Finitely generated ideals
11 Rings of fractions
12 Integral Domain: The Chinese remainder theorem. Divisibility in integral domains
13 Greatest common divisor, least common multiple
14 Euclidean domains
15 The Euclidean algorithm
16 Principal ideal domains
17 Prime and irreducible elements in an integral domain
18 Gauss lemma, irreducibility criteria for polynomials

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Pre-requisite: Algebra-I

Recommended Texts

1 Gallian, J. A. (2017). *Contemporary Abstract algebra* (9th ed.) New York: Brooks/Cole.
2 Malik D. S., Mordeson J. N., Sen M. K. (1997). *Fundamentals of abstract algebra* (1st ed.). New York: WCB/McGraw-Hill.

Suggested Readings

1 Roman, S. (2012). *Fundamentals of group theory* (1st ed.). Switzerland: Birkhäuser Basel.
2 Rose, J. (2012). *A course on group theory* (revised ed.). New York: Dover Publications.
3 Fraleigh, J. B. (2003). *A first course in abstract algebra* (7th ed.). New York: Pearson.

MATH-6117 **Classical Mechanics** 3(3+0)

The purpose of this course is 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. The course aims at familiarizing the students with the dynamics of system of particles, kinetic energy, motion of rigid body, Lagrangian and Hamiltonian formulation of mechanics. At the end of this course the students will be able to understand the fundamental principles of classical mechanics, to master concepts in Lagrangian and Hamiltonian mechanics important to develop solid and systematic problem solving skills. To lay a solid foundation for more advanced study of classical mechanics and quantum mechanics.

Contents

1 Work, power, kinetic energy and energy principle
2 conservative force fields, conservation of energy theorem, impulse
3 Conservation of linear and angular momentum
4 Time varying mass systems (Rockets)
5 Introduction to rigid bodies
6 Translations and rotations
7 Linear and angular velocity of a rigid body about a fixed axis
8 Angular momentum for n particles
9 Rotational kinetic energy
10 Moments and products of inertia
11 Parallel and perpendicular axes theorem
12 Principal axes and principal moments of inertia. Determination of principal axes by diagonalizing the inertia matrix
13 Equimomental systems
14 Coplanar distribution
15 Rotating axes theorem
16 Euler;s dynamical equations of motion. Free rotation of a rigid body with three different principal moments, torque free motion of a symmetrical top
17 The Eulerian angles, angular velocity and kinetic energy in terms of Euler angles

Recommended Texts

1 DiBenedetto, E. (2011). *Classical mechanics: Theory and mathematical modeling*. Basel: Birkhauser.
2 Aruldhas, G. (2016). *Classical mechanics*. Dehli: PHI Private limited.

Suggested Readings

1 Spiegel, M. R. (2004). *Theoretical mechanics* (3rd ed.). Boston: Addison-Wesley Publishing Company.
2 Fowles, G. R., Cassiday, G. L. (2005). *Analytical mechanics* (7th ed.). New York: Thomson Brooks/COLE.
3 Mir, K. L. (2007). *Theoretical mechanics*. Lahore: Ilmi Ketab Khana..

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MATH-6118 Mathematical Methods 3(3+0)

Mathematical methods is an important branch of mathematics. 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

Contents

1 Fourier Methods: The Fourier transforms
2 Fourier analysis of the generalized functions
3 The Laplace transforms
4 Hankel transforms for the solution of PDEs and their application to boundary value problems
5 Green's Functions and Transform Methods: Expansion for Green's functions
6 Transform methods. Closed form Green's functions. Perturbation Techniques
7 Perturbation methods for algebraic equations
8 Perturbation methods for differential equations
9 Variational Methods: Euler-Lagrange equations
10 Integrand involving one, two, three and n variables
11 Special cases of Euler-Lagrange's equations
12 Necessary conditions for existence of an extremum of a functional
13 Constrained maxima and minima

Recommended Texts

1. Powers, D. L. (2005). *Boundary value problems and partial differential equations*, (5th ed.). Boston: Academic Press.
2. Boyce, W. E. (2005). *Elementary differential equations*, (8th ed.). New York: John Wiley and Sons.

Suggested Readings

1. Brown, J. W. and Churchil, R. V. (2006). *Fourier series and boundary value problems*. New York: McGraw Hill.
2. Snider, A. D. (2006). *Partial differential equations*. New York: Dover Publications Inc.
3. Boyce, W. E. (2005). *Elementary differential equations*, (8th ed.). New York: John Wiley and Sons.
4. Krasnov M. L. Makarenko, G. I. and Kiselev, A. A. (1985). *Problems and exercises in the calculus of variations*. USA: Imported Publications, Inc.

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MATH-6119 Complex Analysis 3(3+0)

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. Complex Analysis is a topic that is extremely useful in many applied topics such as numerical analysis, electrical engineering, physics, chaos theory, and much more, and you will see some of these applications throughout the course. In addition, complex analysis is a subject that is, in a sense, very complete. The concept of complex differentiation is much more restrictive than that of real differentiation and as a result the corresponding theory of complex differentiable functions is a particularly nice one.

Contents

1. Introduction: The algebra of complex numbers
2. Geometric representation of complex numbers
3. Polar form of complex numbers
4. Powers and roots of complex numbers
5. Functions of Complex Variables
6. Limit
7. Continuity
8. Differentiable functions, the Cauchy-Riemann equations
9. Analytic functions, entire functions, harmonic functions
10. Elementary functions: The exponential, Trigonometric functions
11. Hyperbolic, Logarithmic and Inverse elementary functions
12. Complex Integrals: Contours and contour integrals, antiderivatives, independence of path
13. Cauchy-Goursat theorem, Cauchy integral formula, Lioville's theorem, Morerea's theorem
14. Maximum Modulus Principle
15. Series: Power series, Radius of convergence and analyticity
16. Taylor's and Laurent's series
17. Integration and differentiation of power series, isolated singular points
18. Cauchy's residue theorem with applications
19. Types of singularities and calculus of residues, Zeros and Poles, Mobius transforms
20. Conformal mappings and transformations

Recommended Texts

1. Mathews J. H., Howell, R.W. (2006). *Complex analysis for mathematics and engineering* (5th ed.). Burlington: Jones & Bartlett Publication.
2. Churchill, R.V., Brown, J.W. (2013). *Complex variables and applications* (9th ed.). New York: McGraw-Hill.

Suggested Readings

1. Remmert, R. (1998). *Theory of complex functions* (1st ed.). New York: Springer-Verlag.
2. Rudin, W. (1987). *Real and complex analysis* (3rd ed.). New York: McGraw-Hill.

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MATH-6120 **Functional Analysis** 3(3+0)

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. This is a basic graduate level course that introduces the student to Functional Analysis and its applications. It starts with a review of the theory of metric spaces, the theory of Banach spaces and proceeds to develop some key theorems of functional analysis. Then continuous to linear operators in Banach and Hilbert spaces and to spectral theory of self-adjoint operators with applications to the theory of boundary value problems, and the theory of linear elliptic partial differential equations.

Contents

1. Metric Spaces
2. Convergence
3. Cauchy's sequences and examples
4. Completeness of metric space
5. Completeness proofs
6. Normed linear Spaces, Banach Spaces
7. Equivalent norms
8. Linear operators
9. Finite dimensional normed spaces
10. Continuous and bounded linear operators
11. Linear functional, Dual spaces
12. Linear operator and functional on finite dimensional Spaces
13. Inner product Spaces
14. Hilbert Spaces
15. Conjugate spaces
16. Representation of linear functional on Hilbert space
17. Orthogonal sets
18. Orthonormal sets and sequences
19. Orthogonal complements and direct sum
20. Reflexive spaces

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Recommended Texts

1. Kreyszig, E. (1989). *Introduction to functional analysis with applications* (1st ed.). New York: John Wiley and Sons.

Suggested Readings

1. Dunford, N., Schwartz, J. T., (1958). *Linear operators, part-1 general theory*. New York: Interscience publishers.
2. Balakrishnan, A. V. (1981). *Applied functional analysis* (2nd ed.). New York: Springer-Verlag.
3. Conway, J. B. (1995). *A Course in functional analysis* (2nd ed.). New York: Springer-Verlag.

MATH-6121 **Real Analysis –II** 3(3+0)

This course is continuation of Real Analysis I, this course will continue to cover the fundamentals of real analysis, concentrating on the Riemann-Stieltjes integrals, Functions of Bounded Variation, Improper Integrals, and convergence of series. Emphasis would be on proofs of main results. The aim of this course is also to provide an accessible, reasonably paced treatment of the basic concepts and techniques of real analysis for students in these areas. This course provides greatly strengthening student's understanding of the results of calculus and the basis for their validity the uses of deductive reasoning, increasing the student's ability to understand definitions, understand proofs, analyze conjectures, find counter-examples to false statements, construct proofs of true statements and enhancing the student's mathematical communication skills.

Contents

1 The Riemann-Stieltjes Integrals
2 Definition and existence of integrals
3 Properties of integrals
4 Fundamental theorem of calculus and its applications
5 Change of variable theorem, integration by parts
6 Functions of Bounded Variation
7 Definition and examples, properties of functions of bounded variation
8 Improper Integrals: Types of improper integrals
9 Tests for convergence of improper integrals
10 Beta and gamma functions
11 Absolute and conditional convergence of improper integrals
12 Sequences and Series of Functions
13 Power series, definition of pointwise and uniform convergence
14 Uniform convergence and continuity
15 Uniform convergence and differentiation, examples of uniform convergence

Pre-requisite: Real Analysis-I

Recommended Texts

1 Bartle, R. G., Sherbert, D. R. (2011). *Introduction to real analysis* (4th ed.). New York: John Wiley & Sons.
2 Rudin, W. (1976). *Principles of mathematical analysis* (3rd ed.). New York: McGraw-Hill.

Suggested Readings

1 Folland, G. B. (1999). *Real analysis* (2nd ed.). New York: John Wiley and Sons.
2 Hewitt, E., Stromberg, K. (1965). *Real and abstract analysis*. New York: Springer-Verlag Heidelberg
3 Lang, S. (1968). *Analysis I*. Boston: Addison-Wesley Publ. Co.

