

**SYLLABUS FOR POST GRADUATE COURSE
MATHEMATICS
(With effect from 2021-2022)**

**Under Choice Based Credit System
with
Semester Pattern and Open Elective**



**DEPARTMENT OF MATHEMATICS
Maharaja Sriram Chandra Bhanja Deo University
(Erstwhile North Orissa University)
Sriram Chandra Vihar
Takatpur, Baripada-757003**

P.G. Department of Mathematics
Maharaja Sriram Chandra Bhanja Deo University, Baripada
M.Sc / M.A Mathematics-Revised Course Structure under
CBCS and Open Elective

SEM-I	Course Code	Course Title	Credit	Exam hrs	Marks		Total
					Internal	Semester	
	MATH-401	Real Analysis	05	03	20	80	100
	MATH-403	Complex Analysis	05	03	20	80	100
	MATH-405	Graph Theory	05	03	20	80	100
	MATH-407	Differential Equation	05	03	20	80	100
	MATH-409	Computer Programming (C Language)	05	06	--	100	100
	Total		25		80	420	500
SEM-II	MATH-402	Operations Research	05	03	20	80	100
	MATH-404	Topology	05	03	20	80	100
	MATH-406	Measure Theory and Integration	05	03	20	80	100
	MATH-408	Linear Algebra	05	03	20	80	100
	MATH-410	Seminar Presentation	05	06	--	100	100
	OE-MATH-412	Basic Probability Theory and Statistics	05	03	20	80	100
	Total		30		100	500	600
SEM-III	MATH-501	Numerical Analysis	05	03	20	80	100
	MATH-503	Functional Analysis	05	03	20	80	100
	MATH-505	Abstract Algebra	05	03	20	80	100
	MATH-507	Elective-I	05	03	20	80	100
	MATH-509	Research Paper Review	05	06	---	100	100
	Total		25		80	420	500
SEM-IV	MATH-502	Probability and Statistics	05	03	20	80	100
	MATH-504	Number Theory	05	03	20	80	100
	MATH-506	Elective-II	05	03	20	80	100
	MATH-508	Dissertation, Presentation and Viva-Voce	05	06	----	100	100
	Total		20		60	340	400
	Grand Total		100				2000
Elective Papers (Any one)							
1. Design and Analysis of Algorithms (Group-A)							
2. Fuzzy Logic and Set Theory (Group-B)							

Program Outcome:

- Students will be able to enhance the knowledge.
- They will get employment opportunities in various field like administration, academic, research, banking, finance etc
- They will get opportunities for further studies and research.
- They can get prospect to join on research work and make career therein.
- They can be able to get opportunity to improve soft skills and personality.

Program Specific Outcome:

- Students will understand real analysis, complex analysis, graph theory, topology, algebra, analysis and design of algorithms, operations research, fuzzy logic, etc and can be able to apply in different field of engineering and research.
- They will be able to compete in the various examination like NET, GATE, etc.
- They can use mathematical theorems, tools and techniques in other interdisciplinary field.
- They can be able to develop algorithms in different field like medical diagnosis, engineering, etc.
- An open elective is introduced in this course for the students of different departments. Students from other departments in Semester-II, can opt this open elective: **Basic Probability Theory and Statistics**, which will be beneficial to them in different field.
- Two **elective papers** are introduced in Sem-III and IV. Students can choose any one elective paper.

SEMESTER-I
MATH-401
REAL ANALYSIS

Full Marks: 100(80+20)

Time:3 Hours

Course Objective:

This course will help the students to do research in the field of pure and applied mathematics. It is very useful in data science. It is the base of many courses of mathematics.

Contents

Unit-I

Real Number System and Set Theory:Completeness Property, Archimedean Property, Denseness of Rationales and Irrationals, Countable and Uncountable. Metric Spaces: Open Sets, Closed Sets.

Unit-II

Continuous Functions, Completeness, Cantor Intersection Theorem, BaireCategory Theorem, Compactness, Totally Boundedness, Finite Intersection Property. Riemann-Stieltjes Integral: Definition and Existence of the Integral.

Unit-III

Riemann-Stieltjes Integral:Properties of the Integral, Differentiation and Integration.Sequence and Series of Functions: Uniform Convergence, Uniform Convergence and Continuity.

Unit-IV

Sequence and Series of Functions:Uniform Convergence and Integration. Uniform Convergence and Differentiation. Equicontinuity, Ascoli's Theorem, Weierstrass Approximation Theorem.

Course Outcome:

The student will be able to understand real number system with set theory, completeness property, archimedean property, denseness of rationales and irrationals. They can understand metric spaces, riemannstieltjes integral. Students can identify closed set, open set, countable set, uncountable set etc. They will understand sequence and series of functions, uniform continuity, uniform convergence, equicontinuity, ascoli's theorem etc.

Books Recommended

1. W. Rudin: Principles of Mathematical Analysis, McGraw-Hill
2. T. Apostol: Mathematical Analysis, Narosa Publishers

Books for Reference

1. H. L. Royden: Real Analysis (Third Edition, Prentice-Hall of India)
2. Hewitt E. and Stomberg K. Real and Abstract Analysis: A Modern Treatment of the Theory of Functions of a Real Variable, Springer
3. K. Ross K. Elementary Analysis: The Theory of Calculus, Springer

SEMESTER-I
MATH-403
COMPLEX ANALYSIS

Full Marks: 100(80+20)

Time:3 Hours

Course Objective:

This course is an important component of the mathematical landscape. It can serve as an effective capstone course for the mathematics and as a stepping-stone to independent research.

Contents

Unit-I

Complex Numbers and Functions: Complex Numbers, Complex Plane, Polar form of Complex Numbers, Powers and Roots, Analytic Function, Cauchy Riemann Equations, Laplace's Equation, Exponential Function, Trigonometric and Hyperbolic Functions, Logarithmic Function.

Unit-II

Complex Integration: Line Integral in the Complex Plane, Cauchy Integral Theorem, Cauchy Integral Formula, Cauchy Goursat's Theorem, Derivatives of Analytic Function, Morera's Theorem, Maximum Moduli of Functions, Liouville's Theorem and Fundamental Theorems of Algebra.

Unit-III

Power Series, Taylor's Series: Sequence, Series, Convergence Test, Power Series, Functions Given by Power Series, Taylor's and Maclaurin Series, Uniform Convergence, Laurent Series and Residue Integration: Laurent Series.

