

Harmonized Curriculum for B. Sc Degree Program in Mathematics

Ethiopia

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1. Background

There has been huge expansion of higher education in the country since 2004 bringing both the total number of higher education institutions and their annual intakes to a record high. Thus it is not difficult to imagine the impact of the expansion on the quality, standard and relevance of the various programs in higher education institutions. As a result the MOE formed six clusters from all public universities and designed a relatively common and standardized curriculum in six areas of science in 2008. These curricula have been implemented since 2008/09 academic year.

Currently, the MOE felt the need to further strengthen and harmonize these curricula so as to properly address the prevailing issues of quality, standard and relevance of higher education. Consequently, for each program of the science faculties, a task force of experts was commissioned by the Higher education Strategy Center (HESC) to prepare a harmonized curriculum seasoned with relevant contents and quality improvement strategies.

Accordingly, the mathematics harmonization team studied the curricula of the various national universities and found some of the following irregularities:

- difference in the total credit hours of compulsory courses,
- difference in the list of supportive courses ,
- not matching course description with the course contents,
- course contents and course codes being beyond BSc level,
- not containing objectives, learning outcomes, teaching-learning and assessment methods ,
- poorly written course objectives, and
- some departments containing less important general education courses.

The above irregularities are corrected in the harmonized draft curriculum.

More over the team has also studied the curricula of a number of European universities in particular of those participated in the Bologna process and incorporated the good practices such as:

- setting the format of course specifications,
- developing the graduate profiles and matching them with course contents,
- developing objectives and learning outcomes,
- improving the contents of the courses we offer, and
- course descriptions and course outlines of some elective courses of senior years.

The good practices are incorporated in the following harmonized curriculum of B. Sc degree program in mathematics. The team also studied the Ethiopian Preparatory schools curricula and found that there is no gap between the curricula and the universities' mathematics curriculum.

2. Rationale of the curriculum

Mathematics is a fundamental field of study that plays a pivotal role in the development of science, technology, business, and computer science. It profoundly influences the socio-economic development of a society and civilization. Thus, it is imperative that students be equipped with strong mathematics knowledge and skills which enable them to be productive in areas where rigorous thought and precision of results are emphasized.

Curriculum development is also a dynamic process which requires continuous assessment. Thus updating and harmonizing national curriculum is vital to ensure the quality, standard and relevance in line with the objective conditions of the country. In light with this, the MOE, higher education strategy center, has taken the task of harmonization of various national universities science curricula that are underway to accomplish the above objectives. The task demands not only to harmonize the curricula designed by cluster of national universities but also to enrich it by incorporating good practices from exemplary European universities.

Thus, the need to design a viable harmonized B. Sc degree curriculum that meets the current global trend is the order of the day.

3. Program Objectives

General objectives

- To train qualified, adaptable, motivated, and responsible mathematicians who will contribute to the scientific and technological development of Ethiopia.
- To impact knowledge by teaching
- To advance knowledge by research

3.2 Specific objectives

- To provide an in-depth understanding of the fundamental principles and techniques of mathematics.
- To develop mathematical thinking, reasoning and an appreciation of mathematics as a primary language of science.
- To develop the mathematical skills needed in modeling and solving practical problems.
- To prepare students for graduate studies in mathematics and related fields.
- Participate in professional activities
- Assist in teaching material preparation
- To produce graduates in mathematics that are adaptable to teach in secondary schools, colleges, universities and work in industries, research institutes etc.

4. Graduate Profile

A graduate of this program will be able to:

- acquire adequate mathematical knowledge to teach in secondary schools, colleges and universities.
- pursue graduate studies in mathematics and related fields of study.
- set up mathematical models, formulate algorithm and implement them using numerical methods.
- assist and participate in conducting research.
- reason logically and think critically.
- demonstrate environmental, social, cultural and political awareness.
- act in an ethical manner, recognize and be guided by social, professional and ethical issues involved in his/her career in particular and in the community in general
- exercise the power of self expression.

5. Program Requirements

Admission requirement

Besides the successfully completion of the preparatory program, a student should meet university admission policy. Diploma holders can apply for admission as per the regulation of the university for advanced standing.

5.2 Graduation Requirements

A student must obtain a minimum of 2.00 CGPA, a minimum of 2.00 major GPA and should have no 'F' in any course he/she took. The total credit hours required is indicated below.

	Category	Cr. hrs
1	Compulsory	66
2	Elective	9
3	Supportive	22
4	General	12
	Total	109

6. Degree Nomenclature

6.1 English

Bachelor of Science Degree in Mathematics

6.2 Amharic

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7. Teaching-Learning, Teaching Materials and Assessment Methods

Teaching-Learning Methods

The main teaching-learning methods employed in the curriculum include:

- Conducting lecture based on active participation of students
- Tutorial classes where students will discuss and solve problems
- Discussion and presentation in group
- Reading assignment
- Practical work (computer Lab.)
- Project work
- Modeling of practical problems
- Class activities

Teaching Materials

Resources used in the teaching-learning process include:

- Textbooks and teaching materials
- Board, marker, chalk, computers, printers, software, LCD and Overhead projectors, geometric models, charts, tables, ...etc
- Library resources
- On-line Lecture notes

Assessment methods

Some of the assessment methods are

- Assignments
- Quizzes
- Project
- Mid and final examinations
- Class activities

8. Quality Assurance

The Department of Mathematics will monitor and maintain the quality of the program according to the quality assurance standards set by the university. To this effect, the department will:

- ensure that contents of the courses are covered.
- ensure that exams, tests, assignments and projects are properly set and conducted.
- ensure that appropriate technology is employed in the teaching-learning process.
- conduct short-term courses and seminars for staff members in order to make use of modern methodology and IT.
- make sure that tutorial classes are well-organized, relevant exercises, home works and assignments are carefully set to enhance and strengthen the students' ability to solve problems and understand the underlying theory.
- ensure that appropriate and recent text books are used for the courses.
provide enough reference books for each course.

- evaluate the courses at the end of each semester based on the feed back obtained from the instructors, the tutors and the students, so as to make the courses more relevant.
- ensure that the lectures are conducted by an appropriate instructors

9. Course Selection and Sequencing

9.1 List of Compulsory Mathematics Courses

No	Course Title	Course No	Cr. hrs
1.	Fundamentals of College Mathematics	Math 203	4
2.	Calculus I	Math 264	4
3.	Introduction to Combinatorics and Graph Theory	Math 274	3
4.	Fundamental Concepts of Geometry	Math 311	3
5.	Transformation Geometry	Math 312	3
6.	Fundamental Concepts of Algebra	Math 321	3
7.	Linear Algebra I	Math 325	3
8.	Linear Algebra II	Math 326	3
9.	Numerical Analysis I	Math 343	3
10.	Linear Optimization	Math 356	3
11.	Calculus II	Math 365	4
12.	Calculus of Functions of Several Variables	Math 366	4
13.	Number Theory	Math 392	3
14.	Project I	Math 405	1
15.	Project II	Math 406	2
16.	Modern Algebra I	Math 423	3
17.	Mathematical Modeling	Math 445	3
18.	Advanced Calculus of Functions of One Variable	Math 461	4
19.	Functions of Complex Variable	Math 464	4
20.	Ordinary Differential Equations	Math 481	3
21.	Partial Differential Equations	Math 484	3
	Sub-Total		66

9.2 List of Elective Mathematics Courses

Students select at least three from the following:

No	Course Title	Course No	Cr. hrs
1.	Logic and Set Theory	Math 403	3
2.	Modern Algebra II	Math 424	3
3.	Introduction to Algebraic Geometry	Math 426	3
4.	Projective Geometry	Math 411	3
5.	Introduction to Differential Geometry	Math 412	3

6.	Introduction to Cryptography	Math 493	3
7.	Computational Number Theory	Math 494	3
8.	Fluid Mechanics	Math 442	3
9.	Numerical Analysis II	Math 440	3
10.	Operations Research	Math 451	3
11.	Nonlinear Optimization	Math 456	3
12.	Graph Theory	Math 472	3
13.	Introduction to Real Analysis	Math 462	3
14.	Advanced Calculus of Several Variables	Math 463	3
15.	Introduction to Topology	Math 465	3
16.	History and Philosophy of Mathematics	Math 408	3
	Total		9

9.3 Supportive Courses

No	Course Title	Course No	Cr. hrs
1	Introduction to Statistics	Stat 270	3
2	Introductory Probability	Stat 276	3
3	Introduction to Computer Science	Comp 201	4
4	Fundamentals of Programming I	Comp 231	4
5	Fundamentals of Database Systems	Comp 351	4
5	Mechanics and Heat	Phys 207	4
	Total		22

9.4 General Education

No	Course Title	Course No	Cr. hrs
1.	Communicative English Language I		3
2.	Writing English Language II		3
3.	Civics and Ethical Education		3
4.	Environmental Science		3
	Total		12

9.5 Summary

	Category	Cr. hrs
1	Compulsory	66
2	Elective	9
3	Supportive	22
4	General	12
	Total	109

10. Service Courses

Based on the need of departments or faculties, the following service courses have been designed.