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MATH-6122 **Numerical Analysis-I** **3(3+0)**

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. It is optimal to verifying numerical methods by using computer programming (MatLab, Maple, C++, etc.)

Contents

1 Error analysis: Floating point arithmetic, Approximations and errors
2 Methods for the solution of nonlinear equations
3 Bisection method, regula-falsi method, Fixed point iteration method
4 Newton-Raphson method, secant method, error analysis for iterative methods
5 Interpolation and polynomial approximation
6 Forward, backward and centered difference formulae
7 Lagrange interpolation, Newton's divided difference formula
8 Interpolation with a cubic spline, Hermite interpolation, Least squares approximation
9 Numerical differentiation and Integration: Forward, backward and central difference formulae
10 Richardson's extrapolation, Newton-Cotes formulae, Numerical integration
11 Rectangular rule, trapezoidal rule, Simpson's 1/3 and 3/8 rules
12 Boole's and Weddle's rules, Gaussian quadrature
13 Numerical solution of a system of linear equations
14 Direct methods: Gaussian elimination method
15 Gauss-Jordan method; matrix inversion; LU-factorization
16 Doolittle's, Crout's and Cholesky's methods
17 Iterative methods: Jacobi, Gauss-Seidel and SOR
18 Eigen values problems
19 Introduction, Power Method, Jaccobi's Method
20 The use of software packages/ programming languages for above mentioned topics is recommended

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Recommended Texts

1. Gerald, C.F., and Wheatley, P.O. (2005). *Applied numerical analysis*, London: Pearson Education, Singapore.
2. Burden, R. L., Faires, J. D. and Burden, A.M. (2015). *Numerical analysis*, (10th ed.). Boston: Cengage Learning.

Suggested Readings

1. Philip, J. (2019). *Numerical applied computational programming with case studies (1st ed.). New York: Apress.*
2. Khoury, R., Harder, D.W. (2016). *Numerical methods and modelling for engineering* (1st ed.). London: *Springer.*
3. Antia, H.M. (2012). *Numerical methods for scientists and engineers* (3rd ed.). New York: Springer.

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MATH-6123 **Number Theory** 3(3+0)

Number theory (or arithmetic or higher arithmetic in older usage) is a branch of pure mathematics devoted primarily to the study of the integers and integer-valued functions. Integers can be considered either in themselves or as solutions to equations (Diophantine geometry). The focus of the course is on study of the fundamental properties of integers and develops ability to prove basic theorems. The specific objectives include study of division algorithm, prime numbers and their distributions, Diophantine equations and the theory of congruences.

Contents

1 Divisibility
2 Euclid's theorem
3 Congruences, Elementary properties
4 Residue classes and Euler's function
5 Linear congruence and congruence of higher degree
6 Congruences with prime moduli
7 The theorems of Fermat
8 Euler and Wilson theorem
9 Primitive roots and indices
10 Integers belonging to a given exponent
11 Composite moduli Indices
12 Quadratic Residues
13 Composite moduli
14 Legendre symbol
15 Law of quadratic reciprocity
16 The Jacobi symbol
17 Number-Theoretic Functions
18 Mobius function
19 The function [x]
20 Diophantine Equations
21 Equations and Fermat's conjecture for n = 2, n = 4

Recommended Texts

1. Rosen, K.H. (2000). *Elementary number theory and its applications*. (4^{th} ed.). Boston: Addison-Wesley.
2. Apostal, T.M. (2010). *Introduction to analytic number theory*. (3^{rd} ed.). New York: Springer.

Suggested Readings

1. Leveque, W. J. (2002). *Topics in number theory*, Volumes I and II. New York: Dover Books.
2. Burton, D. M. (2007). *Elementary number theory*. New York: McGraw-Hill.

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MATH-6124 Partial Differential Equations 3(3+0)

Partial Differential Equations (PDEs) are in the heart of applied mathematics and many other scientific disciplines. The beginning weeks of the course aim to develop enough familiarity and experience with the basic phenomena, approaches, and methods in solving initial/boundary value problems in the contexts of the classical prototype linear PDEs of constant coefficients: the Laplace equation, the wave equation and the heat equation. A variety of tools and methods, such as Fourier series/eigenfunction expansions, Fourier transforms, energy methods, and maximum principles will be introduced. More importantly, appropriate methods are introduced for the purpose of establishing quantitative as well as qualitative characteristic properties of solutions to each class of equations

Contents

1 First order PDEs: Introduction, Formation of PDEs, Solutions of PDEs of first order
2 The Cauchy's problem for quasi linear first order PDEs, First order nonlinear equations
3 Special types of first order equations Second order PDEs
4 Basic concepts and definitions, Mathematical problems, Linear operator
5 Superposition, Mathematical models
6 The classical equations, The vibrating string, The vibrating membrane
7 Conduction of heat solids, Canonical forms and variable
8 PDEs of second order in two independent variables with constant and variable coefficients
9 Cauchy's problem for second order PDEs in two independent variables
10 Methods of separation of variables, Solutions of elliptic
11 Parabolic and hyperbolic PDEs in Cartesian and cylindrical coordinates
12 Laplace transform: Introduction and properties of Laplace transform
13 Transforms of elementary functions, Periodic functions, error functions
14 Dirac delta function, Inverse Laplace transform, Convolution Theorem
15 Solution of PDEs by Laplace transform, Diffusion and wave equations
16 Fourier transforms, Fourier integral representation
17 Fourier sine and cosine representation, Fourier transform pair
18 Transform of elementary functions and Dirac delta function, Finite Fourier transforms
19 Solutions of heat, Wave and Laplace equations by Fourier transforms

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Recommended Texts

1 Zill, D. G., Michael, R. (2009). *Differential equations with boundary-value problems* (5th ed.) New York: Brooks/Cole.
2 Polking, J., Boggess, A. (2005). *Differential equations with boundary-value problems* (2nd ed.). London: Pearson.

Suggested Readings

1 Wloka, J. (1987). *Partial differential equations* (1st ed.). Cambridge: Cambridge University Press.
2 Humi, M, Miller. W. B. (1991). *Boundary value problems and partial differential equations* (1st ed.). Boston: PWS- KENT Publishing Company.
3 Myint, U. T. (1987). Partial *Differential equations for scientists and engineers* (3rd ed.). Boston: Birkhauser.

MATH-6125 **Numerical Analysis-II** 3(3+0)

This course is designed to teach the students about numerical methods and their theoretical bases. The main purpose of this course is to learn the concepts of numerical methods in solving mathematical problems numerically and analyze the error for these methods. The students are expected to know computer programming to be able to write program for each numerical method. Knowledge of calculus and linear algebra would help in learning these methods. The students are encouraged to read certain books containing some applications of numerical methods.

Contents

1 Difference and Differential equation
2 Formulation of difference equations
3 Solution of linear/non-linear difference equations with constant coefficients
4 Solution of homogeneous difference equations with constant coefficients
5 Solution of inhomogeneous difference equations with constant coefficients
6 The Euler method
7 The modified Euler method
8 Runge-Kutta methods
9 Predictor-corrector type methods for solving initial value problems along with convergence
10 Predictor-corrector type methods for solving initial value problems along with instability criteria
11 Runge-Kutta methods for solving initial value problems
12 Predictor-corrector type methods for solving initial value problems.
13 Convergence criteria
14 Instability criteria
15 Finite difference methods
16 Collocation methods for boundary value problems
17 Variational methods for boundary value problems

Pre-requisite: Numerical Analysis-I

Recommended Texts

1. Gerald, C. F. & Wheatley, P.O. (2003). *Applied numerical analysis* (7th ed.). London: Pearson.
2. Balfour, A. & Beveridge, W. T. (1977). *Basic numerical analysis with FORTARAN*. New Hampshire: Heinmann Educational Books Ltd.

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Suggested Readings

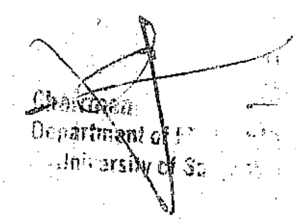
1. Shan and Kuo (1972). *Computer applications of numerical methods*. Islamabad: National Book Foundations.
2. Philip, J. (2019). *Numerical applied computational programming with case studies* (1st ed.). New York: Apress.
3. Khoury, R., Harder, D.W. (2016). *Numerical methods and modelling for engineering* (1st ed.). London: Springer.
4. Antia, H.M. (2012). *Numerical methods for scientists and engineers* (3rd ed.). New York: Springer.

MATH-6126 Integral Equations 3(3+0)

Many physical problems that are usually solved by differential equation methods can be solved more effectively by integral equation methods. This course will help students gain insight into the application of advanced mathematics and guide them through derivation of appropriate integral equations governing the behavior of several standard physical problems. On Completion of this module, the learner will be able to: Use Fourier transforms for solving a wide range of differential and integral equations. Formulate and solve initial and boundary value problems for the heat and wave equations in spherical and cylindrical coordinates. Solve linear Volterra and Fredholm integral equations using appropriate methods. Understand the relationship between integral and differential equations and transform one type into another.

Contents

1. Linear integral equations of the first kind
2. Linear integral equations of the second kind
3. Relationship between differential equation and Volterra integral equation
4. Neumann series
5. Fredholm Integral equation of the second kind with separable Kernels
6. Eigen values
7. Eigenvectors
8. Iterated functions
9. Quadrature methods
10. Least square methods
11. Homogeneous integral equations of the second kind
12. Fredholm integral equations of the first kind
13. Fredholm integral equations of the second kind
14. Abel's integral equations
15. Hilbert Schmidt theory of integral equations with symmetric Kernels
16. Regularization and filtering techniques



Recommended Texts

1. Jerri, J. (2007). *Introduction to integral equations with applications* (2nd ed.). New York: Sampling Publishing,
2. Wazwaz, A. M. (2011). *Linear and nonlinear integral equations: methods and applications*. New York: Springer.

Suggested Readings

1. Lovitt, W. V. (2005). *Linear integral equations*. New York: Dover Publications.
2. Christian, C., Dale, D. and Hamill, W. (2014). *Boundary integral equation methods and numerical solutions* (1st ed.). New York: Springer.
3. Kanwal, R. P. (1996). *Linear integral equations: theory and technique*. Boston: Birkhauser
4. Tricomi, F. G. (1985). *Integral Equations*. New York: Dover Pub.