Unit-IV

Laurent Series and Residue Integration: Singularities and Zeros, Residue Integration Method, Residue Integration of Real Integral, Argument Principle, Conformal Mapping: Geometry of Analytic Function, Linear Fractional Transformation (Möbius Transformation), Special Linear Fractional Transformation.

Course Outcome:

The student will understand the concept of complex numbers, complex plane, complex integration etc. They can be acquainted with Cauchy integral theorem, analytic function, Liouville's theorem. Students will be able to understand the basic concept of power series, Taylor's and Maclaurin's series, Morera's theorem. They can also be able to solve the problems of power series, Taylor's series. They will be able to do convergence test on given series and will understand Laurent series, residue integration etc.

Books Recommended

1. R. V. Churchill and J.W. Brown: Complex Variables and Applications (Fifth Edition, McGraw-Hill Publishing Company, 1990)

2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley
3. Ahlfors L. V. Complex Analysis, Mcgraw Hill.

Books for Reference

1. J. B. Conway: Function of Complex Variable (Springer- Verlag, International Student Edition, Narasa Publishing House-1980).
2. W. Rudin: Real and complex analysis, McGraw-Hill Book Co

SEMESTER-I MATH-405 GRAPH THEORY

Full Marks: 100(80+20)

Time:3 Hours

Course Objective:

This course provides a helpful tool to quantify and simplify the many moving parts of dynamic systems. Graph theory represents a major area of discrete mathematics. It has quite a few connections to other fields of mathematics and computer science.

Contents:

Unit-I

Graphs, Basic Concepts, Different Types of Graphs, Incidence and Degree of a Graph, Isolated and Pedant Vertex, Isomorphism, Sub-Graphs.

Unit-II

Walk, Path and Circuit of a Graph, Cut-Sets, Cut-Vertices, Planar Graphs, Euler Formula, Hamiltonian Paths and Circuits, Chromatic Numbers, Incidence Matrix, Adjacency Matrix, Directed Graphs.

Unit-III

Types of Digraphs, Adjacency Matrix of Digraphs, Trees and Properties, Rooted Trees, Binary Trees, Spanning Trees Prime's & Kruskal's Algorithm, Minimal Spanning Tree.

Unit-IV

Directed Tree, Enumeration of Graphs, Signal Flow Graphs, Network Flows: Graphs as Models of Flow Of Commodities, Flows, Maximal Flows And Minimal Cuts, Max-Flow and Min-Cut Theorem

Course Outcome:

Students will be able to understand the basic concept of a graph, and different types of graphs. They will learn how to find a walk, incidence matrix, adjacency matrix from a given graph. Students will get a knowledge that how to determine the existence of hamiltonian path and circuits in the given graph. They will also be able to know about the concept of undirected graph, tree, spanning tree, algorithms of spanning tree, the basic concept of network flow etc

Books Recommended

1. C.Vasudev: Graph Theory with Applications, New Age International Publishers, New Delhi

2. NarsinghDeo: Graph Theory with Applications to Engineering and Computer Science, Prentice-Hall of India

Books for Reference

1. J.P. Tremblay, R. Manohar: Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw-Hill Edn.
2. Y.N. Singh: Mathematical Foundation of Computer Science, New age International Publishers.

SEMESTER-I **MATH-407** **DIFFERENTIAL EQUATIONS**

Full Marks: 100(80+20)

Time:3 Hours

Course Objective:

This course is mainly used in other fields such as physics, engineering, biology and so on. This course is important because for many physical systems, one can formulate a differential equation that describes how the system changes in time.

Contents

Unit-I

Linear Equations with Constant Coefficients: Equations Reducible to Linear Equations with Constant Coefficients. Euler Equations. Applications: Escape Velocity Problem, Vibration Problem. Existence and Uniqueness of Solutions: Picards Method of Successive Approximation, Existence and Uniqueness Theorem.

Unit-II

Basic Concepts of Power Series, Series Solution about an Ordinary Point, Power Series Solutions of Differential Equations, Legendre Equation and Legendre Polynomial, Power Series Solution about Singular Points.

Unit-III

Bessel's Equation and Bessel Functions, Properties of Bessel Functions. Boundary Value Problems for Ordinary Differential Equations: Sturm–Liouville Problem, Orthogonality of Eigen Functions, Eigen Function Expansion, Green's Function.

Unit-IV

Fourier Series: Periodic Functions and Fourier Series, Fourier Series of Even and Odd Functions, Fourier Series for a Function with Arbitrary Period, Half-Range Fourier Series.

Course outcome:

Students will get an idea about ordinary differential equation with problems. They can solve various problems of picard's theorem. They will be able to understand the various

applications differential equations. Students can also be aware of power series, related problems to power series. They will acquire knowledge on Bessel's function, Legendre polynomial, Green's function etc. Students can understand Fourier series, Fourier series of even and odd functions and half-range Fourier series etc

Books Recommended

1. J. Sinharoy and S. Padhy: A Course on Ordinary and Partial Differential Equations, Kalyani Publishers. [Chapters: 4: 4.6,4.7, 4.8 (a), (b). 6: 6.1,6.2, 6.3. 7: 7.2, 7.3, 7.3.1, 7.4, 7.4.1, 7.4.2. 10: 10.1,10.2, 10.2.1, 10.3. 14: 14.1, 14.1.1, 14.3.]
2. Coddington E. A. An Introduction to Ordinary Differential Equations, Prentice Hall

Books for Reference

1. Hsieh P.F. and Sibuya Y. Basic Theory of Ordinary Differential Equations, UTX, Springer
2. Ross S. L. Differential Equations, Wiley
3. Apostol T. Calculus, Volume II, John Wiley & Sons {ASIA} Pvt Ltd
4. Deo S.G., Lakshmikantham V. and Raghavendra V. Textbook of Ordinary Differential Equations, Tata-McGraw-Hill Publishing Co. Ltd
5. Rama Mohana Rao H. Ordinary differential equations, Edward Arnold, Wiley
6. Coddington E. A. and Levinson N. Theory of Ordinary Differential Equations, Tata McGraw Hill

SEMESTER-I

MATH-409

Practical: Computer Programming C- LANGUAGE (PRACTICAL)

Full Marks: 100

Experiment- 60, Viva-Voce- 20, Record- 20

Time: 6 Hours

Course Objectives:

This course helps the students to work on open source projects. Almost all programming languages can interface with it. This language is majorly used in the creation of hardware devices, operating systems, drivers, kernels etc. It is a powerful programming language that can be used to design browsers.