10.1 For Chemistry Department

Course Title	Course No	Cr. hrs	Lecture hrs	Tutorial hrs
Calculus I for chemists	Math 233	3	3	2
Calculus I for chemists	Math 234	3	3	2
Linear algebra I	Math 325	3	3	2

10.2 For Earth Science Department

Course Title	Course No	Cr. hrs	Lecture hrs	Tutorial hrs
Applied Mathematics IA	Math 231A	4	4	2
Applied Mathematics IIA	Math 232A	4	4	2

10.3 For Physics Department

Course Title	Course No	Cr. hrs	Lecture hrs	Tutorial hrs
Calculus I	Math 264	4	4	2
Calculus II	Math 365	4	4	2
Linear algebra I	Math 321	3	3	2

10.4 For Statistics Department

Course Title	Course No	Cr. hrs	Lecture hrs	Tutorial hrs
Calculus I	Math 264	4	4	2
Calculus II for statistics	Math 335	3	3	2
Linear algebra I	Math 325	3	3	2
Linear algebra II	Math 326	3	3	2
Numerical analysis for statistics	Math 339	3	3	2

11. Course Schedule

	Sem I			Sem II		
	Course Title	Course No	Cr.hrs	Course Title	Course No	Cr.hrs
Y E A R I	Fund. College of Mathematics	Math 203	4	Calculus I	Math 264	4
	Communicative English I	Eng201	3	Writing Skills		3
	Introduction to Statistics	Stat 270	3	Introd to Combinatorics and Graph Theory	Math 274	3
	Introduction to Computer Science	Comp 201	4	Heat and Mechanics	Phys 207	4
	Civics and Esthetical Education		3	Fundamentals of Programming I	Comp 231	4
	Total		17	Total		18

	Sem I			Sem II		
	Course Title	Course No	Cr.hrs	Course Title	Course No	Cr.hrs
Y E A R II	Calculus II	Math 365	4	Calculus of Sev. Variables	Math 366	4
	Fund. Conc. of Algebra	Math 321	3	Linear Algebra II	Math 326	3
	Fundamentals of Database Systems	Comp 351	4	Environmental Science		3
	Linear Algebra I	Math 325	3	Number Theory	Math 392	3
	Numerical Analysis I	Math 343	3	Linear Optimization	Math 356	3
	Fundamental concepts of geometry	Math 311	3	Transformation Geometry	Math312	3
	Total		20	Total		19

		Sem I			Sem II		
		Course Title	Course No	Cr.hrs	Course Title	Course No	Cr.hrs
Y E A R III		Advanced Cal. of One Variable	Math 461	4	Functions of Complex Variables	Math 464	4
		Mathematical Modeling	Math 445	3	Math Elective II	Math	3
		Ordinary Differential Equations (ODE)	Math 481	3	Math Elective III	Math	3
		Math elective I	Math	3	Partial Differential Eq.	Math 484	3
		Modern Algebra I	Math 423	3	Introduction to Probability	Stat	3
		Project I	Math 405	1	Project II	Math406	2
		Total		17	Total		18

12. Course Specifications
12.1 Compulsory Mathematics Courses

Math 203

Course title: Fundamentals of College Mathematics

Course code: Math 203

Credit hours: 4 Contact hrs: 4 Tutorial hrs: 2

Prerequisite: None

Course category: compulsory

Aims

The course intends to prepare mathematics students in the basic concepts and materials necessary for the study of higher mathematics courses. It treats topics rigorously in order to lay a strong foundation for the study of all mathematics courses.

Course description

This course rigorously discusses the basic concepts of logic and set theory, the real and complex number systems, mathematical induction, least upper bound and greatest lower bound, functions and types of functions, polynomial and rational functions, logarithmic and exponential functions, trigonometric functions, hyperbolic functions and their graphs, and analytic geometry.

Course objectives

On completion of the course, successful students will be able to:

- understand mathematical logic,
- apply logic in reasoning and mathematical proofs,
- use quantifiers in open propositions,
- understand concepts of sets and set operations,
- understand the fundamental properties of real and complex numbers,
- find least upper bound and greatest lower bound,
- use mathematical induction in proofs,
- write polar representation of complex numbers,
- understand different types of functions, their inverses and graphs,
- find zero's of some polynomials,
- identify various forms of conic sections and derive their equations,
- use basic properties of logarithmic, exponential, hyperbolic, and trigonometric functions.

Course outline

Chapter 1: Logic and set theory (12 hrs)

- 1.1 Definition and examples of proposition
- 1.2 Logical connectives
- 1.3 Compound (or complex) propositions
- 1.4 Tautology and contradiction
- 1.5 Open proposition and quantifiers
- 1.6 The concept of a set and the underlying set operations

Chapter 2: The real and complex number systems (12 hrs)

- 2.1 The real number system
 - 2.1.1 The natural numbers, Principle of mathematical induction and the Well ordering principle
 - 2.1.2 The integers, rational numbers and irrational numbers
 - 2.1.3 Upper bound, lower bound, lub, glb, completeness property of the set of real numbers, and the Archimedean principle
- 2.2 Complex number system
 - 2.2.1 Definition of complex numbers and the underlying operations
 - 2.2.2 Polar representation of complex numbers and the De-Moiver's formula
 - 2.2.3 Extraction of roots

Chapter 3: Functions (12 hrs)

- 3.1 Review of relations and functions
- 3.2 Real-valued functions and their properties
- 3.3 Types of functions (one-to-one, onto) and inverse of a function
- 3.4 Polynomials, zero's of polynomials, rational functions, and their graphs
- 3.5 Definitions and basic properties of logarithmic, exponential, hyperbolic, trigonometric functions, and their graphs.

Chapter 4: Analytic geometry (28 hrs)

- 4.1 Division of segments and various forms of equation of a line
- 4.2 Conic sections: Equation of a circle, parabola, ellipse and hyperbola
- 4.3 The general second degree equation

Teaching –learning methods

Four contact hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment methods

- Assignments / quizzes / 20%
- Mid semester examination 30%
- Final examination 50%

Teaching materials

- Textbooks:
- Alemayehu Haile and Yismaw Alemu, **Mathematics an introductory course**, Department of mathematics, AAU
 - Abera Abay, **An introduction to Analytic Geometry**, AAU, 1998

- References:
- Raymond A. Barnett, **Precalculus, functions and graphs**, McGram Hill, 1999
 - M. L. Bettinger, **Logic, proof and sets**, Addison-Wesley, 1982
 - Dennis G. Zill, Jacqueline M. Dewar, **Algebra and**

- trigonometry**, 2nd Edition.
- Kinfe Abraha, **Basic Mathematics**, Mekelle University, Mega Printing Press, 2002. Mekelle, Ethiopia
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Math 264

Course title: Calculus I

Course code: Math 264

Credit hours: 4 Contact hrs: 4 Tutorial hrs: 2

Prerequisite: None

Course category: compulsory

Aims

The course aims at providing a firm foundation in the basic concepts and techniques of differential and integral calculus.

Course Description

This course introduces the basic concepts of limit, continuity, differentiation, integration, and some of their applications.

Course objectives

On completion of the course, successful students will be able to:

- understand the formal definition of limit and continuity,
- evaluate limits of functions,
- determine points of discontinuity of functions,
- apply Intermediate Value Theorem,
- evaluate derivatives of different types of functions,
- apply derivatives to solve problems,
- evaluate integrals of different types of functions,
- apply integrals to find areas and volumes.

Course outline

Chapter 1: Limits and continuity (12 hrs)

- 1.1. ϵ - δ Definition of limit
- 1.2 Basic limit theorems
- 1.3 One-sided limits
- 1.4 Infinite limits and limits at infinity
- 1.5. Continuity
- 1.6. The Intermediate Value Theorem and its applications

Chapter 2. Derivatives (14 hrs)

- 2.1 Definition of derivative
- 2.2 Tangent and normal lines
- 2.3 Properties of derivatives
- 2.4 Derivative of functions (polynomial, rational, trigonometric,

- exponential, logarithmic and hyperbolic functions)
- 2.5 The chain rule
- 2.6 Higher order derivatives
- 2.7 Implicit differentiation

Chapter 3. Applications of derivatives (20 hrs)

- 3.1 Extreme values of functions
- 3.2 Rolle's Theorem, the Mean Value Theorem, and their applications
- 3.3 Monotonic functions
- 3.4 The first and second derivative tests
- 3.5 Applications to extreme values and related rates
- 3.6 Concavity & inflection points
- 3.7 Graph sketching
- 3.8 Tangent line approximation and the differentials

Chapter 4. Integrals (18 hrs)

- 4.1 Antiderivatives
- 4.2 Indefinite integrals and their properties
- 4.3 Partitions, upper and lower sum, Riemann sums
- 4.4 Definition and properties of definite integral
- 4.5 The Fundamental Theorem of Calculus
- 4.6 Techniques of integration (integration by parts, integration by substitution, integration by partial fractions)
- 4.7 Application of integration: Area, volume of solid of revolution

Teaching-learning methods

Four contact hours of lectures and two contact hours of tutorials per week. The students do graded home assignments individually or in small groups.

Assessment methods

- Assignment and quizzes 20%
- Mid semester examination 30%
- Final examination 50%

Textbook: - Robert Ellis and Denny Gulick, **Calculus with analytic geometry**, 6th ed, Harcourt Brace Jovanovich, Publishers, 5th ed, 1993.

References:

- Leithold, **The calculus with analytic geometry**, 3rd Edition, Herper & Row, publishers.
- R. T. Smith and R. B. Minton, **Calculus concepts and connections**, McGram-Hill book company, 2006
- D. V. Widder, **Advanced calculus**, Prentice-Hall, 1979
- Ross L. Finney et al, **Calculus**, Addison Wesley, 1995
- E. J. Purcell and D. Varberg, **Calculus with analytic geometry**, Prentice-Hall INC., 1987
- Adams, **Calculus: A complete course**, 5th ed, Addison Wesley, 2003

- R. Wrede and M. R. Spiegel, **Theory of advanced calculus**, 2nd ed., McGraw-Hill, 2002.
- A. E. Taylor and W. R. Mann, **Advanced calculus**, 3rd ed, John-Wiley and Son, INC, 1995.