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MATH-6127 **Advance Group theory-I** 3(3+0)

This course aims to introduce students to some more sophisticated concepts and results of group theory as an essential part of general mathematical culture and as a basis for further study of more advanced mathematics. The ideal aim of Group Theory is the classification of all groups (up to isomorphism). It will be shown that this goal can be achieved for finitely generated abelian groups. In general, however, there is no hope of a similar result as the situation is far too complex, even for finite groups. Still, since groups are of great importance for the whole of mathematics, there is a highly developed theory of outstanding beauty. It takes just three simple axioms to define a group, and it is fascinating how much can be deduced from so little. The course is devoted to some of the basic concepts and results of Group Theory.

Contents

1 Group of automorphisms, inner automorphisms, definition and related results
2 Characteristic and fully invariant subgroups,
3 Symmetric Groups, cyclic permutations
4 Even and odd permutations
5 The alternating groups, conjugacy classes of symmetric and alternating groups
6 Generators of symmetric and alternating groups
7 Simple groups
8 Simplicity of symmetric and alternating groups
9 Group Action on sets or G-sets
10 Orbits and stabilizer subgroups
11 Finite direct products
12 Finitely generated abelian groups
13 P-groups, Sylow's Theorems
14 Application of Sylow's Theorems
15 Linear Groups
16 Types of Linear Groups, Classical Groups

Recommended Texts

1. Rotman, J. J. (1999). *An Introduction to the theory of groups* (4th ed). New York: Springer.
2. Shah, S .K., Shankar A. G. (2013). *Group theory*. London: Dorling Kindersley.

Suggested Readings

1. Rose, H. E. (2009). *A course on finite groups* (1st ed). New York: Springer-Verlag.
2. Fraleigh, J. B. (2003). A *first course in abstract algebra* (7th ed.). Boston: Addison-Wesley Publishing Company.
3. Malik, D. S., Mordeson J. N. and Sen M. K. (1997). *Fundamentals of abstract algebra*. New York: WCB/McGraw-Hill.
4. Rose, J. A. (2012). *Course on group theory* (Revised ed.). New York: Dover Publications.

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MATH-6128 Advance Group theory-II 3(3+0)

This course is the continuation of the course "Advanced Group Theory-1". This course aims to introduce students to some more sophisticated concepts and results of group theory as an essential part of general mathematical culture and as a basis for further study of more advanced mathematics. The ideal aim of Group Theory is the classification of all groups (up to isomorphism). It will be shown that this goal can be achieved for finitely generated abelian groups. This course covers the advanced topics in group theory such as solvable groups, Upper and Lower Central series nilpotent groups and free groups.

Contents

1. Series in groups
2. Normal series
3. Normal series and its refinement
4. Composition series
5. Equivalent composition series
6. Jordan Holder Theorem
7. Solvable groups, definition, examples and related results
8. Upper and Lower Central series
9. Nilpotent groups
10. Characterization of finite nilpotent groups
11. The Frattini subgroups, definition, examples and related results
12. Free groups, definition, examples and related results
13. Free Product, definition, examples and related results
14. Group algebras
15. Representation modules

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Pre-requisite: Advance Group Theory-I

Recommended Texts

1. Rotman, J. J. (1999). *An Introduction to the theory of groups* (4th ed).New York: Springer.
2. Shah, S .K., Shankar A. G. (2013). *Group theory*. London: Dorling Kindersley.

Suggested Readings

1. Rose, H. E. (2009). *A course on finite groups* (1st ed). New York: Springer-Verlag.
2. Fraleigh, J. B. (2003). A *first course in abstract algebra* (7th ed.). Boston: Addison-Wesley Publishing Company.
3. Malik, D. S., Mordeson J. N. and Sen M. K. (1997). *Fundamentals of abstract algebra*. New York: WCB/McGraw-Hill.
4. Rose, J. A. (2012). *Course on group theory* (Revised ed.). New York: Dover Publications.

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MATH-6129 Modern Algebra-I 3(3+0)

The word "algebra" means many things. The word dates back about 1200 years ago to part of the title of al-Khwarizmi's book on the subject, but the subject itself goes back 4000 years ago to ancient Babylonia and Egypt. This course introduces concepts of ring theory. The main objective of this course is to prepare students for courses which require a good back ground in Ring theory, Ring Homomorphism, basics Theorem etc. The focus of this course is the study of ideal theory and several domains in ring theory. Homework, graded homework, class quizzes, tests and a final exam will be used to assess the Student Learning Outcomes: Upon successful completion of the course, students will be able to: Demonstrate ability to think critically by interpreting theorems and relating results to problems in other mathematical disciplines. Demonstrate ability to think critically by recognizing patterns and principles of algebra and relating them to the number system. Work effectively with others to discuss homework problems put on the board. This will be assessed through class discussions.

Contents

1 Polynomial rings
2 Division algorithm for polynomials
3 Prime elements
4 Irreducible elements
5 Euclidean domain
6 Principal ideal domain
7 Greatest common divisor
8 Prime and irreducible elements
9 Unique factorization domain
10 Factorization of polynomials over a UFD
11 Irreducibility of polynomials
12 Eisenstein's irreducibility criterion
13 Maximal ideals
14 Prime ideals
15 Primary ideals
16 Noetherian rings
17 Artinian rings

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Recommended Texts

1. Gallian, J. A. (2017). *Contemporary abstract algebra* (9th ed). New York: Brooks/Cole.
2. Malik, D. S., Mordeson, J. N. and Sen, M. K. (1997). *Fundamentals of abstract algebra*. New York: WCB/McGraw-Hill.

Suggested Readings

1. Roman, S. (2005). *Field theory (Graduate Texts in Mathematics)* (2nd ed.). New York: Springer.
2. Ames, D. B. (1968). *Introduction to abstract algebra.* (1st ed.). Scranton: Pennsylvania international text book Co.

MATH-6130 **Modern Algebra-II** 3(3+0)

The word "algebra" means many things. The word dates back about 1200 years ago to part of the title of al-Khwarizmi's book on the subject, but the subject itself goes back 4000 years ago to ancient Babylonia and Egypt. Modern algebra is a cornerstone of modern mathematics. This course introduces concepts of ring and group theory. The main objective of this course is to prepare students for courses which require a good back ground in Group Theory, Rings, Galois Theory, Symmetric group and permutation group etc. It is assumed that the students possess some mathematical maturity and are comfortable with writing proofs. After completing this course, student will be able to: Define and state some of the main concepts and theorems of Function Analysis. Apply their knowledge of subject in the investigation of examples . Prove basic proportions concerning functional analysis.

Contents

1 Finite and finitely generated Abelian groups
2 Fields
3 Finite fields
4 Field extension
5 Galois theory
6 Galois theory of equations
7 Construction with straight-edge
8 Construction with compass
9 Splitting field of polynomials
10 The Galios groups
11 Some results on finite groups
12 Symmetric group as Galois group
13 Construct able regular n-gones
14 The Galois group as permutation group

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Pre-requisite: Modern Algebra-I

Recommended Texts

1. Malik, D. S., Mordeson, J. N. and Sen, M. K. (1997). *Fundamentals of abstract algebra*. New York: WCB/McGraw-Hill.
2. Roman, S. (2005). *Field theory (Graduate Texts in Mathematics)* (2nd ed.). New York: Springer.

Suggested Readings

1. Howie, J. M. (2006). *Fields and galois theory* (2nd ed.). New York: Springer.
2. Northcott, D. D. (1973). *A first course of Homological algebra* (1st ed.). Cambridge: Cambridge University Press.
3. Jacobson, N. (1985). *Basic algebra I* (1st ed.). New York: Freeman and Co.
4. Ames, D. B. (1968). *Introduction to abstract algebra* (1st ed.). Scranton. Pennsylvania: International text book Co.

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MATH-6131 **Algebraic Topology-I** 3(3+0)

The primary aim of this course is to explore properties of topological spaces. We shall consider in detail examples such as surfaces. To distinguish topological spaces, we need to define topological invariants, such as the "fundamental group" or the "homology" of a space". To enable us to do this, knowledge of basic group theory and topology is essential. Some background in real analysis would also be helpful.

Contents

1 Affine spaces
2 Singular theory
3 Chain complexes
4 Homotopy invariance of homology
5 Relation between n, and H
6 Relative homology
7 The exact homology sequences.
8 Nilpotent groups
9 Homotopy theory
10 Homotopy theory of path and maps
11 Fundamental group of circles
12 Covering spaces
13 Lifting criterion
14 Loop spaces
15 Higher homotopy group.
16 Loop spaces
17 Higher homotopy group.

Recommended Texts

1. Adhikari, M. R. (2016). *Basic algebraic topology and its applications* (1st ed.). New York: Springer
2. Hatcher, A. (2001). *Algebraic topology.* Cambridge: Cambridge University Press.

Suggested Readings

1. Greenberg, M. J. and Harper, J. R. (1981). *Algebraic topology: A first course* (1st ed.). Boulder: Westview Press.
2. Croom, F. H. (1978). *Basic concept of algebraic theory.* New York: Spinger-Verlag.
3. Kosniowski, C. A. (1980). *First course in algebraic topology.* Cambridge : Cambridge University Press

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MATH-6132 Algebraic Topology-II 3(3+0)

This course is a continuation of Algebraic Topology-I. In this course, the objective is the study of knots, links, surfaces and higher dimensional analogs called manifolds with the understanding that continuous deformations do not change objects. So a doughnut (torus) and a coffee mug are essentially the same (homeomorphic) in this course. For example, how does a creature living on a sphere tell that she is not on the plane, on the torus, or perhaps a two holed torus? Can one turn a sphere inside out without creasing it? What would it be like to live inside a three dimensional sphere? Can one continuously deform a trefoil knot to get its mirror image? Can the wind be blowing at every point on the earth at once? Can you tell if a graph is planar? Can you tell if a knot is trivial? Is there a list of all possible two dimensional surfaces? How about three dimensional ones? These are some of the motivating questions for the subject. Algebraic topology attempts to answer such questions by assigning algebraic invariants such as numbers, or groups, to topological spaces. Examples include the Euler number of a surface, the Poincare index of a vector field, the genus of a torus, the fundamental group and more fancy homology groups.