Contents

1. Basic elements of C, Control structure loops, I/O concepts, Arrays, Function, Call by value, Recursion, Storage classes, Pointers, Call by address, Structures, Nested structures.
2. Implement the following by using C
 - Compute the factorial of a given number using different loops & recursion.
 - Write a program to find the sum of n natural numbers.

- Write a program to arrange the numbers in ascending and descending order using array.
- Write a program to generate fibonacci sequence.
- Write a program to solve the quadratic equation $ax^2 + bx + c = 0$.
- Write programs to implement the structure.
- Write programs to implement nested structure.
- Write programs to manipulate pointers.
- Write programs to compute the series like $1 + \frac{1}{2} + \frac{1}{3} + \dots + \frac{1}{n}$ etc.
- Write programs to implement storage classes.
- Write programs to implement call by address & call by value.

Course Outcome:

Students will be able to write the programs of various mathematical problems. They will understand the basic concepts of C-language. They can be acquainted with various loops, arrays, pointers, structures, function, storage classes. Students can write programs including summation series, product series etc. It helps in getting employability in software sector.

Books Recommended

1. Byron Gottfried: Programming with C (Schaum's Outline), 2ndEdn, Tata McGraw-Hill Publishing Company Ltd, New Delhi
2. E. Balagurusamy: Programming in ANCI C, Tata McGraw-Hill Publishing Company Ltd, New Delhi

SEMESTER-II

MATH-402

OPERATIONS RESEARCH

Full Marks: 100(80+20)

Time:3 Hours

Course Objective:

This course is important because it creates implementable solutions to complex business challenges. It incorporates techniques from mathematical modeling, optimization and statistical analysis while emphasizing the human-technology.

Contents:

Unit-I

Introduction to LPP, Simplex Method, Two Phase and Big M Simplex Method. Integer Programming: Fractional Cut Method-All Integer, Fractional Cut Method-Mixed Integer, Branch and Bound Method. Revised Simplex Method.

Unit-II

Duality in Linear Programming: Definition of Primal and Dual, Duality and Simplex Method, The Dual Simplex Method. Transportation Problem: Introduction, Solution of TP (North-West Corner Method, Least-Cost Method, Vogel's Approximation Method), Test for Optimality, Degeneracy in TP, Transportation Algorithm (MODI Method). Assignment Problem, The Travelling Salesman Problem.

Unit-III

Sequencing Problem: Introduction, Processing N Jobs Through Two Machines, Processing Two Jobs Through K Machines. Games & Strategies: Introduction, Two-Person Zero-Sum Games, The Maximin-Minimax Principle, Games without Saddle Points: Mixed Strategies, Dominance Property.

Unit-IV

Network Scheduling By PERT/CPM: Introduction, Network and Basic Components, Logical Sequencing, Rules of Network Construction, Critical Path Analysis. Non-Linear Programming Methods: Introduction, General Non-Linear Programming Problem, Constrained Optimization with Equality Constraints, Constrained Optimization with Inequality Constraints.

Course Outcome:

Operations research will be benefitted to the students on different area, such as finance, budgeting, investment, marketing, personnel management. Students can acquire knowledge about LPP, integer programming. They will understand transportation problem, assignment problem, sequencing problem, game theory, Network scheduling by PERT/CPM and NLPP. This course helps to get employability in food processing industry, research firms, analytical development sector etc.

Books Recommended

1. Kanti Swarup, P.K. Gupta, Man Mohan: Operations Research, Sultan Chand & Sons Publishers, New Delhi
2. M.E. Joshi And K.M. Moudgalya– Optimization Theory and Practice, Narosa Publishing House-2001
3. J.A. Suyman– Practical Mathematical Optimization. Springer Sciences-2005
4. S.D Sharma: Operations Research, Kedarnath Ram Nath & Co Publishers, Meerut

SEMESTER-II

MATH-404

TOPOLOGY

Full Marks: 100(80+20)

Time: 3 Hours

Course Objective:

It is the algebra of topological spaces. It is a way to derive properties of a space to properly classify it, as well as study maps between spaces that can be useful in understanding the transformation.

Contents

Unit-I

Infinite Sets, The Axiom of Choice, Well-Ordered Sets. Topological Spaces, Basis and Sub Basis for a Topology, The Order, Product and Subspace Topology, Closed Sets & Limit Points.

Unit-II

Continuous Functions and Homomorphism, Metric Topology, Product Topology. Connected Spaces, Connected Sets in Real Line, Components and Local Connectedness.

Unit-III

Compact Spaces, Compact Sets in Real Line, Limit Point Compactness, Local Compactness, The Countability Axioms.

Unit-IV

The Separation Axioms, Normal Spaces, The Urysohn Lemma, The Urysohn metrization Theorem, The Tychonoff Theorem.

Course Outcome:

The student can be able to understand the importance and applications of topology in various fields such as computer science, robotics, games and puzzles etc. They will come to know the product and subspace topology, basis and sub-basis of a topology, metric topology. Students will be tutored on compact space, connected space, normal space, and the Urysohn lemma. They will also acquire knowledge on the Urysohn metrization theorem and Tychonoff theorem.

Books Recommended

1. J.R. Munkres: Topology, A First Course (Prentice Hall of India, Pvt.Ltd, 2000) Chapter-1 (1.9,1.10), 2 (2.1 To 2.10), 3, 4 (4.1 To 4.4), 5.

Books For Reference

1. K.D Joshi: Introduction to General Topology, Wiley Easter Ltd. 1983
2. W.J. Pervin: Foundation of General Topology, Academic Press, 1964
3. S.Nanda And S.Nanda: General Topology, Mac-Millan, India

SEMESTER-II

MATH-406

MEASURE THEORY AND INTEGRATION

Full Marks: 100(80+20)

Time:3 Hours

Course Objective:

This course plays an important role in probability theory, real analysis and many other fields in mathematics. It is an important prerequisite for most analysis-based courses.

Contents:

Unit-I

Lebesgue Measures: Measurable Sets, Sets of Measure Zero, Lebesgue Outer Measure, The Sigma-Algebra of Lebesgue Measurable Sets, Borel Set, Outer and Inner Approximation of Lebesgue Measurable Sets, Countable Additivity, Continuity and The Borel-Cantelli Lemma.