Math 274

Course title: Introduction to Combinatorics and Graph Theory

Course code: Math 274

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: None

Course category: Compulsory

Aims

The course sets the necessary background for students to understand the subsequent application area courses such as probability, network, etc

Course description

This course deals with review of sets and functions, fundamental principles of counting, generating functions and recurrence relations, graph theory and its application.

Course objectives

On completion of the course, successful students will be able to:

- know basic concepts of discrete mathematics,
- understand the principles of counting, recurrence relations and generating functions,
- understand the basic concepts of graph and their types,
- know the basic algorithms on graphs,
- use the methods and principles of combinatorics,
- apply combinatorics in counting problems,
- solve simple counting problems,
- construct graphs with given degree patterns,
- apply graph theory to solve network oriented problems.

Course outline

Chapter 1: Elementary counting principles (9 hrs)

- 1.1 Basic counting principle
- 1.2 Permutations and combinations
- 1.3 The inclusion-exclusion principles
- 1.4 The pigeonhole principle
- 1.5 The binomial theorem

Chapter 2: Elementary probability theory (8 hrs)

- 2.1 Sample space and events
- 2.2 Probability of an event

- 2.3 Conditional probability
- 2.4 Independent events
- 2.5 Random variables and expectation

Chapter 3: Recurrence relations (7 hrs)

- 3.1 Definition and examples
- 3.2 Linear recurrence relations with constant coefficient
- 3.3 Solutions of linear recurrence relations
- 3.4 Solutions of homogeneous and nonhomogeneous recurrence relations

Chapter 4: Elements of graph theory (10 hrs)

- 4.1 Definition and examples of a graph
- 4.2 Matrix representation of a graph
- 4.3 Isomorphic graphs
- 4.4 Path and connectivity of a graph
- 4.5 Complete, regular and bipartite graphs
- 4.6 Eulerian and Hamiltonian graphs
- 4.7 Trees and forests (Rooted and Binary trees)
- 4.8 Planar graphs
- 4.9 Graph coloring

Chapter 5: Directed graphs (6 hrs)

- 5.1 Definition and examples of digraphs
- 5.2 Matrix representation of digraphs
- 5.3 Paths and connectivity

Chapter 6: Weighted graphs and their applications (8 hrs)

- 6.1 Weighted Graphs
- 6.2 Minimal Spanning trees
- 6.3 Shortest path problem
- 6.4 Critical Path Problem

Teaching- learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment methods

- Assignment /quizzes/	20%
- Mid semester examination	30%
- Final examination	50%

Teaching materials

- References:
- N. CH SN Iyengar et al, **Discrete mathematics**, Vikas publishing house PVT LTD, 2004
 - S. Roman, **An introduction to discrete mathematics**, CBS College publishing, 1986
 - B. Harris, **Graph Theory and its applications**, Academic press, 1970
 - Iyengar, S. N, **Elements of Discrete Mathematics**
 - Lipschutz, S., **Schaum's outline series, Discrete Mathematics**
 - Steven Roman, **An Introduction to Discrete Mathematics**
 - Mattson, H.F., **Discrete Mathematics with Application**
 - Oystein Ore, **Theory of graphs**, American mathematical Society, 1974
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Math 311

Course title: Fundamental Concepts of Geometry

Course code: Math 311

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: None

Course category: Compulsory

Aims

The course intends to introduce students to various types of elementary geometry from an advanced standpoint. The axiomatic approaches dealt with in the course empower students in performing advanced mathematical proofs in subsequent courses.

Course description

This course covers absolute geometry, Euclidean geometry and its consistency, Hyperbolic geometry and its consistency.

Course objectives

On completion of the course, successful students will be able to:

- understand the basic notions in absolute geometry,
- apply concepts of algebraic geometry in Euclidian and hyperbolic geometry,
- apply the distance function and related concepts to prove the congruence between triangles,
- understand the basic axioms of Euclidian geometry and its consistency,
- apply axioms and theorems to solve different problems,

- understand the properties of congruence and similarity theorems and apply them to solve problems,
- understand the basic axioms and unique properties of hyperbolic geometry and its consistency,
- understand The Poincare Model,
- distinguish the difference between Euclidian and hyperbolic geometry,
- develop skills in mathematical proofs.

Course outline

Chapter 1: Absolute geometry

- 1.1 Axioms of incidence
- 1.2 Distance functions and the ruler postulate
- 1.3 The axiom of betweenness
- 1.4 Plane separation postulate
- 1.5 Angular measure
- 1.6 Congruence between triangles
- 1.7 Geometric inequalities
- 1.8 Sufficient conditions for parallelism
- 1.9 Saccheri quadrilaterals
- 1.10 The angle-sum inequality for triangles
- 1.11 The critical function
- 1.12 Pen triangles and critically parallel rays

Chapter 2: The Euclidean geometry

- 2.1 Parallel postulate and some consequences
- 2.2 The Euclidean parallel projections
- 2.3 The basic similarity theorem
- 2.4 Similarity between triangles
- 2.5 The Pythagorean theorem
- 2.6 Equivalent forms of the parallel postulate

Chapter 3: Hyperbolic geometry

- 3.1 The Poincare model
- 3.2 The Hyperbolic parallel postulate
- 3.3 Closed triangles and angle sum
- 3.4 The defect of a triangle and the collapse of similarity theorem

Chapter 4: The consistency of the Hyperbolic geometry

- 4.1 Inversion of a punctured plane
- 4.2 Cross ratio and inversion
- 4.3 Angular measure and inversion
- 4.4 Reflection across L-line in the Poincare model
- 4.5 Uniqueness of the L-lines through two points
- 4.6 The ruler postulate; betweenness: Plane separation and angular measure

Chapter 5: The consistency of the Euclidean geometry

- 5.1 The coordinate plane and isometries
- 5.2 The ruler postulate
- 5.3 Incidence and parallelism
- 5.4 Translations and rotations
- 5.5 Plane separation postulate
- 5.6 Angle congruence

Teaching-learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment methods

- Assignments/quizzes/ 20%
- Mid semester examination 30%
- Final examination 50%

Teaching materials

Textbooks: - Edwin E. Moise, **Elementary Geometry from an advanced standpoint**

- References:
- James R. Smart, **Modern geometries**, 5th ed, Brook/Cole Publ. Co., 1988
 - Marvin J. Green Berg, **Euclidian and non Euclidian geometries**, 2nd ed, W. H. Freeman and Co. 1974
 - R. L. Faber, **Foundations of Euclidian and non Euclidian geometry**, Marcel dekker INC., 1983
 - Judith N. Cedarberg, **A Course in Modern Geometries**, 2001, 2nded.
 - David A. Thomas, **Modern Geometry**, 2002
 - James W. Anderson, **Hyperbolic Geometry**, 2005, 2nd ed.
 - Edward C. Wallace Stephen F. West, **Roads to Geometry**, 2004, 3rd ed.
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Math 312

Course title: Transformation Geometry

Course code: Math 312

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 325, Math 311

Course category: Compulsory

Aims

The main theme of the course is to introduce to students the interplay between transformation and geometry. It rigorously treats various transformations in Affine space. It is a pre requisite for differential and projective geometries.

Course description

This course covers group of transformations, Affine Geometry, orthogonal transformations, orientation preserving transformations, representation of orthogonal transformations, similarity transformations, Affine transformations, and projective transformations.

Course objectives

On completion of the course, successful students will be able to:

- understand the basic properties of transformations,
- recognize the axioms and the associated theorems of affine geometry,
- understand the basic properties of orthogonal transformations,
- understand the basic similarity transformations and their representations,
- understand the basic properties of affine transformations,
- identify several classes of affine transformations,
- understand the relationship between affine transformations and linear mappings.

Course outline

Chapter 1: Group of transformations

- 1.1 Definition of transformation
- 1.2 Examples of group of transformations

Chapter 2: Affine geometry

- 2.1 Axioms of an affine space
- 2.2 Geometry in an affine space
- 2.3 Lines and planes in an affine space
- 2.4 Concurrency
- 2.5 Classical theorems (Menelaus, Ceva, Desargues, and Pappus.)

Chapter 3: Orthogonal transformations

- 3.1 Properties of orthogonal transformations
- 3.2 Orientation preserving and orientation reversing orthogonal transformations
- 3.3 The fundamental types of orthogonal transformations of the plane (translations, reflections and rotation)
- 3.4 Representation of orthogonal transformations as product of the fundamental orthogonal transformations
- 3.5 Orthogonal transformations of the plane in coordinates

Chapter 4: Similarity transformations

- 4.1 Properties of similarity transformations
- 4.2 Homothetic transformations
- 4.3 Representation of similarity transformations as the product of homothetic and an orthogonal transformations
- 4.4 Similarity transformations of the plane in coordinates

Chapter 5: Affine transformations

- 5.1 Definition and examples of affine transformations (orthogonal and Similarity transformations, Skew reflection, compressions, Shear)
- 5.2 Properties of Affine transformations
- 5.3 Affine transformations and linear mappings

Teaching-learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment methods

- Assignments/quizzes/ 20%
- Mid semester examination 30%
- Final examination 50%

Teaching materials

- Textbooks: - G. E. Martin, **Transformation geometry: An introduction to symmetry**, Springer-Verlag, 2009
- P. S. Modenov, **Geometric transformation**

- References: - Judith N. Cedrberg, **A course in modern geometries**, 2nd ed., 2001
- David A. Thomas, **Modern geometry**, 2002
- Edward C. Wallace & Stephen F. West, **Roads to geometry**, 3rd ed., 2004
- **College geometry: A problem solving approach with applications**, 2nd ed., 2008

Math 321

Course title: Fundamental Concepts of Algebra

Course code: Math 321

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 203

Course category: Compulsory

Aims

This course intends to introduce the students to the basic notions of formal logics from the perspectives of truth, proof, and arguments. It presents the notion of sets and algebraic structures which lay foundations for subsequent mathematics courses.