Contents

1 Relative homology
2 The exact homology sequences
3 Excion theorem and application to spheres
4 Mayer Victoris sequences
5 Jordan-Brouwer separation theorem
6 Spherical complexes
7 Betti number
8 Euler characteristic
9 Cell Complexes
10 Adjunction spaces

Pre-requisite: Algebraic Topology-I

Recommended Texts

1. Adhikari, M. R. (2016). *Basic algebraic topology and its applications* (1st ed.). New York: Springer
2. Hatcher, A. (2001). *Algebraic topology*. Cambridge: Cambridge University Press.

Suggested Readings

1. Greenberg, M. J. and Harper, J. R. (1981). *Algebraic topology: A first course* (1st ed.). Boulder: Westview Press.
2. Croom, F. H. (1978). *Basic concept of algebraic theory.* New York: Spinger-Verlag.
3. Kosniowski, C. A. (1980). *First course in algebraic topology*. Cambridge : Cambridge University Press

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MATH-6133 Advanced Functional Analysis 3(3+0)

This course is intended both for continuing mathematics students and for other students using mathematics at a high level in theoretical physics, engineering and information technology, and mathematical economics. This course introduces concepts of Fundamental Theorems and Spectral Theory. On satisfying the requirements of this course, students will have the knowledge and skills to explain the fundamental concepts of functional analysis and their role in modern mathematics and applied contexts. Moreover, it demonstrate accurate and efficient use of functional analysis techniques and the capacity for mathematical reasoning through analyzing, proving and explaining concepts from functional analysis.

Contents

Fundamental Theorems:

1 Zorn's lemma
2 Statement of Hahn-Banach theorem for real vector spaces
3 Hahn-Banach theorem for complex vector spaces
4 Hahn-Banach theorem for normed spaces
5 Uniform boundedness theorem
6 Open mapping theorem
7 Closed graph theorem

Spectral Theory:

1 Spectral properties of bounded linear operations on Normed Spaces
2 Further properties of Resolvent and spectrum
3 Use of complex Analysis in spectral theory
4 Compact linear operators on Normed Spaces

Recommended Texts

1. Kreyszig, E. (1989). *Introductory functional analysis with applications* (1st ed.).New York: John Wiley.
2. Brown, A.L. (1970). *Elements of functional analysis* (1st ed.). New York: Von Nostrand and Reinhold Company.

Suggested Readings

1. Oden, J. T. (1979). *Applied functional analysis* (1st ed.). New Jersey: Prentice-Hall Inc.
2. Brown, A.L. (1970). *Elements of functional analysis* (1st ed.). New York: Von Nostrand and Reinhold Company.

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MATH-6134 **Theory of Modules** **3(3+0)**

This subject presents the foundational material for the la... of the basic algebraic structure pervading contemporary pure mathematics, namely fields and modules. The basic definitions and elementary results are given, followed by two important applications of the theory. This course introduces concepts of modules. The main objective of this course is to prepare students for courses which require a good back ground in Modules Theory, Primary component and Invariance Theorem etc.

Contents

1 Elementary notions and examples
2 Modules
3 Sub modules
4 Quotient modules
5 Finitely generated and cyclic modules
6 Exact sequences
7 Elementary notions of homological algebra
8 Noetherian rings and modules
9 Artinian rings and modules
10 Radicals
11 Semisimple rings and modules
12 Tensor product of modules
13 Bimodules
14 Algebra and coalgebra
15 Torsion module
16 Primary components
17 Invariance theorem

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Recommended Texts

1. Wang, F. and Kim, H. (2016). *Foundations of commutative rings and their modules* (1st ed.). New York: Springer.
2. Berrick, A. J. and Keating, M. E. (2000). *An introduction to rings and modules: With K-Theory in View*. (1st ed.). Cambridge: Cambridge University Press.

Suggested Readings

1. Hartley, B. and Hawkes, T. O. (1980). *Rings, modules and linear algebra* (1st ed.). London: Chapman and Hall.
2. Herstein I. N. (1995). *Topics in algebra with application* (3rd ed.). New York: Books/Cole.
3. Jacobson, N. (1989). *Basic algebra* (2nd ed.). Colorado: Freeman
4. Blyth, T. S. (1977). *Module theory* (1st ed.). Oxford: Oxford University Press.

MATH-6135 Astronomy-I **3(3+0)**

All Physics and Astronomy courses are expected to incorporate critical thinking abilities, quantitative skills and communication skills as core objectives in their course material and course work. They will also be required to demonstrate knowledge, understanding and use of the principles of physics and/or astronomy. In addition, there are objectives specific to Physics, Mathematics and Astronomy discipline courses. Both our overall and course-specific learning objectives are listed below. Students are required to demonstrate: (1) Knowledge, understanding and use of the principles of physics and/or astronomy. (2) Ability to use reasoning and logic to define a problem in terms of principles of physics. (3) Ability to use mathematics and computer applications to solve physics and/or astronomy problems. (4) Ability to design and/or conduct experiments and/or observations using principles of physics and/or astronomy and physics or astronomical instrumentation. (5) Ability to properly analyze and interpret data and experimental uncertainty in order to make meaningful comparisons between experimental measurements or observation and theory

Contents

1 Introduction to Astronomy
2 The great and small circles
3 Spherical angle and spherical triangle
4 Applications to the Earth
5 Longitude and latitude
6 Horizontal and equatorial systems of coordinates
7 Observer's meridian
8 Diurnal motion
9 Circumpolar stars
10 Right ascension
11 The equation of time
12 Basics of spherical trigonometry
13 The celestial sphere

Recommended Texts

1. Roy, A. E. (1982). *Astronomy: Principles and practice* (1st ed.). Bristor: London: Adam Hilger Ltd.
2. Wooland, E. W. and Clemence, G. M. (1966). *Spherical astronomy* (1st ed.). Boston: Academic Press.

Suggested Readings

1. Smart, W. M. (1977). *Textbook on spherical astronomy* (1st ed.). Cambridge: Cambridge University Press.

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MATH-6136 **Astronomy-II** 3(3+0)

An objective of the Course is to provide new research students in astronomy with an introduction and overview to research topics of major current and future interest. This will allow students to acquire some understanding and appreciation of research fields in addition to those they will be investigating as part of their graduate studies. Another objective is to provide new students with the opportunity to interact with each other, and also with lecturers who are leaders in their research field. As well as providing an introduction to astronomy research, the Course includes talks on career advice, public engagement activities in astronomy (of particular importance due to the popularity of astronomy with the general public, including children), unconscious bias in science and gender issues.

Contents

1 Introduction to celestial navigation on earth
2 Celestial sphere
3 Time-keeping system
4 Refraction
5 Parallax and triangulation
6 Aberration
7 Precession
8 Nutation
9 Tropical measurements
10 Magnitude systems
11 Naked Eye Observations
12 Observational techniques
13 Optics and telescopes
14 Radio telescopes and Doppler imaging

Pre-requisite: Astronomy-I

Recommended Texts

1. Roy, A. E. (1982). *Astronomy: Principles and practice* (1st ed.). Bristor: London: Adam Hilger Ltd.
2. Wooland, E. W. and Clemence, G. M. (1966). *Spherical astronomy* (1st ed.). Boston: Academic Press.

Suggested Readings

1. Smart, W. M. (1977). *Textbook on spherical astronomy* (1st ed.). Cambridge: Cambridge University Press.

MATH-6137 **Electromagnetism-I** 3(3+0)

Electromagnetism is a branch of physics involving the study of the electromagnetic force, a type of physical interaction that occurs between electrically charged particles. The electromagnetic force is carried by electromagnetic fields composed of electric fields and magnetic fields, and it is responsible for electromagnetic radiation such as light. It is one of the four fundamental interactions (commonly called forces) in nature, together with the strong interaction, the weak interaction, and gravitation. At high energy the weak force and electromagnetic force are unified as a single electroweak force. Students will learn properties of coulomb's law, magnetic shells, conductivity and current density vector to flows.

Contents

1 Electrostatics: Coulomb's law
2 Electric field and potential. lines of force and equipotential surfaces
3 Gauss's law and deduction
4 Conductor condensers
5 Dipoles, forces dipoles
6 Dielectrics, polarization and apparent charges
7 Electric displacement
8 Energy of the field, minimum energy
9 Magnetostatic field
10 The magnetostatic law of force, magnetic shells
11 Force on magnetic doublets
12 Magnetic induction, paradia and magnetism
13 Steady and slowly varying currents
14 Electric current
15 Linear conductors
16 Conductivity
17 Resistance
18 Kirchoff's laws
19 Heat production
20 Current density vector
21 Magnetic field of straight and circular current
22 Magnetic flux

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Recommended Texts

1. Ferraro (1956). *Electromagnetic theory* (Revised ed.). London: The Athlon Press
2. Reitz J. R. and Milford (1960). *Foundations of electromagnetic theory* (3rd ed.). Boston: Addison-Wesley.

Suggested Readings

1. Pugh and Pugh (1960). *Electricity and magnetism* (1st ed.). Boston: Addison-Wesley.

MATH-6138 **Electromagnetism-II** 3(3+0)

Electromagnetism is a branch of physics involving the study of the electromagnetic force, a type of physical interaction that occurs between electrically charged particles. The electromagnetic force is carried by electromagnetic fields composed of electric fields and magnetic fields, and it is responsible for electromagnetic radiation such as light. It is one of the four fundamental interactions (commonly called forces) in nature, together with the strong interaction, the weak interaction, and gravitation. At high energy the weak force and electromagnetic force are unified as a single electroweak force. Students will learn properties of simple introduction to Legendre polynomials, method of images, images in a plane, images with spheres and cylinders.

Contents

1 Vector potential
2 Forces on a circuit in magnetic field
3 Magnetic field energy
4 Law of electromagnetic induction
5 Co-efficient of self and mutual induction
6 Alternating current and simple I.C.R circuits in series and parallel
7 Power factor, the equations of electromagnetism
8 Maxwell's equations in free space and material media
9 Solution of Maxwell's equations, plane electromagnetic waves in homogeneous and isotropic media
10 Reflection and refraction of plane waves
11 Wave guides Laplace equation in plane
12 Polar and cylindrical coordinates
13 Simple introduction to Legendre polynomials
14 Method of images
15 Images in a plane
16 Images with spheres and cylinders

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Pre-requisite: Electromagnetism-I

Recommended Texts

1. Ferraro (1956). *Electromagnetic theory* (Revised ed.). London: The Athlon Press.
2. Reitz J. R. and Milford (1960). *Foundations of electromagnetic theory* (3rd ed.). Boston: Addison-Wesley.