Unit-II

Lebesgue Measure: Non-Measurable Sets, Lebesgue Measurable Functions: Sum, Products and Compositions. Sequential Point wise Limits and Simple Approximation, Littlewood's Three Principles, Egoroff's Theorem, and Lusin's Theorem.

Unit-III

Lebesgue Integration: The Riemann Integral, The Lebesgue Integral of a Bounded Measurable Function Over a Set of Finite Measure, The Bounded Convergence Theorem, The Lebesgue Integral of a Measurable Nonnegative Function, Fatou's Lemma, The Monotone Convergence Theorem.

Unit-IV

Lebesgue Integration: The General Lebesgue Integral, The Lebesgue Dominated Convergence Theorem, The General Lebesgue Dominated Convergence Theorem, Countable Additivity and Continuity of Integration, Uniform Integrability: The Vitali Convergence Theorem.

Course Outcome:

Students will acquire knowledge on Lebesgue measures, measurable sets, Borel sets, sets of measure zero. They will understand Littlewood's three principles, Egoroff's theorem, and Lusin's theorem. Students can be acquainted with Lebesgue integration, bounded convergence theorem, Fatou's lemma, monotone convergence theorem. They will also understand uniform integrability and the Vitali convergence theorem.

Books Recommended

1. H.L. Royden: Real Analysis, Macmillan
2. G. De. Barra: Measure Theory and Integration, New Age International
3. Halmos P.R. Measure Theory, Graduate text in Mathematics, Springer-Verlag
4. Cohn D. L. Measure Theory, Springer
5. Rana I. K. An Introduction to Measure and Integration, Narosa Publishing House

SEMESTER-II

MATH-408

LINEAR ALGEBRA

Full Marks: 100(80+20)

Time: 3 Hours

Course Objective:

This course helps to understand geometric concepts such as planes, in higher dimensions and perform mathematical operations on them. This is a field of mathematics that could be called the mathematics of data. It is helpful for machine learning practitioners.

Contents

Unit-I

Vector Spaces: Elementary Basic Concepts, Linear Independence and Bases, Dual Spaces, Inner Product Spaces.

Unit-II

Linear Transformations: The Algebra of Linear Transformation, Characteristic Roots, Matrices, Eigen Values, Eigen Vectors, Rank, Nullity and Kernel of Matrix.

Unit-III

Canonical Forms: Triangular Form, Nilpotent Transformation, Introduction to Rational Canonical and Jordan Canonical Form, Trace and Transpose, Consistency of Linear System of Equations, Determinant and Related Theorems.

Unit-IV

Gauss Jordan Method for finding the Inverse. Caley – Hamilton Theorem, Hermitian, Unitary and Normal Transformation, Complex Matrices: Conjugate of a Matrix, Hermitian and Skew Hermitian Matrices, Unitary Matrix.

Course Outcome:

Students will understand vector space, linear independence and dependence of vectors, dual spaces, inner product spaces. They will be tutored about linear transformation, operations in matrices. Students can be able to understand different canonical forms, related theorems in determinant. They can determine the inverse of matrix using gauss jordan method, and can gain knowledge on complex matrices with operations.

Books Recommended:

1. I.N. Herstein, Topics in Algebra, Wiley

Books For Reference:

1. K. Hoffman and R. Kunze, Linear Algebra, PHI, 1971.
2. S. Roman, Advanced Linear Algebra, Springer, 2007.

SEMESTER-II **MATH-410** **SEMINAR PRESENTATION**

Full Marks: 100 (Documentation/Record: 60+ Presentation: 20 + Viva-Voce: 20)
Time:6 Hours

Course Objective:

Conducting seminar among students is a good habit. This would help to get more information on the particular seminar topic. Seminars are capable of keeping the students updated with the technologies. Seminars provide the latest information about the things, which are happening in science and technology. Students cannot improve their knowledge from textbooks alone.

Contents

Seminar Presentation on Current Research of Pure and Applied Mathematics/Computer Science/Mathematical Physics etc.

Course Outcome:

Students will gain knowledge on current research of different field in pure and applied mathematics. They can acquire knowledge by the presentation of specific topics and techniques of different research work. Students will get an opportunity to participate in methods of scientific analysis and research procedures. This paper will help them to express

their ideas and keep the discussion at a high level of interest. Students will pay attention thoughtfully to contribute their ideas. They will exchange the facts with efforts and the problem solving skills. They can be able to develop vocabulary, articulation, problem solving and critical thinking skills by their presentation. This paper also helps them in self learning and promotes independent thinking.

SEMESTER-II
OE-MATH-412 (OPEN ELECTIVE)
BASIC PROBABILITY THEORY AND STATISTICS

Full Marks: 100(80+20)

Time:3 Hours

Course Objectives:

Statistical knowledge helps to use the proper methods to collect the data, employ the correct analyses and effectively present the results. Probability theory provides a means of getting an idea of the likelihood of occurrence of different events resulting from a random experiment in terms of quantitative measures.

Contents

Unit-I

Probability: Sample Space, Events, Complement of an Event, Mutually Exclusive Events, Union and Intersection of Events, Counting Sample Points, Multiplication Rules, Probability of an Event, Additive Rules, Conditional Probability, Independent Events.

Unit-II

Probability: Multiplicative Rules, Bayes' Rule, Theorem of Total probability, Concept of a Random Variable, Discrete Probability Distribution, Continuous Probability Distribution, Probability Density Function.

Unit-III

Probability: Cumulative Distribution Function, Joint Probability Distribution of Discrete and Continuous Random Variable, Marginal Distribution, Conditional Probability Distribution, Mathematical Expectation, Variance and Co-Variance of Random Variables.

Unit-IV

Statistics: Measures of Central Tendency: Arithmetic Mean, Median, Mode. Dispersion: Mean Deviation, Standard Deviation. Skewness: Characteristics of Skewness, Objective of Skewness, Karl Pearson's Coefficient of Skewness, Bowley's Coefficient of Skewness.

Course Outcome:

Students will be able to understand the fundamental concept of sample space, events, counting principles of sample points. They can be aware of random variables and probability distribution, mathematical expectation. Students can also be able to identify between discrete and continuous probability distribution. They will be tutored regarding the fundamentals of statistics. Students can also be able to find the central tendency, dispersion and coefficient of

skewness of the given data series. This course helps to get employability in the post of market researcher, financial analyst, economist, business analyst, cost estimator etc.