Course description

The course mainly covers arguments, validity of statements and mathematical proofs, relations, classification of sets, cardinal numbers, groups, rings, and the system of integers.

Course objectives

On completion of the course, successful students will be able to:

- understand arguments and validity of propositions and use them in mathematical proofs,
- understand the notion of relations, equivalence of sets and cardinal numbers,
- understand the properties of binary operations and algebraic structures,
- understand the basic properties of groups,
- grasp the concept of group and ring homomorphisms and use them to prove homomorphism of groups and rings respectively,
- understand the axiomatic approach of the construction of integers,
- apply the principle of mathematical induction to prove statements involving integers.

Course outline

Chapter 1: Mathematical logic (9 hrs)

- 1.1 Review of propositional logic, connectives, compound propositions, equivalent propositions, tautology and contradictions, predicate Logic, open proposition and qualified propositions
- 1.2 Argument and validity of statements
- 1.3 Mathematical proofs

Chapter 2: Set theory (12 hrs)

- 2.1 Review of sets and set operations, ordered pairs, relations and functions
- 2.2 Order and equivalence relation

- 2.3 Classification of sets
- 2.4 Cardinal numbers

Chapter 3: Groups (12 hrs)

- 3.1 Binary operations, algebraic structures
- 3.2 Identity element and inverses
- 3.3 Morphisms
- 3.4 Definition and examples of groups
- 3.5 Subgroups, cosets, and Lagrange's theorem
- 3.6 Normal subgroups and quotient groups
- 3.7 Homomorphisms

Chapter 4: Rings (9 hrs)

- 4.1 Definition of rings and examples
- 4.2 Subrings and characteristic of a ring
- 4.3 Ideals and quotient rings
- 4.4 Homomorphism of rings
- 4.5 Integral domains and the field of quotients
- 4.6 Polynomial rings
- 4.7 Prime fields

Chapter 5: The system of integers (6 hrs)

- 5.1 Properties of addition and multiplication
- 5.2 Order axioms of the system of integers
- 5.3 Well-ordering axioms
- 5.4 Mathematical induction
- 5.5 Characterization of the system of integers

Teaching- learning methods

Three contact hours of lecture and two hours of tutorials per week. Students do home assignments.

Assessment methods

- Assignments /quizzes/	20%
- Mid semester examination	30%
- Final examination	50%

Teaching materials

Textbook: - Demissu Gemedu and Seid Mohammed, **Fundamental Concepts of Algebra**, Dept. of Mathematics, AAU, 2008

References:

- B. Fraleigh John, **A First Course in Abstract Algebra**, 2nd ed,

- Addison-Wesley publishing Company, Reading
 - J. J Gerald, **Introduction to modern algebra(revised)**, 4th ed; University Book Stall, Reading, 1989
 - D. S. Dummit and R. M. Foote, **Abstract algebra**, 3rd ed, John Wiley and Sons, 2004.
 - P. B. Bhattachara *et-al*, **Basic abstract algebra**, 2nd ed, Cambridge University press, 1995
 - N. H. Ma-Coy *et-al*, **Introduction to abstract algebra**, Academic Press, 2005
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Math 325

Course title: Linear Algebra I

Course code: Math 325

Credit hours: 3

Contact hrs: 3

Tutorial hrs: 2

Prerequisite: None

Course category: compulsory

Aims

The aim of this course is to lay down a strong foundation for advanced studies in linear algebra and related courses. Linear algebra is useful in studies of many applied sciences.

Course Description

This course covers vectors, lines and planes, vector spaces, matrices, system of linear equations, determinants, eigenvalues and eigenvectors, and linear transformations.

Course objectives

On completion of the course, successful students will be able to:

- understand the basic ideas of vector algebra,
- understand the concept of vector space over a field,
- find scalar and vector products,
- understand the basic theory of matrix,
- find adjoint of a matrix,
- solve system of linear equations,
- determine row reduced echelon forms of a matrix,
- determine the eigenvalues and eigenvectors of a square matrix,
- grasp Gram-Schmidt process,
- find an orthogonal basis for a vector space,
- invert orthogonal matrix,
- understand the notion of a linear transformation,
- find the linear transformation with respect to two bases,
- find the eigenvalues and eigenvectors of an operator.

Course outline

Chapter 1: Vectors (12 hrs)

- 1.1 Definition of points in n-space
- 1.2 Vectors in n-space; geometric interpretation in 2 and 3-spaces
- 1.3 Scalar product, and norm of a vector, orthogonal projection, and direction cosines
- 1.4 The vector product
- 1.5 Applications on area and volume
- 1.6 Lines and planes

Chapter 2: Vector spaces (9 hrs)

- 2.1 The axioms of a vector space
- 2.2 Examples of different models of a vector space
- 2.3 Subspaces, linear combinations and generators
- 2.4 Linear dependence and independence of vectors
- 2.5 Bases and dimension of a vector space
- 2.6 Direct sum and direct product of subspaces

Chapter 3: Matrices (10 hrs)

- 3.1 Definition of a matrix
- 3.2 Algebra of matrices
- 3.3 Types of matrices: square, identity, scalar, diagonal, triangular, symmetric, and skew symmetric matrices
- 3.4 Elementary row and column operations
- 3.5 Row reduced echelon form of a matrix
- 3.6 Rank of a matrix using elementary row/column operations
- 3.7 System of linear equations

Chapter 4: Determinants (12 hrs)

- 4.1 Definition of a determinant
- 4.2 Properties of determinants
- 4.3 Adjoint and inverse of a matrix
- 4.4 Cramer's rule for solving system of linear equations (homogenous and non homogenous)
- 4.5 The rank of a matrix by subdeterminants
- 4.6 Determinant and volume
- 4.7 Eigenvalues and eigenvectors of a matrix
- 4.8 Diagonalization of a symmetric matrix

Chapter 5: Linear Transformations (9 hrs)

- 5.1 Definition of linear transformations and examples
- 5.2 The rank and nullity of a linear transformation and examples
- 5.3 Algebra of linear transformations

- 5.4 Matrix representation of a linear transformation
- 5.5 Eigenvalues and eigenvectors of a linear transformation
- 5.6 Eigenspace of a linear transformation

Teaching- learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment method

- Assignment/quizzes/ 20%
- Mid semester examination 30%
- Final examination 50%

Teaching materials

Textbooks: - Serge Lang; **Linear Algebra**
Demissu Gameda, **An Introduction to Linear Algebra**, Department of Mathematics, AAU, 2000

- References: - D. C. Lay, **Linear algebra and its applications**, Pearson Addison Wesley, 2006
- Bernard Kolman & David R. Hill, **Elementary linear algebra**, 8th ed., Prentice Hall, 2004
 - H. Anton and C Rorres, **Elementary linear algebra**, John Wiley & Sons, INC., 1994
 - K. Hoffman & R. Kunze, **Linear Algebra**, 2nd ed., Prentice Hall INC. 1971
 - S. Lipschutz, **Theory and problems of linear algebra**, 2nd ed. McGraw-Hill1991

Math 326

Course title: Linear Algebra II

Course code: Math 326

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 325

Course category: Compulsory

Aims

The course intends to develop further concepts in linear algebra providing a foundation for studies in a number of other areas of mathematics and related fields.

Course description

This course covers the characteristic equation of a matrix, orthogonality, matrix factorizations, canonical forms, direct sum decomposition of vector spaces, bilinear, quadratic and positive definite forms.

Course objectives

On completion of the course, successful students will be able to:

- find the eigenvalues and eigenvectors of a square matrix,
- identify similar matrices,
- diagonalize a matrix when this is possible,
- define inner product space,
- find and apply the LU factorization of a matrix,
- understand the Gram-Schmidt process,
- find an orthogonal basis for a subspace,
- find an orthogonal complement of a subspace,
- recognize and invert orthogonal matrices,
- comprehend the three canonical forms of matrices.