Suggested Readings

1. Pugh and Pugh (1960). *Electricity and magnetism* (1st ed.). Boston: Addison-Wesley.

MATH-6139 **Fluid Mechanics-I** 3(3+0)

Fluid mechanics is the branch of physics concerned with the mechanics of fluids (liquids, gases, and plasmas) and the forces on them. It has applications in a wide range of disciplines, including mechanical, civil, chemical and biomedical engineering, geophysics, oceanography, meteorology, astrophysics, and biology. The course of fluid mechanics is introducing fundamental aspects of fluid flow behavior. Students will learn properties of Newtonian fluids; apply concepts of mass, momentum and energy conservation to flows.

Contents

1. Introduction: Definition of Fluid, basics equations
2. Methods of analysis, dimensions and units. Fundamental concepts
3. Fluid as a continuum, velocity field, stress field, viscosity, surface tension, description and classification of fluid motions
4. Fluid Statics: The basic equation of fluid static
5. The standard atmosphere
6. Pressure variation in a static fluid
7. Fluid in rigid body motion. Basic equation in integral form for a control volume, basic laws for a system
8. Relation of derivatives to the control volume formulation
9. Conservation of mass
10. Momentum equation for inertial control volume
11. Momentum equation for control volume with rectilinear acceleration
12. Momentum equation for control volume with arbitrary acceleration
13. The angular momentum principle
14. The first law of thermodynamics
15. The second law of thermodynamics
16. Introduction to differential analysis of fluid motion
17. Conservation of mass
18. Stream function for two-dimensional incompressible flow
19. Motion of a fluid element (kinematics), momentum equation

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Recommended Texts

1. Fox, R. W. and McDonald, A. T. (2004). *Introduction to fluid mechanics* (6th ed.). New York: John Wiley & Sons.
2. White, F. M. (2006). *Fluid mechanics* (5th ed.). New York: Mc. Graw Hill.

Suggested Readings

1. Granger, R. A. (1985). *Fluid mechanics* (1st ed.). Montana: Winston Publisher.
2. Bruce, R., Rothmayer, A. P., Theodore, H. O. and Wade, W. H. (2013). *Fundamental of fluid mechanics* (7th ed.). New York: Willey Son Publisher.
3. Nakayama, Y. (2018). *Introduction to fluid mechanics* (2nd ed.). Oxford: Butterworh Heineman Publisher.

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MATH-6140 **Fluid Mechanics-II** 3(3+0)

Covers properties of fluids, laws of fluid mechanics and energy relationships for incompressible fluids Studies flow in closed conduits, including pressure loss, flow measurement, pipe sizing and pump Selection, momentum equation for frictionless flow, Euler's equations, Bernoulli equation-Integration of Euler's equation, laminar flow and Boundary layers

Contents

1 Incompressible inviscid flow
2 Momentum equation for frictionless flow
3 Euler's equations
4 Euler's equations in streamline coordinates
5 Bernoulli equation- Integration of Euler's equation along a streamline for steady flow
6 Relation between first law of thermodynamics and the Bernoulli equation
7 Unsteady Bernoulli equation-Integration of Euler's equation along a streamline
8 Irrotational flow
9 Internal incompressible viscous flow
10 Fully developed laminar flow
11 Fully developed laminar flow between infinite parallel plates
12 Fully developed laminar flow in a pipe
13 Part-B Flow in pipes and ducts
14 Shear stress distribution in fully developed pipe flow
15 Turbulent velocity profiles in fully developed pipe flow
16 Energy consideration in pipe flow
17 External incompressible viscous flow
18 Boundary layers, the boundary concept, boundary thickness, laminar flat plate
19 Boundary layer: exact solution, momentum, integral equation, use of momentum integral equation for flow with zero pressure gradient
20 Pressure gradient in boundary-layer flow

Pre-requisite: Fluid Mechanics-I

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Recommended Texts

1. Fox, R. W. and McDonald, A. T. (2004). *Introduction to fluid mechanics* (5th ed.). New York: John Wiley & Sons.
2. White, F. M., (2006). *Fluid mechanics* (5th ed.). New York: Mc. Graw Hill.

Suggested Readings

1. Bruce, R., Rothmayer, A. P., Theodore, H. O. and Wade, W. H. (2013). *Fundamental of fluid mechanics* (7th ed.). New York: Willey Son Publisher.
2. Nakayama, Y. (2018). *Introduction to fluid mechanics* (2nd ed.). Oxford: Butterworh Heinemann Publisher.
3. Granger, R. A. (1985). *Fluid mechanics* (1st ed.). Montana: Winston Publisher.

MATH-6141 Operations Research-I 3(3+0)

Operations research (OR) is an analytical method of problem-solving and decision-making that is useful in the management of organizations. In operations research, problems are broken down into basic components and then solved in defined steps by mathematical analysis. The objective of Operations Research, as a mathematical discipline, is to establish theories and algorithms to model and solve mathematical optimization problems that translate to real-life decision-making problems.

Contents

1 Linear Programming
2 Formulation and graphical solution
3 Simplex method
4 M-technique
5 Two-phase technique
6 Special cases
7 Sensitivity analysis
8 The dual problem
9 Primal dual relationship
10 The dual simplex method
11 Sensitivity
12 Post optimal analysis
13 Transportation model
14 Northwest corner
15 Least cost
16 Vogel's approximation methods
17 The method of multipliers
18 The assignment models
19 The transshipment model
20 Network minimization
21 Shortest route algorithms for variables

Recommended Texts

1. Hamdy, A. T. (2006). *Operations research an introduction* (6th ed.). New York: Macmillan.
2. Gillet, B. E. (1979). *Introduction to operations research,* (1st ed.). New York: McGraw Hill.

Suggested Readings

1. Harvy, C. M. (1979). *Operations research: A practical introduction* (1st ed.). North Holland: CRC Press
2. Gillet, B. E. (1979). *Introduction to operations research,* (1st ed.). New York: McGraw Hill.

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MATH-6142 **Operations Research-II** 3(3+0)

Operations research (OR) is an analytical method of problem-solving and decision-making that is useful in the management of organizations. In operations research, problems are broken down into basic components and then solved in defined steps by mathematical analysis. Disciplines that are similar to, or overlap with, operations research include statistical analysis, management science, game theory, optimization theory, artificial intelligence and network analysis. All of these techniques have the goal of solving complex problems and improving quantitative decisions. The objective of Operations Research, as a mathematical discipline, is to establish theories and algorithms to model and solve mathematical optimization problems that translate to real life decision making problems. Students would be able to identify and develop complecated operational research modals from the verbal description of the real system. The understanding of the mathematical tools that are needed to solve optimization problems would be increased. They would be analyze the results and propose the theoretical language understandable to decision making processes in Management Engineering.

Contents

1 Algorithm for cyclic network
2 Maximal flow problems
3 Matrix definition of LP- problems
4 Revised simplex methods
5 Bounded variables decompositions algorithm
6 Parametric linear programming
7 Application of integer programming
8 Cutting plane algorithm
9 Mixed fractional cut algorithm
10 Branch methods
11 Bound methods
12 Zero-one implicit enumeration
13 Element of dynamics programming
14 Problems of dimensionality
15 Solutions of linear program by dynamics programming

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Pre-requisite: Operation Research-I

Recommended Texts

1. Hamdy, A. T. (2006). *Operations research an introduction* (6th ed.). New York: Macmillan.
2. Gillet, B. E. (1979). *Introduction to operations research.* (1st ed.). New York: McGraw Hill.

Suggested Readings

1. Harvy, C. M. (1979). *Operations research: A practical introduction* (1st ed.). North Holland: CRC Press

MATH-6143 **Quantum Mechanics–I** 3(3+0)

Quantum mechanics (QM; also known as quantum physics, quantum theory, the wave mechanical model and matrix mechanics), part of quantum field theory, is a fundamental theory in physics. It describes physical properties of nature on an atomic scale. Classical physics, the description of physics that existed before the theory of relativity and quantum mechanics, describes many aspects of nature at an ordinary (macroscopic) scale, while quantum mechanics explains the aspects of nature at small (atomic and subatomic) scales, for which classical mechanics is insufficient. This course will introduce Dirac's braket formulation of quantum mechanics and make students familiar with various approximation methods applied to atomic, nuclear and solid-state physics, and to scattering.

Contents

1 Inadequacy of classical mechanics
2 Black body radiation, photoelectric effect
3 Compton effect
4 Bohr's theory of atomic structure
5 Wave-particle duality
6 The de-Broglie postulate
7 The uncertainty principle
8 Uncertainty of position
9 Momentum
10 Statement and proof of the uncertainty principle
11 Energy-time uncertainty
12 Eigenvalues and eigen functions
13 Operators and eigen functions
14 Linear operators
15 Operator formalism in quantum mechanics
16 Orthonormal systems
17 Hermitian operators and their properties,
18 Simultaneous eigen functions
19 Parity operators, postulates of quantum mechanics
20 The Schrödinger wave equation
21 Motion in one dimension
22 Step potential, potential barrier, potential well, and harmonic oscillator

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Recommended Texts

1. Taylor, G. (1970). *Quantum mechanics* (1st ed.). George Allen and Unwin.
2. Powell, T. L. and Crasemann, B. (1961). *Quantum mechanics* (1st ed.). Boston: Addison Wesley

Suggested Readings

1. Merzdacker, E (1988). *Quantum mechanics* (1st ed.). New York: John Wiley.

MATH-6144 **Quantum Mechanics–II** 3(3+0)

Quantum mechanics (QM; also known as quantum physics, quantum theory, the wave mechanical model and matrix mechanics), part of quantum field theory, is a fundamental theory in physics. It describes physical properties of nature on an atomic scale. Classical physics, the description of physics that existed before the theory of relativity and quantum mechanics, describes many aspects of nature at an ordinary (macroscopic) scale, while quantum mechanics explains the aspects of nature at small (atomic and subatomic) scales, for which classical mechanics is insufficient. This course is continuation of Quantum Mechanics-I and cover more advance topics.