Books Recommended

1. Ronald E. Walpole, Sharon L. Myers, Keying Ye, "Probability and Statistics for Engineers and Scientists", 8th Edition, Pearson Education.
2. R.S.N Pillai, V. Bagavathi, "Statistics" , S. Chand & Company LTD.
3. S.C Gupta, V.K. Kapoor, "Fundamental of Mathematical Statistics", Sultan Chand and Sons.
4. Murray R Spiegel, Jhon J Schiller, R Alu Srinivasan, "Probability and Statistics" 3rd Edition Schaum's Out Lines.

Books for Reference

1. Parimal Mukhopadhyay, "Mathematical Statistic" Books and Allied (P) Ltd.
2. Robert V. Hogg and Allen T. Craig, "Introduction to Mathematical Statistics" Pearson Education Asia

SEMESTER-III **MATH-501** **NUMERICAL ANALYSIS**

Full Marks: 100(80+20)

Time:3 Hours

Course Objective:

Numerical methods provide a way to solve problems quickly and easily compared to analytic solutions. This course is concerned with all aspects of the numerical solution of a problem, from the theoretical development and understanding of numerical methods to their practical implementation as reliable and efficient computer programs.

Contents

Unit-I

Solutions of Linear Simultaneous Equations: Gauss Elimination Method, Gauss-Jordan Method, Crout's Triangularization Method. Iterative Methods of Solution of Simultaneous Linear Equations: Jacobi's Iteration Method, Gauss-Seidel Iteration Method, Relaxation Method.

Unit-II

Solutions of Equations in one and two Variables: Fixed Point Iteration Method, Accelerating of Convergence, Zeros of Polynomials and Muller's Method, Newton's Method.

Unit-III

Interpolation: Hermite Interpolation, Cubic Spline Interpolation, Parametric Curves, Least Square Approximation, Discrete Least Square Approximation, Orthogonal Polynomials, Chebyshev Polynomials and Economization, Rational Approximation.

Unit-IV

Numerical Solution of Ordinary Differential Equations: Picard's Method, Taylor's Series Method, Euler's Method, Modified Euler's Method, Runge's Method, Runge-Kutta Method, Predictor-Corrector Methods: Milne's Method, Adams-Bashforth Method.

Course Outcome:

Students will come to know that how to solve linear simultaneous equations by using Gauss elimination method, Gauss-Jordan method and Crout's triangularization method etc. They can solve the equations in one and two variables and also will understand accelerating of convergence, zeros of polynomials and Muller's method, Newton's method. Students will understand different methods of interpolation and approximation techniques. This course helps to get job in research labs, industry, IT sector etc.

Books Recommended

1. Numerical Analysis (7th Edition) by R.L. Burden and J.D. Faires (Books / Cole, Thomson Learning)
2. Methods of Numerical Integration (4th Edition) by P. J. Davis and Rabinowitz (AP)
3. An Introduction to Numerical Analysis by Kendall E. Atkinson, Mc-Graw Hill.

SEMESTER-III MATH-503 FUNCTIONAL ANALYSIS

Full Marks: 100(80+20)

Time: 3 Hours

Course Objective:

This can provide a framework for explaining technology. The methods of this course were developed for creating a new technological devices and systems, System engineering and analysis. It plays a fundamental role in the theory of differential equations, particularly partial differential equations, theoretical physics, numerical analysis representation theory and probability.

Contents

Unit-I

Fundamental of Normed Spaces: Normed Spaces, Examples, Continuity of Linear Maps, Equivalent Norms, Hahn-Banach Theorem for Real Line Spaces, Banach Spaces and Examples, Quotient Spaces.

Unit-II

Bounded Linear Maps on Banach Spaces: Uniform Bounded Principle, Open Mapping Theorems, Closed Graph Theorems, Spectrum of a Bounded Operator.

Unit-III

Spaces of Bounded Linear Functional: Dual and Transposes, Dual of $L^p([A,B])$ and $C([A,B])$, Weak and Weak* Convergence, Reflexivity.

Unit-IV

Geometry of Hilbert Spaces: Inner Product Spaces, Hilbert Spaces and Examples, Orthogonal Sets, Bessel's Inequality, Complete Orthogonal Sets and Preservation Identity. Geometry of Hilbert Spaces: Approximation and Optimization, Projection and Riesz Representation.

Course Outcome:

Students will understand the fundamental of normed spaces, hahn-banach theorem and demonstrate significant applications of the theory of functional analysis. They will be tutored about fundamentals of bounded linear maps on banach spaces, uniform bounded principle, open mapping theorems, closed graph theorems, spectrum of a bounded operator etc. Students can be able to understand geometry of hilbert spaces including examples. They will also be familiar with projection and riesz representation theorems. This course helps to get employability in the post of functional analyst, data scientist, machine learning engineer etc.

Books Recommended

1. B.V. Limaye- Functional Analysis, New Age International Ltd (2ndEdn), 1995.
Ch:II (Art:5,6,7: 7.1-7.11,8), Ch-III (Art: 9: 9.1-9.3, 10,12: 12.1-12.4), Ch-IV (Art:13, 14: 14.1-14.5,15: 15.1-15.4,16: 16.1-16.2), Ch-VI (Art:21,22,23,24: 24.1-24.6)

SEMESTER-III
MATH-505
ABSTRACT ALGEBRA

Full Marks: 100(80+20)

Time:3 Hours

Course Objective:

This course is useful in real-life applications. The development of vector spaces helps physicists and mathematicians to solve the complex space and location problem. Group theory and ring theory are used in many interdisciplinary applications.

Contents

Unit-I

Group Theory: Homomorphisms, Automorphisms, Cauchy's Theorem, Cayley's Theorem, Sylow's Theorem.

Unit-II

Group Theory: Direct Products, Finite Abelian Groups. Ring Theory: Definition and Examples of Rings, Some Special Classes of Rings, Homomorphisms, Ideals and Quotient Rings.

Unit-III

More Ideals and Quotient Rings, The Field of Quotients of an Integral Domain, Euclidean Rings, A Particular Euclidean Ring, Polynomial Rings, Polynomial over the Rational Field.

Unit-IV

Extension Fields, Roots of Polynomials, More About Roots, The Elements of Galois Theory.