Course outline

Chapter 1: The characteristic equation of a matrix

Eigenvalues and eigenvectors
The characteristic polynomial
Similarity of matrices and characteristic polynomial
The spectral radius of a matrix
Diagonalization
Decomposable matrices
Minimal polynomial and Cayley-Hamilton theorem

Chapter 2: Orthogonality

2.1 The inner product
2.2 Inner product spaces
2.3 Orthonormal sets
2.4 The Gram-Schmidt orthogonalization process
2.5 Cauchy-Schwartz and triangular inequalities
2.6 The dual space
2.7 Adjoint of linear operators
2.8 Self-adjoint linear operators
2.9 Isometry
2.10 Normal operators and the spectral theorem
2.11 Factorization of a matrix (LU, Cholesky, QR)
2.12 Singular value decomposition

Chapter 3: Canonical forms

3.1 Elementary row and column operations on matrices
3.2 Equivalence of matrices of polynomials

- 3.3 Smith canonical forms and invariant factors
- 3.4 Similarity of matrices and invariant factors
- 3.5 The rational canonical forms
- 3.6 Elementary divisors
- 3.7 The normal and Jordan canonical forms

Chapter 4: Bilinear and quadratic forms

- 4.1 Bilinear forms and matrices
- 4.2 Alternating bilinear forms
- 4.3 Symmetric bilinear forms and quadratic forms
- 4.4 Real symmetric bilinear forms

Chapter 5: Direct sum decomposition of vector spaces

- 5.1 Definition of a direct sum of vector spaces
- 5.2 Projection and invariant subspaces of a linear operator
- 5.3 Primary decomposition theorem

Teaching –learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment methods

- Assignments / quizzes / 20%
- Mid semester examination 30%
- Final examination 50%

Teaching materials

Textbooks: - Serge Lang, **Linear Algebra**
 - Schaum's Outline in Linear Algebra

References: - S. Lipschutz, **Theory and problems of linear algebra**, 2nd Ed., McGraw-Hill 1991
 - Larson/Edwards, **Elementary Linear Algebra**, D.C. Heath and Company, Lexington, 1988
 - J.N. Sharma and et al, **Linear Algebra**, Krishna Prakashan Media(P) Ltd., 2003
 - Isaak and Manougian, **Basic Concepts of Linear Algebra**, 1st ed., George J. McLead Limited, 1976
 - Otto Bretscher, **Linear algebra with application**, 3rd ed., Prentice Hall, 2005
 - Howard Anton, **Elementary linear algebra**, 8th ed., John Wiley, 2000
 - K. Hoffman & R. Kunze, **Linear Algebra**, 2nd ed., Prentice Hall INC., 1971

Math 343

Course title: Numerical Analysis I

Course code: Math 343

Credit hours: 3

Contact hrs: 3

Computer lab hrs: 2

Prerequisite: Math 264, Comp 231

Course category: Compulsory

Aims

The course aims at introducing students in finding numerical solutions to problems for which analytical solutions either do not exist or are not readily or cheaply obtainable. It enables students to apply linear algebra and calculus. It also aims to help student develop programming skills.

Course description

This course covers basic concepts in error estimation, solutions of non-linear equations, solutions of system of linear equations and non-linear equations, finite differences, numerical interpolations, numerical differentiation and numerical integration.

Course objectives

On completion of the course, successful students will be able to:

- understand sources of errors,
- identify absolute and relative errors,
- understand a range of iterative methods for solving linear and non-linear systems of equations,
- comprehend the convergence properties of the numerical methods,
- understand the roles of finite differences,
- grasp practical knowledge of polynomial interpolation in numerical differentiation and integration,
- appreciate the application of basic linear algebra and calculus concepts in deriving the numerical algorithms,
- examine how a small change in the data and ill-conditioned algorithms affect the solution of the mathematical problems,
- translate mathematical algorithms into computer programming,
- interpret computer outputs

Course outline

Chapter 1: Basic concepts in error estimation (12 hrs)

- 1.1 Sources of errors
- 1.2 Approximations of errors
- 1.3 Rounding off errors
- 1.4 Absolute and relative errors
- 1.5 Propagation of errors
- 1.6 Instability

Chapter 2: Nonlinear equations (8 hrs)

- 2.1 Locating roots
- 2.2 Bisection method
- 2.3 Interpolation and Secant methods
- 2.4 Iteration Methods
- 2.5 Conditions for convergence
- 2.6 Newton-Raphson Method

Chapter 3: System of equations (15 hrs)

- 3.1 Direct methods for system of linear equations (SLE)
 - 3.1.1 Gaussian method
 - 3.1.2 Gaussian method with partial pivoting
 - 3.1.3 Jordan's method
 - 3.1.4 Jordan's method for matrix inversion
 - 3.1.5 Matrix decomposition
 - 3.1.6 Tri-diagonal matrix method
- 3.2 Indirect methods for SLE
 - 3.2.1 Gauss Jacobi method
 - 3.2.2 Gauss Seidel method
- 3.3 Systems of non-linear equations using Newton's method

Chapter 4: Finite differences (5 hrs)

- 4.1 Shift operators
- 4.2 Forward difference operators
- 4.3 Backward difference operators
- 4.4 Central difference operators

Chapter 5: Interpolations (11 hrs)

- 5.1 Linear interpolation
- 5.2 Quadratic interpolation
- 5.3 Lagrange's interpolation formula
- 5.4 Divided difference formula
- 5.5 Newton interpolation formula (forward and backward formulas)

Chapter 6: Application of interpolations (5 hrs)

- 6.1 Finding roots
- 6.2 Differentiation
- 6.3 Integration (Trapezoidal and Simpson's rule)

Teaching- learning methods

Three contact hours of lectures and two hours of computer lab per week. Students do home assignment.

Assessment methods

Computer lab assignment	20%
Mid semester examination	30%
Final examination	50%

Teaching materials

Textbook: - Gerald C. F. and Wheatly P. O., **Applied numerical analysis** 5th ed, Edsion Wesley,Co

References: - Richard L. Burden, **Numerical Analysis**, 1981, 2nd Ed.
- P.A. Strock, **Introduction to numerical analysis**
- Volkov, **Numerical methods** 1986
- Frank Ayres, **Theory and Differential Equations** (Schuam's outline series, 1981)
- Robert Ellis and Denny Glick, **Calculus with Analytical Geometry-**
3rd Ed.

Math 356

Course title: Linear Optimization

Course code: Math 356

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 325

Course category: Compulsory

Aims

The course intends to introduce students to both theoretical and algorithmic aspects of linear optimization. It is a basis for further study in the area of optimization.

Course description

This course deals with linear programming, geometric and simplex methods, duality theory and further variations of the simplex method, sensitivity analysis, interior point methods, transportation problems, and theory of games.

Course objectives

On completion of the course, successful students will be able to:

- understand the interplay between geometry and linear algebra,
- define a linear programming,
- understand matrix algebra,
- solve systems of linear equations,
- understand the fundamental principles of linear programming,
- formulate optimization problems,
- understand decision process with respect to an optimization problem,

- solve linear programs graphically,
- test convexity of sets,
- understand theorems and algorithms of the simplex method,
- solve linear programming problems by the simplex method,
- understand duality theorems,
- apply theorems and algorithms in duality theory,
- do sensitivity analysis,
- comprehend the transportation problem,
- solve transportation problems,
- solve pure strategy games.

Course outline

Chapter 1: Introduction to matrices

- 1.1 Introduction (definition of LP, Motivation, ...)
- 1.2 Matrices (Rank, Elementary row operations)
- 1.3 System of linear equations
 - 1.3.1 $n \times n$ system: Gaussian Elimination Method
 - 1.3.2 $m \times n$ system: Basic solutions
- 1.4 System of linear inequalities

Chapter 2: Linear programming models of practical problems

- 2.1 Introduction
- 2.2 Decision process and relevance of optimization
- 2.3 Model and model building

Chapter 3: Geometric methods

- 3.1 Graphical solution methods
- 3.2 Convex sets
- 3.3 Polyhedral sets and extreme points
- 3.4 The Corner Point theorem

Chapter 4: The Simplex method

- 4.1 Linear programs in standard form
- 4.2 Basic feasible solutions
- 4.3 Fundamental theorem of linear programming
- 4.4 Algebra of the simplex method
- 4.5 Optimality test and basic exchange
- 4.6 The simplex algorithm
- 4.7 Degeneracy and finiteness of simplex algorithm
- 4.8 Finding a starting basic feasible solution
 - 4.8.1 The two-Phase method
 - 4.8.2 The Big-M method
- 4.9 Using solver (MS EXCEL) in solving linear programming

Chapter 5: Duality theory and further variations of the simplex method

- 5.1 Dual linear programs
- 5.2 Duality theorems
- 5.3 The dual simplex method
- 5.4 The Primal-Dual simplex method

Chapter 6: Sensitivity analysis

- 6.1 Introduction
- 6.2 Variation of coefficients of objective function
- 6.3 Variation of vector requirement
- 6.4 Variation of constraints
- 6.5 Addition of new constraints or variables
- 6.6 Solver outputs and interpretations

Chapter 7: Interior point methods

- 7.1 Basic ideas
- 7.2 One iteration of Karmarkar's projective algorithm
 - 7.2.1 Projective transformation
 - 7.2.2 Moving in the direction of steepest descent
 - 7.2.3 Inverse transformation
- 7.3 The algorithm and its polynomiality
- 7.4 A purification scheme
- 7.5 Converting a given LP into the required format

Chapter 8: Transportation problem

- 8.1 Introduction
- 8.2 Transportation table
- 8.3 Determination of an initial basic feasible solution
 - 8.3.1 North-West corner rule
 - 8.3.2 Row minima rule
 - 8.3.3 Cost minima rule
- 8.4 Optimality conditions
- 8.5 Unbalanced transportation problems and their solutions
- 8.6 Degenerate transportation problems and their solutions

Chapter 9: Theory of games

- 9.1 Introduction
- 9.2 Formulation of two-person zero-sum games
- 9.3 Pure and mixed strategies
- 9.4 Solving pure strategy games
 - 9.4.1 Reduction by dominance
 - 9.4.2 The minimax (or maxmin) criterion
- 9.5 Some basic probabilistic considerations
- 9.6 Solving games with the simplex methods
- 9.7 $2 \times n$ and $m \times 2$ games

Teaching-learning methods

Three contact hours of lectures and two contact hours of tutorials per week. The students do graded home assignments individually or in small groups.