Contents

1 Motion in three dimensions
2 Angular momentum
3 Commutation relations between components of angular momentum
4 Representation in spherical polar coordinates
5 Simultaneous Eigen functions of Lz and L2
6 Spherically symmetric potential
7 The hydrogen atom
8 Scattering Theory
9 The scattering cross-section
10 Scattering amplitude
11 Scattering equation
12 Born approximation
13 Partial wave analysis
14 Perturbation Theory
15 Time independent perturbation of non-degenerate and degenerate cases
16 Time-dependent perturbations
17 Identical Particle
18 Symmetric and anti-symmetric Eigen function
19 The Pauli exclusion principle.

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Pre-requisite: Quantum Mechanics-I

Recommended Texts

1 Taylor, G. (1970). *Quantum mechanics* (1st ed.). New South Wales: George Allen and Unwin.
2 Powell, T. L. and Crasemann, B. (1961). *Quantum mechanics* (1st ed.). Boston: Addison Wesley.

Suggested Readings

1 Merzdacker, E (1988). *Quantum mechanics* (1st ed.). New York: John Wiley.

MATH- 6145 **Analytical Dynamics** 3(3+0)

In classical mechanics, analytical dynamics, or more briefly dynamics, is concerned with the relationship between motion of bodies and its causes, namely the forces acting on the bodies and the properties of the bodies, particularly mass and moment of inertia. Analytical dynamics develops Newtonian mechanics to the stage where powerful mathematical techniques can be used to determine the behavior of many physical systems. The mathematical framework also plays a role in the formulation of modern quantum and relativity theories.

Contents

1 Generalized coordinates
2 Constraints
3 Degree of freedom
4 D'Alembert principle
5 Holonomic and non-Holonomic systems, Hamilton's principle
6 Derivation of Lagrange equation from Hamilton's principle and Derivation of Hamilton's equation from a variational principle
7 Equations and Examples of Gauge transformations
8 Equations and examples of canonical transformations
9 Orthogonal Point transformations
10 The Principle of Least Action
11 Applications of Hamilton's equation to central force problems
12 Applications to Harmonic oscillator
13 Hamiltonian formulism
14 Lagrange bracket and Poisson brackets with application
15 The Hamilton Jacobi theory, Hamilton Jacobi Theorem
16 The Hamilton Jacobi equation for Hamilton characteristic functions
17 Bilinear co-variant, Quasi coordinates
18 Transpositional relations for Quasi coordinate
19 Lagrange's equation for Quasi coordinates
20 Appel's equation for quasi coordinates
21 Whittaker equation with applications
22 Chaplygian system and Chaplygian equation

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Recommended Texts

1 ~~Greenwood, D. T. (1965). *Classical dynamics*. New Jersey: Prentice-Hall, inc.~~
2 Aruldhas, G. (2016). *Classical mechanics*. New Dehli: PHI Private limited.
3 Chorlton, F. (1983). *Textbook of dynamics*. Cambridge: E. Horwood.

Suggested Readings

1 Woodhouse, N. M. J. (2009). *Introduction to analytical dynamics* (2nd ed.). New York: Springer-Verlag.
2 Chester, W. (1979). *Mechanics*. London: New South Wales: George Allen and Unwin Ltd.

MATH-6146 **Special Relativity** **3(3+0)**

Calculus Vector transformations Tensors for GTR to understand why we need these two theories. For that see the problems with Galilean transformation and equivalence of inertial and gravitational mass. The most important thing to study SR is to accept geometry as the concept behind it. The math is not difficult; it's the way of thinking you have to adopt. Draw space time diagrams, something to transform to another frame of reference (Lorentz transforms are available). Keep in mind that the view in the other reference frame is just a different view of the same situation that nothing really has changed, even if it looks different on Euclidean paper.

Contents

1 Historical background
2 Fundamental concepts of special theory of relativity
3 Galilean transformations,
4 Lorentz transformations (for motion along one axis)
5 Length contraction
6 Time dilation
7 Simultaneity
8 Velocity addition formulae.3-dimensional
9 Lorentz transformations
10 Introduction to 4-vector formalism
11 Lorentz transformations in the 4-vector formalism
12 The Lorentz groups
13 The Poincare groups
14 Introduction to classical mechanics
15 Minkowski space-time and null cone
16 4-velocity and 4-momentum and 4-force
17 Application of special relativity to Doppler shift and Compton effect
18 Aberration of light
19 Particle scattering
20 Binding energy
21 Particle production and decay
22 Special relativity with small acceleration

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Recommended Texts

1. Qadir, A. (1989). *An introduction to the special relativity theory* (1st ed.). Singapore: World Scientific.
2. Sardesai, P. L. (2008). *A primer of special relativity* (2nd ed.). Delhi: Offset.

Suggested Readings

1. Sardesai, P.L. (2008). *A primer of special relativity* (2nd ed.). Delhi: Offset.
2. D'Inverno, R. (1992). *Introducing Einstein's relativity* (1st ed.). Oxford: Oxford University Press.

MATH-6147 Numerical Solution of Partial Differential Equations 3(3+0)

This course addresses post graduate students of all fields who are interested in numerical methods for partial differential equations, with focus on a rigorous mathematical basis. Many modern and efficient approaches are presented, after fundamentals of numerical approximation are established. Of particular focus are a qualitative understanding of the considered partial differential equation, fundamentals of finite difference, finite volume, finite element, and spectral methods, and important concepts such as stability, convergence, and error analysis.Students who have successfully taken this module should be aware of the issues around the discretization of several different types of PDEs, have a knowledge of the finite element and finite difference methods that are used for discretizing, be able to discretise an elliptic partial differential equation using finite element and finite difference methods, carry out stability and error analysis for the discrete approximation to elliptic, parabolic and hyperbolic equations in certain domains. Students are able to solve following problems: advection equation, heat equation, wave equation, Airy equation, convection-diffusion problems, KdV equation, hyperbolic conservation laws, Poisson equation, Stokes problem, Navier-Stokes equations, interface problems.

Contents

1 Finite-Difference Formulae
2 Parabolic Equations
3 Finite difference methods
4 Convergence analysis
5 Stability analysis
6 Parabolic Equations
7 Alternative derivation of difference equations
8 Miscellaneous topics,
9 Hyperbolic equations
10 Characteristics,
11 Elliptic equations
12 Systematic iterative methods.

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Recommended Texts

1. Ames, W. F. (1992). *Numerical methods for partial differential equations* (3rd ed.). New York: Academic Press.
2. Smith, G. D. (1986). *Numerical solution of partial differential equations: Finite difference Methods* (3rd ed.). Oxford: Oxford University Press.

Suggested Readings

1. Ames, W. F. (1992). *Numerical methods for partial differential equations* (3rd ed.). New York: Academic Press.
2. Smith, G. D. (1986). *Numerical solution of partial differential equations: Finite difference Methods* (3rd ed.). Oxford: Oxford University Press.

MATH-6148 **Elastic Theory** 3(3+0)

Elasticity theory is the mathematical framework which describes such deformation. By elastic, we mean that the material rebounds to its original shape after the forces on it are removed; a rubber eraser is a good example of an elastic material. The objectives of this course are to introduce to the students the analysis of linear elastic solids under mechanical and thermal loads, to introduce theoretical fundamentals and to improve the ability to use the principles of theory of elasticity in engineering problems. Students who successfully complete the course should be expert in using indicial notion, Cartesian tensor analysis, analysis of stress and deformation, basic filed equations of linear elastic solids and to formulate solution strategies of various boundary value problems.

Contents

1 Cartesian tensors
2 Analysis of stress
3 Analysis of strain
4 Generalized Hook's law
5 Crystalline structure
6 Point groups of crystals
7 Reduction in the number of elastic moduli due to crystal symmetry
8 Equations of equilibrium
9 Boundary conditions
10 Compatibility equations
11 Plane stress
12 Plane strain problems
13 Two dimensional problems in rectangular coordinates
14 Two dimensional problems in polar coordinates
15 Torsion of rods
16 Torsion of beams

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Recommended Texts

1. Sokolinikoff. (1956). *Mathematical theory of elasticity* (2nd ed.). New York: McGraw Hill.
2. Dieulesaint, E. and Royer, D. (1974). *Elastic waves in solids* (1st ed.). New York: Wiley.

Suggested Readings

1. Funk, Y. C. (1965). *Foundations of solid mechanics* (1st ed.). New Jersey: Prentice – Hall.
2. Sadd, N. H. (2005). *Theory applications and numeric.* New York: Elsevier.
3. Boresi, A. P. (2000). *Elasticity in engineering mechanics.* New York: Wiley.

MATH-6149 **History of Mathematics** 2(2+0)

In this course, we will explore some major themes in mathematics—calculation, number, geometry, algebra, infinity, formalisms—and their historical developments in various civilizations. We will see how the earlier civilizations influenced or failed to influence later ones and how the conceps evolved in these various civilizations. The aims of teaching and learning mathematics are to encourage and enable students to: ... understand and be able to use the language, symbols and notation of mathematics, develop mathematical curiosity and use inductive and deductive reasoning when solving problems.

Contents

1 History of Numerations
2 Egyptian
3 Babylonian
4 Hindu contributions
5 Arabic contributions
6 Algebra: Including the contributions of Al-Khwarzmi
7 Algebra: Including the contributions of Ibn Kura
8 History of Geometry
9 History of Euclud's elements
10 History of Analysis
11 The Calculus: Newton
12 The Calculus: Leibniz
13 The Calculus: Gauss
14 The contributions of Bernoulli brothers
15 The Twentieth Century Mathematics

Recommended Texts

1. Boyer, B., Mersbach, U. V. (1989). *The history of mathematics* (2nd ed.). San Francisco: Jossey-Bass.
2. Berlinghoff, William, P, Fernando, Q. G. (2004). *Math through the ages: A gentle history for teachers and others* (Expanded ed.). London: Oxton House and MAA.

Suggested Readings

1. Burton, D. M. (2011). *The history of mathematics: An introduction* (7th ed.). New York: McGraw-Hill.
2. Katz, V. J., (2009). *A history of mathematics, an introduction* (3rd ed.) New York: Addison-Wesley.
3. Dunham and William. (1990). *Journey through genius: The great theorems of mathematics*. London: Penguin Pub.