Course Outcome:

Students will be able to get knowledge of group theory and its applications. They can determine whether a function is homomorphic or automorphic between two groups. They will be tutored on cauchy's theorem, cayley's theorem and sylow's theorems. Students will come to know finite abelian group, ring theory, special classes of rings etc. They will be able to understand ideals, quotient rings, integral domain. They will also be able to know extension field and elements of galois theory.

Books Recommended

1. I.N. Herstein: Topics in Algebra, Vikas Publishing House Pvt. Ltd.
Chapters: 2(2.7-2.9, 2.12-2.14), 3(3.1-3.10), 5(5.1, 5.3-5.6)
2. Joseph A. Gallian: Contemporary Abstract Algebra, Cengage
3. Musili, Introduction to Rings and Modules, Narosa.

Books for Reference

1. Seymour Lipschutz: Theory and Problems of Linear Algebra, Schaum's Outline Series: McGraw-Hill Book Company.

SEMESTER-III MATH-507(ELECTIVE-I)

GROUP-A DESIGN AND ANALYSIS OF ALGORITHMS-I

Full Marks: 100(80+20)

Time: 3 Hours

Course Objective:

This course is very important to solve different types of problems of mathematics, computer science and information technology. The analysis of algorithm is required to focus on CPU usage, memory usage, disk usage and network usage. Analysis of algorithm is an important part of computational complexity theory, which provides theoretical estimation for the required resources of an algorithm to solve a specific computational problem.

Contents

Unit-I

The Role of Algorithms in Computing: Algorithms, Algorithms as a Technology. Running Time of an Algorithm: Definition, Best Case, Average Case, Worst Case Running Time of an Algorithm. Growth of Functions: Asymptotic Notations, Standard Notation and Common Function. Recurrences: The Substitution Method, The Recursion- Tree Method, The Master Method.

Unit-II

Insertion Sort Algorithm, The Divide and Conquer Approach: Merge Sort Algorithm and Its Analysis. Heap Sort: Heaps, Maintaining the Heap Property, Building a Heap, The Heap Sort Algorithms and Its Analysis.

Unit-III

Quick Sort: Description of Quick Sort, Performance of Quick Sort, Analysis of Quick Sort, Sorting in Linear Time: Counting Sort Algorithm. Dynamic Programming: Matrix Chain Multiplication Algorithm.

Unit-IV

Longest Common Subsequence and Its Analysis. Greedy Algorithms: An Activity-Selection Problem, Huffman Codes, Dynamic Programming Versus Greedy Strategy.

Course Outcome:

Students will be able to know the role of algorithms in computing. They will be tutored regarding best case, average case, worst case running time of algorithms. Students will come to know about growth of functions, asymptotic notations, various methods of recurrences. They can be able to solve the recurrences by using appropriate method. Students will be learned different sorting techniques and their analysis. They will also be tutored about various algorithms of dynamic programming and greedy algorithm. This skill of developing algorithm helps them getting job in IT sector.

Books Recommended:

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein: Introduction Of Algorithms (Second Edition, Prentice Hall of India, New Delhi) Chapters-1,2 (2.1,2.3), 3,4 (4.1, 4.2,4.3), 6(6.1,6.2,6.3,6.4), 7 (7.1, 7.2, 7.4), 8 (8.2), 15(15.2, 15.4), 16 (16.1, 16.3)

Book for Reference:

1. S.K Basu: Design Methods & Analysis of Algorithms (Prentice Hall of India, New Delhi)

SEMESTER-III
MATH-507 (ELECTIVE-I)
GROUP-B
FUZZY LOGIC AND SET THEORY-I

Full Marks:100(80+20)

Time:3 Hours

Course Objective:

This course is useful in natural language processing and various intensive applications in artificial intelligence. Fuzzy logic is extensively used in modern control systems such as expert systems. It is used in numerous fields such as control systems engineering, industrial automation, robotics etc.

Contents

Unit-I

Multi-Level Interval Numbers: Two Level Interval Numbers, Arithmetic Operation with Two Level Intervals, More General Two Level Intervals, Interval Numbers with N-Levels, General N-Level Intervals, Infinite Level Interval Numbers, Fuzzy Numbers: Fuzzy Numbers with a Maximum, Triangular, Bell-Shaped, Flat and Trapezoidal Fuzzy Numbers, Piecewise-

Quadratic Fuzzy Numbers with a Flat, Fuzzy Number Describing ‘Large’, Fuzzy Numbers in the Set of Integers, Fuzzy Numbers of Dimension Two.

Unit-II

Arithmetic with Fuzzy Numbers: Introduction to Operations with Fuzzy Numbers, Addition, Subtraction, Multiplication, and Division of Fuzzy Numbers, Distance between Triangular Fuzzy Numbers, Fuzzy Operations in the Set of Integers. Fuzzy Sets: Definition of Fuzzy Sets, Fuzzy Sets and Fuzzy Numbers, Basic Operations on Fuzzy Sets, Properties of Fuzzy Sets.

Unit-III

Algebraic Product and Sum of Fuzzy Sets, Power and Related Operations on Fuzzy Sets, The Extension Principle, Fuzzy Relations: Definition of Fuzzy Relation, Basic Operations on Fuzzy Relations, Direct Product.

Unit-IV

Projections of a Fuzzy Relations, Max-Min and Min-Max Compositions, Basic Properties of Fuzzy Relations, Fuzzy Relations and Approximate Reasoning. Classical and Many-Valued Logic: Basic Concept of Classical Logic, Propositional and Predicate Calculus, Three Valued Logic, Many-Valued Logic.

Course Outcome:

Students will be able to understand multi-level internal numbers, fundamental concepts on fuzzy numbers. They can operate fuzzy numbers and fuzzy sets. They will come to know fuzzy relations, basic operations on fuzzy relations. Students can understand projections of a fuzzy relations, max-min and min-max compositions, basic properties of fuzzy sets. They will also be able to understand classical and many-valued logic. This skills of using theory provides opportunity of getting employability in R & D sector.

Books Recommended

1. George Bojadziev, “Fuzzy Sets, Fuzzy Logic, Applications” World Scientific

SEMESTER-III MATH-509 RESEARCH PAPER REVIEW

**Full Marks: 100 (Documentation/Record: 60+ Presentation: 20 + Viva-Voce: 20)
Time: 6 Hours**

Course Objective:

This course is useful to carefully identify and synthesize relevant literature to evaluate a specific research question, substantive domain, theoretical approach or methodology and thereby provide readers with a state-of-the-art understanding of the research topic.