Assessment methods

- Assignment /quizzes/ 20%
- Mid semester examination 30%
- Final examination 50%

Teaching materials

- References:
- Bertsimas and J. Tsitsiklis, **Introduction to linear optimization**, Athena Scientific, 1997
 - Brian D. Bunday, **Basic linear programming**, Edward Arnold, 1984
 - H. A. Taha, **Operations research, an introduction**, Macmillan publishing company, 2002
 - F. S. Hillier and G. J. Lieberman, **Introduction to operations research**, Holde-day, 2001
 - Robert Fourer, David M. Gay, and Brian W. Kernighan, **A modeling language for mathematical programming**, Boyd & Fraser publishing company, 1997
 - R. J. Vanderbei, **Linear programming: Foundations and extensions**, 2001
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Math 365

Course title: Calculus II

Course code: Math 365

Credit hours: 4 Contact hrs: 4 Tutorial hrs: 2

Prerequisite: Math 264

Course category: Compulsory

Aims

The main theme of this course is to lay strong foundation to theoretical concepts and techniques in calculus that are needed for the advanced studies in pure and applied mathematics.

Course description

This course covers inverse functions, derivatives of inverse functions, techniques of integration focusing on trigonometric substitution and partial fractions, Trapezoidal rule and Simpson's rule, arc length, indeterminate forms, sequences, series and power series.

Course objectives

On completion of the course, successful students will be able to:

- find derivatives of inverse functions,
- evaluate integrals of different types of functions,
- evaluate limits by L' Hopital's Rule,
- approximate functions by Taylor's polynomial,
- determine convergence or divergence of a series,
- find the interval of convergence of a power series,
- approximate a function by using its power series,
- apply integrals (arc length, surface area),
- approximate integrals by Trapezoidal, and Simpson's rules,
- find the Taylor's series expansion of a function

Course outline

Chapter 1. Inverse functions (12 hrs)

- 1.1 Properties of inverse functions
- 1.2 Derivative of inverse functions
- 1.3 Inverses of trigonometric functions and their derivatives
- 1.4 Exponential and logarithmic functions
- 1.5 Exponential growth and decay
- 1.6 Inverse of hyperbolic functions and their derivatives

Chapter 2. Techniques of integration (12 hrs)

- 2.1 Elementary integration formulas
- 2.2 Integration by parts
- 2.3 Integration by trigonometric substitution
- 2.4 Integration by partial fractions
- 2.5 Trigonometric integrals
- 2.6 Trapezoidal and Simpson's rule
- 2.7 Application of integration (area, volume, arc length, surface area)

Chapter 3 Indeterminate forms, improper integrals and Taylor's formula (12 hrs)

- 3.1 Cauchy's formula
- 3.2 Indeterminate forms (L' Hopital's Rule)
- 3.3 Improper integrals
- 3.4 Taylor's formula
- 3.5 Approximation by Taylor's polynomial

Chapter 4. Sequence and series (30 hrs)

- 4.1 Sequences
 - 4.1.1 Convergence and divergence of sequences
 - 4.1.2 Properties of convergent sequences
 - 4.1.3 Bounded and monotonic sequences
- 4.2 Infinite series
 - 4.2.1 Definition of infinite series
 - 4.2.2 Convergence and divergence of series

- 4.2.3 Properties of convergent series
- 4.2.4 Convergence tests for positive term series (integral, comparison, ratio and root tests)
- 4.2.5 Alternating series
- 4.2.6 Absolute convergence, conditional convergence
- 4.2.7 Generalized convergence tests
- 4.3 Power series
 - 4.3.1 Definition of power series
 - 4.3.2 Convergence and divergence, radius and interval of convergence
 - 4.3.3 Algebraic operations on convergent power series
 - 4.3.4 Differentiation and integration of a power series
 - 4.3.5 Taylor & Maclaurin series
 - 4.3.6 Binomial Theorem

Teaching-learning methods

Four contact hours of lectures and two contact hours of tutorials per week. The students do home assignments individually or in small groups.

Assessment methods

- | | |
|----------------------------|-----|
| • Assignment /quizzes/ | 20% |
| • Mid semester examination | 30% |
| • Final Exam | 50% |

Teaching materials

Textbook: - Robert Ellis and Denny Gulick, **Calculus with analytic geometry**, 5th ed, 1993

References:

- Leithold, **The calculus with analytic geometry**, 3rd Edition, Herper & Row, publishers.
- R. T. Smith and R. B. Minton, **Calculus concepts and connections**, McGraw-Hill book company, 2006
- D. V. Widder, **Advanced calculus**, Prentice-Hall, 1979
- Ross L. Finney et al, **Calculus**, Addison Wesley, 1995
- E. J. Purcell and D. Varberg, **Calculus with analytic geometry**, Prentice-Hall INC., 1987
- Adams, **Calculus: A complete course**, 5th ed, Addison Wesley, 2003
- R. Wrede and M. R. Spiegel, **Theory of advanced calculus**, 2nd ed., McGraw-Hill, 2002.
- A. E. Taylor and W. R. Mann, **Advanced calculus**, 3rd ed, John-Wiley and Son, INC, 1995.

Math 366

Course title: Calculus of Functions of Several Variables

Course code: Math 366

Credit hours: 4 Contact hrs: 4 Tutorial hrs: 2

Prerequisite: Math 365

Course category: compulsory

Aims

The course extends the notion of differential and integral of functions of one variable to functions of several variables to develop more advanced ideas that are essential in pure and applied mathematics.

Course description

This course covers review of vector algebra, vector valued functions, functions of several variables, their derivatives and integrals with applications, and calculus of vector fields: Green's theorem, line and surface integrals, Stoke's theorem, and Divergence theorem.

Course objectives

On completion of the course, successful students will be able to:

- understand vector algebra,
- write equations of lines and planes in space,
- sketch graphs of functions of two variables in 3-space,
- evaluate partial derivatives,
- find gradients and directional derivatives of a function of several variables,
- use differentials for approximation,
- use tangent plane approximation,
- apply partial derivatives to physical problems,
- evaluate multiple integrals of different functions of several variables,
- apply integrals to physical problems,
- understand the core theorems of the course.

Course outline

Chapter 1. Vector valued functions

- 1.1 Definition and examples of vector in space
- 1.2 Distance between two points, vectors algebra(dot product, projections, cross product)
- 1.3 Lines and planes in space
- 1.4 Introduction to vector-valued functions
- 1.5 Calculus of vector-valued functions
- 1.6 Change of parameter; arc length
- 1.7 Unit, tangent, normal
- 1.8 Curvature

Chapter 2. Limit and continuity of function of several variables

- 2.1. Definitions and examples of real valued functions of several variables
- 2.2 Domain and range of functions of several variables
- 2.3 Graphs and level curves
- 2.4 Limit and continuity

Chapter 3. Differentiation of functions of several variables

- 3.1 Partial derivatives and its geometrical interpretation
- 3.2 Differentiability of functions of several variables
- 3.3 The Chain rule
- 3.4 Implicit differentiation

Chapter 4. Application of partial derivatives

- 4.1 Directional derivatives and gradient of functions of several variables
- 4.2 Tangent planes
- 4.3 Differentials and tangent plane approximations
- 4.4 Extreme values
- 4.5 Lagrange's multiplier
- 4.6 Taylor's theorem

Chapter 5 Multiple integrals

- 5.1 Double integrals
- 5.2 Double integrals in polar coordinates
- 5.3 Surface area
- 5.4 Triple integrals
- 5.5 Triple integrals in cylindrical and spherical coordinates
- 5.6 Change of variables in multiple integrals

Chapter 6. Calculus of vector field

Vector field
The divergence and curl of a vector field
Line integrals
Green's theorem

Teaching-learning methods

Four contact hours of lectures and two contact hours of tutorials. The students do home assignments individually or in small groups.

Assessment methods

- Assignment and quizzes 20%
- Mid semester examination 30%
- Final examination 50%

Textbook: - Robert Ellis and Denny Gulick, **Calculus with analytic geometry**, 5th ed, 1993.

References:

- Leithold, **The calculus with analytic geometry**, 3rd Edition, Herper & Row, publishers.
- R. T. Smith and R. B. Minton, **Calculus concepts and connections**, McGraw-Hill book company, 2006
- D. V. Widder, **Advanced calculus**, Prentice-Hall, 1979
- Ross L. Finney et al, **Calculus**, Addison Wesley, 1995
- E. J. Purcell and D. Varberg, **Calculus with analytic geometry**, Prentice-Hall INC., 1987
- Adams, **Calculus: A complete course**, 5th ed, Addison Wesley, 2003
- R. Wrede and M. R. Spiegel, **Theory of advanced calculus**, 2nd ed., McGraw-Hill, 2002.
- A. E. Taylor and W. R. Mann, **Advanced calculus**, 3rd ed, John-Wiley and Son, INC, 1995.

Math 392

Course title: Introduction to Number Theory

Course code: Math 392

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 321

Course category: Compulsory

Aims

The course intends to provide basic concepts in number theory, which mainly deals with properties of integers. It is a prerequisite for higher courses in applied mathematics such as cryptography and computational number theory.

Course description

This course covers algebraic structure of integers, basic notions of divisibility theory, Diophantine equations, theory of congruence and equations over finite rings, decimal representations of rational numbers, continued fractions, and quadratic extension of rational numbers.

Course objectives

On completion of the course, successful students will be able to:

- explain basic properties of integers;
- use prime factorization of integers to find the LCM and GCF of two or more integers,
- compute the LCM and GCF of two or more integers with the help of Euclidean Algorithm,

- apply different techniques to solve Diophantine Equations,
- understand the basic notions of congruences,
- construct the rings of integers modulo n ,
- apply Euler- Fermat Theorem,
- express a rational number as a decimal expansion,
- differentiate the different types of continued fractions.