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MATH-6150 **Heat Transfer** **3(3+0)**

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energy (heat) between physical systems. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes. The objectives of heat transfer include the following: Insulation, wherein across a finite temperature difference between the system and its surrounding, the engineer seeks to reduce the heat transfer as much as possible. The learning outcomes of this course are: to explain the basics of heat transfer, to explain the importance of heat transfer, to define the concept of boiling and condensation, to define the concept of heat exchangers, to explain heat transfer by conduction, to explain the Fourier heat conduction law, to define thermal conductivity coefficient and diffusion coefficient, to explain heat transfer with convection, to explain Newton's law, to explain free transport phenomenon, to explain the forced convection, to explain heat transfer by radiation.

Contents

1 Steady-State Conduction-One Dimension
2 Steady-State Conduction-Multiples Dimensions
3 Unsteady-State Conduction,
4 Principles of Convection
5 Empirical and practical Relations
6 Forced –Convection Heat Transfer
7 Natural Convection Systems
8 Radiation Heat Transfer

Recommended Texts

1. Holman, J. P. (1996). *Heat transfer* (8th ed.). New York: McGraw Hill.
2. Kays, W. M. and Crawford, M. E. (1993). *Convective heat & mass transfer* (3rd ed.). New York: McGraw Hill.

Suggested Readings

1. Incropera, F. P. and Dewitt, D. P. (1985). *Fundamentals of heat & mass transfer* (2nd ed.). New York: Wiley.
2. Cenegel, Y., Ghajar, A. J. (2015). *Heat and mass transfer: Fundamentals and applications* (5th ed.). New York: Mc-Graw Hill.
3. Lienhar IV, J. H. and Lienhar V, J. H. (2019). *A heat transfer textbook* (5th ed.). New York: Dover Publications.
4. Incropera, F. P. (2006). *Fundamentals of heat and mass transfer* (6th ed.). New York: John Wiley and Sons.

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MATH-6151 **Bio-Mathematics** **3(3+0)**

Mathematical and theoretical biology is a branch of biology which employs theoretical analysis, mathematical models and abstractions of the living organisms to investigate the principles that govern the structure, development and behavior of the systems, as opposed to experimental biology which deals with the conduction of experiments to prove and validate the scientific theories. The objective of this course is to meet the current and future needs for the interaction between mathematics and biological sciences. Mathematical modeling is being applied in every major discipline in the biomedical sciences. A very different applications, and surprisingly successful, is in psychology, modeling of various human interactions, blood flow and functioning of different organs in human body. Mathematics may be divided into the broad categories of analysis (calculus), algebra, geometry and logic. This subject fits largely into the calculus category and follows on from material you will have learned in first year and from other related courses you may have taken, although algebra and areas will also be involved. This course is very useful for those majoring in Applied Mathematics, those planning to teach, or those students of Mathematics who are interested in the application of mathematical techniques to real-world problem solving.

Contents

1 An introduction to the use of continuous differential equations in the biological sciences
2 An introduction to the use of discrete differential equations in the biological sciences
3 Single species
4 Interacting population dynamics
5 Modeling infectious and dynamic diseases
6 Modeling infectious diseases
7 Modeling dynamic diseases
8 Regulation of cell function,
9 Molecular interactions
10 Neural and biological oscillators
11 Introduction to biological pattern formation
12 Mathematical tools such as phase portraits
13 Bifurcation diagrams
14 Perturbation theory
15 Parameter estimation techniques
16 Interpretation of biological models.

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Recommended Texts

1. Murray, J. D. (2001). *Mathematical biology*. New York: Springer-Verlag.
2. Britton, N. F. (2003). *Essential Mathematical Biology*. New York: Springer- Verlag

Suggested Readings

1. Keener, J. and Sneyd, J. (1998). *Mathematical physiology*. New York: Springer.
2. Edelstein-Keshet, L. (1988). *Mathematical Models in Biology*. New York: Random House.

MATH-6152 Theory of Automata 3(3+0)

Automata theory is the study of abstract machines and automata, as well as the computational problems that can be solved using them. It is a theory in theoretical computer science. The word automata (the plural of automaton) comes from the Greek word αὐτόματα, which means "self-making". The major objective of automata theory is to develop methods by which computer scientists can describe and analyze the dynamic behavior of discrete systems, in which signals are sampled periodically. ... Inputs: assumed to be sequences of symbols selected from a finite set I of input signals. The aim is to introduce to the students to the foundations of computability theory. Other objectives include the application of mathematical techniques and logical reasoning to important problems. and to develop a strong background in reasoning about finite automata and formal languages. At the end of the course the students should be able to: define the notion of countable and uncountable set, define the various categories of languages and grammars, define various categories of automata, define the notion of computability and decidability, and reduce a problem to another(when possible) to develop proofs of decidability/undecidibility. The course introduces some fundamental concepts in automata theory and formal languages including grammar, finite automaton, regular expression, formal language, pushdown automaton, and Turing machine. Not only do they form basic models of computation, they are also the foundation of many branches of computer science, e.g. compilers, software engineering, concurrent systems, etc.

Contents

1 Regular expressions
2 Regular Languages
3 Finite Automata
4 Context-free Grammars
5 Context-free languages
6 Push down automata
7 Decision Problems
8 Parsing
9 Turing Machines

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Recommended Texts

1. Martin, J. C. (2010). *Introduction to languages and theory of computation* (4th ed.). New York: Mc Graw Hill.

Suggested Readings

1. Cohen, D. I. A. (1996). *Introduction to computer theory* (2nd ed.). New York: Wiley.
2. Linz, P. (2017). *Introduction to Formal Languages and Automata* (6th ed.). New York: Jones and Barlett
3. Michael S. (2013). *Introduction to the Theory of Computation* (3rd ed.). New York: Cengage Learning

MATH-6153 Measure Theory 3(3+0)

The objectives of the course are to introduce the concepts of measure and integral with respect to a measure, to show their basic properties, to provide a basis for further studies in analysis, probability, and dynamical Systems, to construct Lebesgue's measure and learn the theory of Lebesgue integrals on real line and in n-dimensional Euclidean space. After the course the students will know and understand the basic concepts of measure theory and the theory of Lebsgue integration. The students will understand the main proof techniques in the field, and will also be able to apply the theory abstractly and concretely. The students will be able to write the elementary proofs himself, as well as more advanced proofs under guidance. The students will be able to use measure theory and integration in Riemann integration and calculus.

Contents

1 Introduction to Lebesgue measure
2 Outer measure
3 Properties of outer measure
4 Further properties of outer measure
5 Measurable sets
6 Properties of measurable sets
7 Non measurable sets
8 Measurable functions
9 Properties of measurable functions
10 Convergence of sequences of measurable functions
11 Lebesuge integration, introduction
12 Lebesgue integrals of simple
13 Bounded functions
14 Lebesgue integrals of non negative functions
15 Lebesgue integration of general functions
16 General convergence theorems
17 convergence in measure

Recommended Texts

1. Roydon, H. L. and Fitzpatrick, P. M. (2017). *Real analysis* (4th ed.). New York: Collier Macmillan Co.
2. Barra, G. De. (1981). *Measure theory and integration* (1st ed.). Ellis: Harwood Ltd.

Suggested Readings

1. Rudin, W. (1987). *Real and complex analysis,* (3rd ed.). New York: McGraw Hill Book Company.
2. Bartle R.G. (1995). *The Elements of integration and Lebesgue measure* (1st ed.). Wiley-Interscience.
3. Halmos, P. R. (1975). *Measure theory* (1st ed.). NY: Springer.

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MATH-6154 **Special Functions** 3(3+0)

Special functions are particular mathematical functions that have more or less established names and notations due to their importance in mathematical analysis, functional analysis, geometry, physics, or other applications. The term is defined by consensus, and thus lacks a general formal definition, but the List of mathematical functions contains functions that are commonly accepted as special. The main aim of this course is the study of basic special functions and proves the properties and relations related to these functions. Furthermore, the simple sets of polynomials are discussed.

Contents

1 The Weierstrass gamma function
2 Euler integral representation of gamma function
3 Relations satisfied by gamma function
4 Euler's constant
5 The order symbols o and O
6 Properties of gamma function
7 Beta function. integral representation of beta function
8 Relation between gamma and beta functions
9 Properties of beta function, Legendre's duplication formula
10 Gauss' multiplication theorem
11 Hypergeometric series, the functions F(a,b;c;z) and F(a,b;c;l), integral representation of hypergeometric function,
12 The hypergeometric differential equation, The contiguous relations, Simple transformations,
13 A theorem due to Kummer,
14 Confluent hypergeometric series, Integral representation of confluent hypergeometric function, the confluent hypergeometric,
15 Differential equation, Kummer's first formula
16 Simple sets of polynomials, Orthogonality,
17 The three term recurrence relation, The Christofell-Darboux formula,
18 Normalization, Bessel's inequality
19 Generating functions
20 Differential equations
21 Recurrence relations

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Recommended Texts

1. ~~Richard, B. (2016). *Special functions and orthogonal polynomials*. Cambridge: Cambridge~~ University Press.
2. Rainville, E. D. (1971). *Special functions* (3rd ed.). New York: The Macmillan Company

Suggested Readings

1. Whittaker and Watson. (1978). *A course in modern analysis*, (2nd ed.). Cambridge : Cambridge University Press.
2. Lebedev. N. N. (1972). *Special functions and their applications* (2nd ed.). New York: Prentice Hall.

MATH-6155 **Theory of Splines-I** 3(3+0)

This course is designed to teach students about basics of scientific computing for solving problems which are generated by data using interpolation and approximation techniques and learn how to match numerical method to mathematical properties. This course gives the students the knowledge of problem classes, basic mathematical and numerical concepts and software for solution of engineering and scientific problems formulated as using data sets. After successful completion, students should be able to design, implement and use interpolations for computer solution of scientific problems involving problems generated by set of data

Contents

1 Basic concepts of Euclidean geometry
2 Scalar and vector functions
3 Barycentric coordinates
4 Convex hull
5 Matrices of affine maps
6 Translation, rotation, scaling
7 Reflection and shear,
8 Curve fitting, least squares line fitting
9 Least squares power fit
10 Data linearization method for exponential functions, nonlinear least-squares method for exponential functions
11 Transformations for data linearization
12 linear least squares, Polynomial fitting,
13 Basic concepts of interpolation, Lagrange's method, error terms and error bounds of Lagrange's method
14 Divided differences method,
15 Newton polynomials, error terms and error bounds of Newton polynomials
16 central difference interpolation formulae
17 Gauss's forward interpolation formula, Gauss's backward interpolation formula
18 Hermite's methods.