Content:

Review of recent research papers including pure mathematics /applied mathematics/ computer science/computer applications

Course Outcome:

Students can clarify the state of knowledge, can identify needed research, and even can be able to create a consensus where none existed before. Writing a good review can also help to advance the students career. The purpose of review is to gain an understanding of the existing research and debates relevant to a particular topic or area of study, and to present that knowledge in the form of a written report. Conducting a review helps the students to build knowledge in their field. They will learn about important concepts, research methods, and experimental techniques that are used in their field. They will also gain insight into how researchers apply the concepts they are learning in their unit to real world problems. Another great benefit of reviews is that, they will get a better understanding of how research findings are presented and discussed in particular discipline.

SEMESTER-IV MATH-502 PROBABILITY AND STATISTICS

Full Marks: 100(80+20)

Time: 3 Hours

Course Objectives:

Statistical knowledge helps to use the proper methods to collect the data, employ the correct analyses and effectively present the results. Probability theory provides a means of getting an idea of the likelihood of occurrence of different events resulting from a random experiment in terms of quantitative measures.

Contents

Unit-I

Random Variables and Probability Distribution: Concept of a Random Variable, Discrete Probability Distribution, Continuous Probability Distributions, Joint Probability Distribution.

Unit-II

Mathematical Expectation: Mean of Random Variable, Variance and Covariance of Random Variables, Means and Variance of Linear Combinations of Random Variables, Chebyshev's Theorem.

Unit-III

Discrete and Continuous Probability Distribution: Introduction and Motivation, Discrete Uniform Distribution, Binomial, Negative Binomial and Poisson Distribution. Continuous Uniform Distribution, Normal Distribution, Gamma and Exponential Distributions.

Unit-IV

Measures of Central Tendency, Measures of Dispersions, Measure of Skewness and Kurtosis. Multivariate Analysis: Correlation, Correlation Coefficient, Rank Correlation, Regression Analysis, Multiple Regression. Sampling Theory: Population and Sample, Sampling with and without Replacement, Random Samples.

Course Outcome:

Students will be able to understand the fundamental concept of random variables and probability distribution, mathematical expectation. They can be able to identify between

discrete and continuous probability distribution. They will be tutored regarding multivariate analysis and sampling theory. Students can also be able to solve the problems of various probability distributions and can do statistical analysis on the data set. The applicability of this theory helps in engaging themselves in IT sector.

Books Recommended

1. Ronald E. Walpole, Sharon L. Myers, Keying Ye, “Probability and Statistics for Engineers and Scientists”, 8th Edition, Pearson Education.
[3.1 To 3.4, 4.1 To 4.4, 6.1 To 6.6]
2. S.C Gupta, V.K. Kapoor, “Fundamental of Mathematical Statistics”, Sultan Chand and Sons.
3. Murray R Spiegel, Jhon J Schiller, R Alu Srinivasan, “Probability and Statistics” 3rd Edition Schaum’s Out Lines. [5.1 To 5.12]

Books for Reference

1. Parimal Mukhopadhyay, “Mathematical Statistic” Books and Allied (P) Ltd.
2. Robert V. Hogg and Allen T. Craig, “Introduction to Mathematical Statistics” Pearson Education Asia

SEMESTER-IV

MATH-504

NUMBER THEORY

Full Marks: 100(80+20)

Time:3 Hours

Course Objective:

Number theory is important because the simple sequence of counting numbers from one to infinity conceals many relationships beneath its surface. This course helps to discover interesting relationships between different sorts of numbers and to prove that these are true. This course is very useful in the field of cryptography.

Contents

Unit-I

Number Theory and Fundamentals of Arithmetic: Divisibility, Greatest Common Divisor, Prime Numbers, The Fundamental Theorem of Arithmetic, The Series of Reciprocals of the Primes, The Euclidean Algorithm, The Greatest Common Divisor of More Than Two Numbers. The Mobius Function $\mu(n)$, The Euler Totient Function $\varphi(n)$, A Relation Connecting φ and μ , A Product Formula For $\varphi(n)$.

Unit-II

Congruences: Definition and Basic Properties of Congruences, Residue Classes and Complete Residue Systems, Linear Congruences, Reduced Residue Systems and The Euler-Fermat Theorem, Polynomial Congruences Modulo P , Lagrange’s Theorem, Applications of Lagrange’s Theorem, Simultaneous Linear Congruences, The Chinese Remainder Theorem, Applications of the Chinese Remainder Theorem, Polynomial Congruences with Prime Power Moduli.

Unit-III

Periodic Arithmetical Functions and Gauss Sums: Functions Periodic Modulo k , Existence of Finite Fourier Series for Periodic Arithmetical Functions, Ramanujan's Sum and Generalizations, Multiplicative Properties of the Sums $s_k(n)$, Gauss Sums Associated with Dirichlet Characters.

Unit-IV

Quadratic Residues and Quadratic Reciprocity Law: Quadratic Residues, Legendre's Symbol and Its Properties, Evaluation of $(-1|P)$ and $(2|P)$, Gauss' Lemma, Quadratic Reciprocity Law, Applications of the Reciprocity Law.

Course Outcome:

Students will come to know about number theory and fundamentals of arithmetic. They will be tutored about different arithmetical functions, quadratic residues, quadratic reciprocity law and congruencies. Students can be able to understand Lagrange's theorem, applications of Lagrange's theorem with related examples. They will also understand the Chinese Remainder theorem with applications, Ramanujan sum and generalizations etc. This course helps to get job opportunity in the field of cryptographic analysis program and IT sector.

Books Recommended

1. Tom M. Apostol: Introduction to Analytic Number Theory, Springer International, Norosa Publishing House.
Chapter: 1, 2 (2.1-2.5), 5 (5.1-5.9), 8 (8.1-8.5), 9 (9.1-9.6)
2. Neal Koblitz: A Course of Number Theory and Cryptography, Second Edition, Springer Verlag New York-1987

Books for Reference

1. RamanujachanjKumanuri and Christina Romero: Number Theory with Computer Applications, Printice Hall, New Jersey-1998
2. H. Delfs & H. Knebl- Introduction to Cryptography Principle and Application, Springer Verlag-2002
3. D.R Stinson: Cryptography- Theory of Practice (3rdEdn) Chapman Hall/ CRC-2006

SEMESTER-IV **MATH-506 (ELECTIVE-II)** **GROUP-A** **DESIGN AND ANALYSIS OF ALGORITHMS-II**

Full Marks: 100(80+20)

Time: 3 Hours

Course Objective:

This course is very important to solve different types of problems of mathematics, computer science and information technology. The analysis of algorithm is required to focus on CPU usage, memory usage, disk usage and network usage. Analysis of algorithm is an important

part of computational complexity theory, which provides theoretical estimation for the required resources of an algorithm to solve a specific computational problem.