Course outline

Chapter 1: Basic properties of integers

- 1.1 Algebraic structure of integers
- 1.2 Order Properties: The relation of the Well Ordering Axiom and Mathematical Induction
- 1.3 Divisibility of integers
 - 1.3.1 Basic notions of factors, prime numbers, factorization, common multiple, common factor, etc.
 - 1.3.2 The concept of relatively primeness
 - 1.3.3 Euclidean algorithm and application to GCF
 - 1.3.4 Numbers with different bases and related concepts

Chapter 2: Diophantine equations

- 2.1 Linear equations in one or more variables
- 2.2 The method of Euler in linear equations
- 2.3 Some general notions of Diophantine equations

Chapter 3: Theory of congruence

- 3.1 The notion of congruence and residue classes
- 3.2 Operations on congruence classes and basic properties
- 3.3 Basic facts from group theory in the notion of congruences
- 3.4 Systems of linear congruences

Chapter 4: The Euler – Fermat theorem

- 4.1 The notion of complete system of residues
- 4.2 Euler quotient function, $\varphi(m)$
- 4.3 Euler-Fermat Theorem
- 4.4 An introduction to higher order congruence
- 4.5 Application of the Euler-Fermat Theorem to such congruences

Chapter 5: Decimal expansion of rational numbers

- 5.1 The notion of decimal representation
- 5.2 Types of decimal representations
- 5.3 Characterizing the rationals using decimal representation

Chapter 6: Other topics in number theory

- 6.1 Some examples of set of algebraic integers
- 6.2 Different completions of rational numbers
- 6.3 Continued fractions in real numbers

Teaching- learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignment.

Assessment methods

- Assignments/quizzes/ 20%
- Mid semester examination 30%
- Final examination 50%

- References:
- David M. Burton, **Elementary Number theory**, 5th ed., McGraw-Hill, 2002
 - Adams, W.W Goldstein, **Introduction to Number Theory**, Prentice-Hall, 1976
 - Yismaw Alemu, **Introduction to Elementary Theory of Numbers**, Department of Mathematisc, AAU
 - L. Hua, **Introduction to number theory**, Springer-Verlag, 1982
 - O. Ore, **An invitation to number theory**, Random House, 1967
 - Hardy, G.H, Wright, E.M, **Introduction To the Theory of Numbers**, The Clarendon Press, 4th Ed, Oxford, 1965.
 - Jones & Jones, **Elementary number theory**, Springer-Verlag, 1998
 - K. H. Rosen, **Elementary number theory and its applications**, Addison-Wesley, 1984
 - A. Baker, **A concise introduction to the theory of numbers**, Cambridge university press, 1984

Math 405

Course title: Project I

Course code: Math 405

Credit hour: 1

Prerequisite: Permission of project advisor

Course category: Compulsory

Aims

Guided Research allows study in the form of a research project, in a particular area of specialization that is not offered by regularly scheduled courses.

Course description

This course involves identifying a problem, studying the problem, gathering data and relevant materials and an open presentation of the development of the project work.

Course objectives

At the end of project I, the student will be able to:

- formulate researchable project problem or prove conjecture,
- do independent literature reading,
- write project proposal,
- present project progress report.

Course outline: See below

Math 406

Course title: Project II

Course code: Math 406

Credit hours: 2

Prerequisite: Math 405

Course category: Compulsory

Aims (see above)

Course description

This course involves analyzing, modeling, reformulating and/or proving a conjecture in implementing the problem identified in Project I and presenting the findings.

Course objectives

At the end of project II, the student will be able to:

- analyze mathematical problem or prove conjecture,
- write scientific project report,
- present final project report.

Course outline (Math 405 and Math 406)

The project work has three major components: Literature study, research project, and seminar presentation. The relative weight of each will vary according to topic area, the level of preparedness of the participant(s), and the number of students in the study group. Possible research tasks include formulating and proving a conjecture, proving a known theorem in a novel way, investigating a mathematical problem by computer experiments, or studying a problem of practical importance using mathematical methods.

Math 423

Course title: Modern Algebra I

Course code: Math 423

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 321

Course category: Compulsory

Aims

The course intends to provide students with a solid introduction to modern group theory, ring theory and fields and its extension. It is a prerequisite for studies in higher algebra.

Course description

This course deals with topics: Groups, isomorphism theorem, permutations group, direct product, direct sum of abelian groups, group action, rings, polynomial rings, PID and UFD and field and field extensions.

Course objectives

On completion of the course, successful students will be able to:

- understand the concept of groups and its properties,
- understand the action of a group on a set,
- determine the conjugacy classes,
- understand the concepts of a ring, subrings , ideals and quotient rings,
- grasp the concepts of Euclidean domain, unique factorization domain and principal ideal domains,
- understand the concept of field extension,
- distinguish between the different types of field extensions,
- state and prove the main theorems of classical group, ring and field theory,
- apply the main theorems of group rings and fields.

Course outline

Chapter 1: Groups

- 1.1 Definition and examples of a group
- 1.2 Subgroups
- 1.3 Cyclic groups
- 1.4 Cosets and Lagrange's theorem
- 1.5 Normal subgroups and quotient groups
- 1.6 Groups homomorphism
- 1.7 Isomorphism theorems
- 1.8 Direct sum of abelian groups and product of groups
- 1.9 Group of permutations
- 1.10 Group actions, conjugacy classes, and Cayley's theorem

Chapter 2: Rings

- 2.1 Definition and examples of rings
- 2.2 Subrings
- 2.3 Ideals and quotient rings
- 2.4 Homomorphism of rings
- 2.5 Isomorphism theorems
- 2.6 Prime and maximal ideals
- 2.7 Quotient of integral domains
- 2.8 ED, UFD and PID
- 2.8 The ring of polynomials
- 2.9 Roots of polynomials, factorization of polynomials

Chapter 3: Introduction to field theory

- 3.1 Field extensions
- 3.2 Finite and algebraic extensions
- 3.3 Algebraic closure
- 3.4 Splitting fields and normal extensions
- 3.5 Separable and inseparable extensions
- 3.6 Finite fields

Teaching- learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignment.

Assessment methods

Assignment	20%
Mid semester examination	30%
Final examination	50%

Teaching materials

Textbook: - B. Fraleigh John, **A First Course in Abstract Algebra**, 2nd ed, Addison-Wesley publishing Company, Reading

References:

- J. J Gerald, **Introduction to modern algebra(revised)**, 4th ed; University Book Stall, Reading, 1989
- D. S. Dummit and R. M. Foote, **Abstract algebra**, 3rd ed, John Wiley and Sons, 2004.
- P. B. Bhattachara *et-al*, **Basic abstract algebra**, 2nd ed, Cambridge University press, 1995
- N. H. Ma-Coy *et-al*, **Introduction to abstract algebra**, Academic Press, 2005
- C. C. Pinter, **A book of abstract algebra**, McGram Hill, 1986
- T. A. Whitelaw, **Introduction to abstract algebra**, Chapman and Hall, 2000
- J. A. Gallian, **Contemporary abstract algebra**, D. C. Heath & Comp., 1994

Math 445

Course title: Mathematical Modeling

Course code: Math 445

Credit hours: 3

Contact hrs: 3

Tutorial hrs: 2

Corequisite: Math 481

Course category: Compulsory

Aims

The course aims at providing a concise mathematical formulation of characteristic problems of real life with emphasis on quantitative aspects of the problems. It develops the basic concepts and methods in modeling focusing on forecasting relevant solutions to specified area problems.

Course description

This course covers basic concepts and methods in modeling, dimensional analysis, graphical methods and applications, approximation and testing, Eulerian and Lagrangian modeling, consecutive equations, applications (growth and decay models, population growth model, interacting species, traffic flow, diffusion and population models, etc)

Course objectives

On completion of the course, successful students will be able to:

- understand the importance of model,
- understand properties of models,
- give examples of models,
- understand dimensional analysis,
- use graph in modeling,
- develop mathematical models representing a physical problem,
- test stability of the model,
- use models for forecasting.

Course content

Chapter 1: Introduction to modeling

- 1.1 Models and reality
- 1.2 Properties of models
- 1.3 Building a model
- 1.4 Examples of models
- 1.5 Why study modeling

Chapter 2: Arguments from scale

- 2.1 Effects of size
- 2.2 Dimensional analysis

Chapter 3: Graphical methods

- 3.1 Using graphs in modeling
- 3.2 Comparative statics
- 3.3 Stability questions

Chapter 4: Application (students supposed to do practical modeling problems)

Teaching –learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignments. Project (if appropriate) will be given.

Assessment methods

- Assignments / quizzes /project/ 20%
- Mid semester examination 30%
- Final examination 50%

Teaching materials

References:

- J. Berry & K. Houston, **Mathematical Modeling**, Edward Arnold, London, 1995
- J. N. Kapoor, **Mathematical Modeling**, Wiley, 2000
- Charles R. Mac Cluer, **Industrial mathematics, modeling in industry, science and government**, Prentice Hall, 2000.
- Glyn James, **Advanced modern engineering mathematics**, 2nd ed, prentice Hall, 1999.
- F. R. Giordano, M. D. Weir and W. P. Fox, **A first course in mathematical modeling**, 2^{dn} ed, 1997.
- Friedman and W. Littman, **Industrial mathematics**, SIAM Pub., 1994.