Recommended Texts

1. David, S. (2006). *Curves and surfaces for computer graphics*. New York: Springer Science + Business Media Inc.
2. ~~John, H. M., Kurtis, D. F. (1999). *Numerical methods using MATLAB*~~. New Jersey: Prentice Hall.

Suggested Readings

1. Rao, S. S. (1992). *Optimization theory and applications* (2nd ed.). New York: Wiley Eastern Ltd.
3. Sudaran R. K. (1996). *A first course in optimization theory* (3rd ed.). Cambridge: Cambridge University Press.
2. Chang E. K. P. and Zak, S. I. I. (2004). *An introduction to optimization* (3rd ed.). New York: Wiley.

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MATH-6156 **Theory of Splines-II** 3(3+0)

The goal of the course is to provide the students with a strong background on numerical approximation strategies and a basic knowledge on the theory of splines that supports numerical algorithms. Interactive graphics techniques for defining and manipulating geometrical shapes used in computer animation, car body design, aircraft design, and architectural design. In this course follow a modular approach and contribute different components to the development of an interactive curve and surface modeling system. Curve Modeling Techniques: Students will implement various curve interpolation and approximation techniques that allow the interactive specification of three-dimensional curves (e.g. Bezier, B-spline, rational curves). Surface modeling techniques: Students will implement various surface interpolation and approximation techniques that allow the interactive specification of three-dimensional surfaces (e.g. Bezier, B-spline, rational surfaces). Simple, 3D Modeling System: Students will integrate the curve and surface modules into a system that allows the user to interactively design and store simple, 3D geometries.

Contents

1. Parametric curves (scalar and vector case). Algebraic form
2. Hermite form, control point form, Bernstein Bezier form
3. Matrix forms of parametric curves
4. Algorithms to compute B.B. form, Convex hull property
5. Affine invariance property, Variation diminishing property
6. Rational quadratic form, Rational cubic form
7. Tensor product surface, B.B. cubic patch
8. Quadratic by cubic B.B. patch, B.B. quartic patch
9. Splines, Cubic splines
10. End conditions of cubic splines, Clamped conditions
11. Natural conditions, second derivative conditions
12. Periodic conditions, Not a knot conditions
13. General splines, Natural splines, Periodic splines
14. Truncated power function, Representation of spline in terms of truncated power functions
15. Odd degree interpolating splines

Pre-requisite: Theory of Splines-I

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Recommended Texts

1. Farin, G. (2002). *Curves and surfaces for computer aided geometric design: a practical guide* (5th ed.). New York: Academic Press.
2. Faux, I. D. & Pratt, M. J. (1979). *Computational geometry for design and manufacture* (1st ed.). New York: Halsted Press.

Suggested Readings

1. Bartle, H. R., Beatly, C. J. (2006). *An Introduction to spline for use in computer graphics and geometric modeling* (4th ed.). Massachusetts: Morgan Kaufmann.
2. Boor, C. D. (2001). *A practical guide to splines* (Revised ed.). New York: Springer Verlag.

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MATH-6157 **Methods of Optimization-I** 3(3+0)

Optimization is a widely used technique in operational research that has been employed in a range of applications. The aim is to maximize or minimize a function (e.g. maximizing profit or minimizing environmental impact) subject to a set of constraints. At the start of the course, the course delivery, the pre requisites of the course will be discussed. On successful completion of the course the students will be able to model engineering maxima/minima problems as optimization problems. The students will be able to use computers to implement optimization algorithms. The students will learn efficient computation procedures to solve optimization problems.

Contents

1 Introduction to optimization
2 Review of related mathematical concepts
3 Unconstrained optimization
4 Conditions for local minimizers
5 One dimensional search methods
6 Gradient methods
7 Newton's method (analysis and modifications)
8 Conjugate direction methods
9 Quasi Newton method
10 Application to neural network
11 Single Neuron Training
12 Linear integer programming
13 Genetic algorithms
14 Real number genetic algorithm

Recommended Texts

1. Chong, E. K. P. and Stanislaw, H. Z. (2012). *An introduction to optimization* (4th ed.). New York: Wiley Series in Discrete Mathematics and Optimization.
2. Singiresu, S. R. (1992). *Optimization theory and applications* (2nd ed.). New York: Wiley Eastern Ltd.

Suggested Readings

1. Sundaram, R. K. (1996). *A first course in optimization theory,* (3rd ed.). Cambridge: Cambridge University Press.
2. Singiresu, S. R. (1992). *Optimization theory and applications* (2nd ed.). New York: Wiley Eastern Ltd.

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MATH-6158 **Methods of Optimization-II** 3(3+0)

This is continuation of Methods of Optimization I. Optimization is a widely used technique in operational research that has been employed in a range of applications. The aim is to maximize or minimize a function (e.g. maximizing profit or minimizing environmental impact) subject to a set of constraints. At the start of the course, the course delivery, the pre requisites of the course will be discussed. On successful completion of the course the students will be able to model engineering maxima/minima problems as optimization problems. The students will be able to use computers to implement optimization algorithms. The students will learn efficient computation procedures to solve optimization problems.

Contents

1 Non-linear constrained optimization
2 Problems with equality constraints
3 Problem Formulation
4 Tangent spaces
5 Normal spaces
6 Lagrange condition
7 Second-order conditions
8 Problems with inequality constraints
9 Karush-Kuhn-Tucker Condition
10 Second-order conditions
11 Convex optimization problems
12 Convex functions
13 Algorithms for constrained optimization
14 Lagrangian algorithms

Pre-requisite: Methods of Optimization-I

Recommended Texts

1. Sundaram, R. K. (1996). *A first course in optimization theory,* (3rd ed.). Cambridge: Cambridge University. Press.
2. Chong, E. K. P. and Stanislaw, H. Z. (2012). *An introduction to optimization* (4th ed.) New York: Wiley Series in Discrete Mathematics and Optimization.

Suggested Readings

1. Singiresu, S. R. (1992). *Optimization theory and applications* (2nd ed.). New York: Wiley Eastern Ltd.
2. Chong, E. K. P. and Stanislaw, H. Z. (2012). *An introduction to optimization* (4th ed.). New York: Wiley Series in Discrete Mathematics and Optimization.

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MATH-6159 **Control Theory** 3(3+0)

In control system engineering is a subfield of mathematics that deals with the control of continuously operating dynamical system in engineered processes and machines. The objective is to develop a control model for controlling such systems using a control action in an optimum manner without delay or overshoot and ensuring control stability.

Contents

1 System dynamics and differential equations, some system equations
2 System control
3 Mathematical methods and differential equations. The classical and modern control theory
4 Transfer functions and block diagram, Review of Laplace Transforms
5 Applications to differential equations, Transfer functions and Block diagrams
6 State space formations, State space forms, using transfer functions to define state variables, direct solution of the state equation
7 Solutions of the state equation by Laplace transforms, the transformation from companion to the diagonal state form
8 The transform function from the state equation, Transient and steady state response analysis
9 Response of first order system, Response of second order system, Response of higher order systems
10 Steady state error
11 Feedback control
12 The concept of stability
13 Routh stability criterion
14 Introduction to Liapunor's method
15 Quadratic form
16 Determination of liapunov's function,
17 The Nyquist stability criterion
18 The frequency response
19 An introduction to conformal mapping
20 Applications of conformal mappings to the frequency response
21 Controllability, Observability, Decomposition of system state
22 A transformation into the companion form
23 State feedback of SISO system
24 Multivariable system observations

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Recommended Texts

1. Burghes, D. and Graham, A. (1980). *Introduction to control theory including optimal control*. New York: Ellis Horwood Ltd

Suggested Readings

1. Barnett, S. and Camron, R. G. (1985). *Introduction to mathematical control theory* (2nd ed.). Oxford: Oxford V. P.

MATH-6160 Applied Matrix Theory 3(3+0)

Matrix theory is a branch of mathematics which is focused on study of matrices. Initially, it was a sub-branch of linear algebra, but soon it grew to cover subjects related to graph theory, algebra, combinatorics and statistics as well. The aim of this course is to introduce the key mathematical ideas in matrix theory, which are used in modern methods of data analysis, scientific computing, optimization, and merely all quantitative fields of science and engineering. While the choice of topics is motivated by their use in various disciplines, the course will emphasize the theoretical and conceptual underpinnings of this subject, just as in other (applied) mathematics course. The main focus of this course is to study the basics of matrices and their applications. Moreover, it concerns with the variational principles, Weyl's inequalities, Gershgorin's theorem and perturbations of the spectrum. The aim of this course is to introduce the key mathematical ideas in matrix theory, which are used in modern methods of data analysis, scientific computing, optimization, and merely all quantitative fields of science and engineering. While the choice of topics is motivated by their use in various disciplines, the course will emphasize the theoretical and conceptual underpinnings of this subject, just as in other (applied) mathematics course.

Contents

1 Eigen values
2 Eigen vectors
3 The Jordan canonical forms
4 Bilinear and quadratic forms
5 Matrix analysis of differential equations
6 Variational principles
7 Perturbation theory
8 The Courant minimax theorem
9 Weyl's inequalities
10 Gershgorin's theorem
11 Perturbations of the spectrum
12 Vector norms and related matrix norms
13 The condition number of a matrix

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Recommended Texts

1. Strang, G. (2005). *Linear algebra and its applications*. Cambridge: Academic Press.
2. William, G. (2009). *Linear algebra with applications* (7th ed.). Boston: Allyn and Bacon. Inc.

Suggested Readings

1. Stewart, G. W. (1973). *Introduction to matrix computations*. New York: Academic Press.
2. William, G. (2009). *Linear algebra with applications* (7th ed.). Boston: Allyn and Bacon. Inc.
3. Strang, G. (2005). *Linear algebra and its applications*. Cambridge: Academic Press.