Contents

Unit-I

Data Structures for Disjoint Sets: Disjoint Set Operations, Elementary Graph Algorithms: Representation of Graphs, Breadth-First-Search, Depth-First-Search, Minimum Spanning Trees: Growing a Minimum Spanning Tree, Krushkal's Algorithm, Prim's Algorithm.

Unit-II

Single Source Shortest Paths: The Bellman-Ford Algorithm, Dijkstra's Algorithm, All Pair Shortest Paths: The Floyd-Warshall Algorithm, Maximum Flow: Flow Networks, The Ford-Fulkerson Method, String Matching: The Naive String-Matching Algorithm, The Rabin-Karp Algorithm.

Unit-III

Computational Geometry: Line-Segment Properties, Determining whether any Pair of Segments Intersects. NP-Completeness: NP-Completeness and The Classes P and NP, Reductions. Polynomial Time: Definition, A Formal Language Framework.

Unit-IV

Polynomial Time Verification: Hamiltonian-Cycle Problem, Verification Algorithm, The Complexity Class NP, NP-Completeness Problems (Only Definition and List of NP-Complete Problems without Proof) and Reducibility: Reducibility, Circuit Satisfiability, Approximation Algorithm: Performance Ratios for Approximation Algorithms, Travelling Sales Man Problem.

Course Outcome:

Students will be able to understand data structures for disjoint sets, various elementary graph algorithms and the algorithms to find minimum spanning tree. They will come to know the fundamental concepts of the shortest path problems, such as single source and all pair shortest paths. Students can be able to understand the problems with algorithms of flow network and the different string matching algorithms and problems with applications. They will be tutored regarding the algorithms and problems of computational geometry with applications. They will also come to know regarding the fundamental concept of NP-completeness, classes P, classes NP, reduction algorithms. Students will get an idea of polynomial time verification and approximation algorithms with applications. The skill of developing design and analysis of algorithms helps them in getting job in IT sector.

Books Recommended

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein: Introduction to Algorithms (Second Edition, P.H.I, New Delhi)
Chapters-21(21.1), 22(22.1, 22.2, 22.3), 23 (23.1, 23.2), 24(24.1, 24.3), 25(25.2), 26(26.1, 26.2), 32(32.1, 32.2), 33(33.1, 33.2), 34(34.1, 34.2, 34.3), 35(35.2)

Books for Reference

1. S.K. Basu: Design Methods & Analysis of Algorithms. (P.H.I, New Delhi)

SEMESTER-IV MATH-506 (ELECTIVE-II) GROUP-B FUZZY LOGIC AND SET THEORY-II

Full Marks: 100(80+20)

Time: 3 Hours

Course Objective:

This course is useful in natural language processing and various intensive applications in artificial intelligence. Fuzzy logic is extensively used in modern control systems such as expert systems. It is used in numerous fields such as control systems engineering, industrial automation, robotics etc.

Contents:

Unit-I

Fuzzy Logic: What is Fuzzy Logic, Linguistic Variables, Linguistic Modifiers, Truth, Proposition of Fuzzy Logic, Composition Rules for Propositions.

Unit-II

Quantification Rules, Qualification Rules, Semantic Equivalence, Semantic Entailment, Approximate Reasoning.

Unit-III

Decision Making and Applications: Decision Making, Fuzzy Delphi Method for Forecasting, Fuzzy Zero Based Budgeting

Unit-IV

Fuzzy Logic Control and Applications: Introduction, Modeling the Control Parameters, If and Then Rules, Rule Evaluation, Conflict Resolution, Diffusification, Washing Machine, Fuzzy Logic Control Predictor-Prey System.

Course Outcome:

Students will be able to understand the fundamental idea of fuzzy logic, linguistic variables and modifiers. They will be tutored on quantification and qualification rules. They will also come to know decision making with applications and fuzzy logic control with applications. Students can be able to know about if-then rules with evaluation and fuzzy logic control predictor-prey system etc. The knowledge of application of this theory helps students getting employability in IT sector.

Book Recommended

1. George Bojadziev, Maria Bojadziev, "Fuzzy Sets, Fuzzy Logic, Applications"
World Scientific

SEMESTER-IV

MATH-508

DISSERTATION, PRESENTATION AND VIVA-VOCE

Full Marks: 100

Course Objective:

This course enables to get an opportunity to develop a deeper knowledge and understanding of a particular area of study. The aim of this dissertation is to test the independent research skills, students have acquired during their time at university.

Contents

Any one of the following subjects shall be chosen from part A or part B

Part-A: Soft Computing / Artificial Intelligence

1. Fuzzy Set
2. Rough Set
3. Data Mining
4. Soft Set
5. Near Set
6. Knowledge Management
7. Biotechnology
8. Expert System
9. Image Processing
10. Neural Network
11. Cluster Techniques
12. Pattern Recognition
13. Cloud Computing
14. Mobile Computing
15. Granular Computing
16. Signal Processing
17. Analysis and Design of Algorithms

Part-B: Graph Theory

1. Trees and Fundamental Circuits, Dual Graphs
2. Planar Graphs, Vector Spaces of a Graph
3. Matrix Representation of Graphs, The Four Color Problem, Coverings
4. Directed Graphs, Graphs in Switching and Coding Theory
5. Network Analysis by Graph, Graph Theory in Operations Research

Course Outcome:

The dissertation is the task that the students have to do at Semester -IV level. It is a task that helps the students in presenting the research they have done while pursuing their degree. It could give an idea of how much knowledge they boast of the things learned in the academics and how dedicated they are, towards doing their own research on a topic. When the students start the research, they only have some random idea about their topic for research paper. Additionally, when they will start writing the paper then, they will be able to feel like what

new they can do because many others have already done the same research. However, when the students will start working on their topic, they will find a little gap between the topics and there they will find a way to fill the gap. They will find a way to present their research paper to the world and that's the more important points for their studies.