Math 461

Course title : Advanced Calculus of One Variable

Course code : Math 461

Credit hours : 4 Contact hrs: 4 Tutorial hrs: 2

Prerequisite : Math 365

Course category: compulsory

Aims

The main theme of this course is to present the basic concepts of calculus of one variable from an advanced point of view. It provides students an understanding of the rigorous treatment of mathematical proofs. It is a prerequisite for advanced study in analysis.

Course description

This course deals with the Well Ordering Principle, principle of mathematical induction, least upper bound property of the real number system, sequence of real numbers, the topology of the real numbers, limits, continuity, differentiation, and the Riemann integral and its properties.

Course objectives

On completion of the course, successful students will be able to:

- understand the essential properties of the real number system
- understand the concept of sequences in depth and related results,
- understand the topology of the real numbers,
- understand the concepts of limit and continuity in a more general settings,
- master the theory of differentiation and its consequences,
- understand the definition of the Riemann integral,
- understand proofs of the standard results about the Riemann integral,
- compute Riemann integrals of functions.

Course outline

Chapter 1: Topology of the real number system

- 1.1 Principle of mathematical induction and the Well Ordering Principle
- 1.2 The least upper bound property and some of its consequences
- 1.3 Convergent sequences
- 1.4 Limit theorems
- 1.5 Monotone sequences
- 1.6 Nested interval theorem
- 1.7 Bolzano-Weierstrass theorem
- 1.8 Cauchy sequences
- 1.9 Limit superior and inferior of a sequence
- 1.10 Open and closed sets
- 1.11 Compact sets; the Heine -Borel theorem

Chapter 2 : Limit and continuity of a function

- 2.1 Limit and limit theorems
- 2.2 Definition and algebra of continuous functions
- 2.3 Definition and properties of differentiable functions (such as maximum and minimum value and the Intermediate Value Theorem)
- 2.4 Uniform continuity and its consequences
- 2.5 Monotonic functions

Chapter 3 : Differentiation

- 3.1 Differentiable functions
- 3.2 Properties of differentiable function
- 3.3 Higher derivatives
- 3.4 Extended mean value theorem and Taylor's formula

Chapter 4: The Riemann integral

- 4.1 Definition of the integral
- 4.2 Conditions for Riemann integrability
- 4.3 The class of Riemann integrable functions
- 4.4 Properties of Riemann integrable functions

Teaching –learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignment.

Assessment methods

- Assignments/quizzes/ 25%
- Mid semester examination 35%
- Final Examination 40%

Teaching materials

- Textbook - D. R. Lick, **Advanced calculus of one variable**
- References: - R. R. Goldberg, **Methods of real analysis**, 1970
- S. C. Malik, **Mathematical Analysis**, 2nd ed., 1992
- Douglas S. Bridges, **Foundations of real and abstract analysis**, Springer, 1998
- Robert G. Bartle, **The elements of real analysis**, John Wiley & Sons INC., 1964
- Walter Rudin, **Principles of mathematical analysis**, 3rd ed., McGraw-Hill, 1976
- Hans Sagan, **Advanced Calculus**, Houghton Mifflin company
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Math 464

Course title: Functions of Complex Variables

Course code: Math 464

Credit hours: 4 Contact hrs: 4 Tutorial hrs: 2

Prerequisite: Math 366

Course category: Compulsory

Aims

This course promotes students to appreciate striking results and applications of complex analysis which are not revealed in the theory of functions of one variable and equips them with profound and elegant mathematical proofs. It is a prerequisite for a number of other courses in pure and applied mathematics.

Course description

The course mainly covers the complex number system, complex differentiability, analytic functions, conformal mappings, complex integration Cauchy's theorem, Cauchy integral formula, power series representations of analytic functions, Laurent series, residue theorem, evaluation of definite integrals, and Mobius transformation.

Course objectives

On completion of the course, successful students will be able to:

- understand the significance of differentiability of complex functions,
- define analytic function,
- distinguish between differentiable functions and analytic functions,
- apply Cauchy-Riemann equations,
- evaluate integrals along a path in the complex plane,
- understand the statement of Cauchy's Theorem,
- understand Cauchy integral formula,
- apply Cauchy integral formula to evaluate line integrals,
- represent analytic functions by a power series,
- prove Fundamental Theorem of Algebra,
- distinguish the singularities of a function,
- write the Laurent series of a function,
- calculate the residue,
- apply the Residue theorem,
- understand the properties of Mobius transformation and its action on circles.

Course outline

Chapter 1: Complex numbers

- 1.1 Definition of the complex numbers and their operations
- 1.2 Geometric representation and polar form of complex numbers
- 1.3 De-Moivre's formula
- 1.4 Root extraction
- 1.5 The Riemann and the extended complex plane

Chapter 2: Analytic functions

- 2.1 Elementary functions
- 2.2 Open and closed sets, connected sets and regions in complex plane
- 2.3 Definitions of limit and continuity
- 2.4 Limit theorem
- 2.5 Definition of derivative and its properties
- 2.6 Analytic function and their algebraic properties
- 2.7 Conformal mappings
- 2.5 The Cauchy Riemann equations and harmonic conjugates

Chapter 3: Cauchy's Theorem

- 3.1 Definition and basic properties of line integrals
- 3.2 Intuitive version of Cauchy's theorem

- 3.3 Cauchy's theorem on simply connected regions
- 3.4 Cauchy – Goursat theorem for a rectangle
- 3.5 The Cauchy integral formula
- 3.6 The Maximum Principle

Chapter 4: Series representation of analytic functions

- 4.1 Basic definitions and properties of sequence and series
- 4.2 Taylor's theorem
- 4.3 Liouville's theorem
- 4.4 Laurent series and classification of singularities

Chapter 5: Calculus of residues

- 5.1 Calculation of residues
- 5.2 The Residue theorem and its application
- 5.3 Evaluation of definite integrals

Chapter 6: The Mobius transformation

- 6.1 Examples of mapping by functions
- 6.2 Magnification, translation, and rotation
- 6.3 The map $w = \frac{1}{z}$
- 6.4 Definition of Mobius transformation and basic properties
- 6.5 The cross -ratios

Teaching –learning methods

Four contact hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment method

- Assignments/quizzes/ 25%
- Mid semester examination 35%
- Final examination 40%

Text book: - R. V. Churchill and J. W. Brown, **Complex variables and applications**, Mc Graw-Hill, Inc
 - Jerrold Marsden & Michael J. Hoffman, **Basic Complex Analysis**

References: - Robert B. Ash, **Complex variables**, Academic press, 1971
 - R. E. Greene and S. G. Krantz, **Functions of one complex variable**, John Wiley & Sons, INC., 1997
 - N. Levinson & R. M. Redheffer, **Complex variables**, The McGraw-Hill publishing company Ltd, 1980
 - A. I. Markushevich, **Theory of functions of complex variable**, Prentice-Hall INC., 1965

- N. H. Asmar, **Applied complex analysis with partial differential equations**, Prentice Hall, 2002
 - A. D. Wunsch, **Complex variables with applications**, Addison-Wesley, 1994
 - John B. Reade, **Calculus with complex numbers**, Taylor & Francis, 2003
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Math 481

Course title: Ordinary Differential Equations

Course code: Math 481

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 366

Course category: Compulsory

Aims

The course targets to introduce the basic theory of linear ODEs and systems of linear ODEs together with various techniques of solution methods. It enables students to apply concepts and techniques gained in linear algebra and calculus. It is a prerequisite for the study of a number of applied mathematics courses.

Course description

This course covers basic definitions and terminology, preliminary theory of first and higher order linear ordinary differential equations (ODEs), method of solutions and their applications, series solution, Laplace transform, and systems of first order linear differential equations.

Course objectives

On completion of the course, successful students will be able to:

- distinguish various classes of differential equations,
- understand the underlying theory of linear ODEs,
- understand various techniques of solving ODEs,
- apply the techniques to solve ODEs problems,
- apply the theory of power series to solve certain classes of differential equations,
- derive the properties of Laplace transform,
- apply Laplace transform to solve certain classes of ODE,
- understand the interrelation between ODEs and linear algebra,
- express physical problems in terms of differential equation.

Course outline

Chapter 1: Basic definitions and terminology

1.1 Definition of ODE and examples

- 1.2 Order of a differential equation, linear and nonlinear ODE
- 1.3 Nature of Solutions of ODE: particular and general solutions

Chapter 2: First Order differential equations

- 2.1 Initial value problem
- 2.2 Existence of a unique solution (Picards theorem)
- 2.3 Method of separable of variables
- 2.4 Homogeneous equations
- 2.5 Exact equations, non exact equations and integrating factor
- 2.6 Linear equations
- 2.7 Orthogonal trajectories

Chapter 3: Higher order linear differential equations

- 3.1 Preliminary theory
 - 3.1.1 Initial value problems (IVP) and existence of a unique solution to IVP
 - 3.1.2 Boundary value problems(BVP)
- 3.2 Theory of solutions of linear equations
 - 3.2.1 Linear dependence and linear independence, the Wronskian
 - 3.2.2 Homogeneous linear equations
 - 3.2.3 Superposition principle
 - 3.2.4 Linearly independent solutions and existence of fundamental set of solutions for homogeneous equations
 - 3.2.5 Particular and general solutions of nonhomogeneous equations
- 3.3 Solution methods of certain class of linear equations
 - 3.3.1 Reduction of order
 - 3.3.2 Constructing a second solution from a known solution
 - 3.3.3 The method of undetermined coefficients
 - 3.3.4 Variation of parameters
- 3.4 Applications of second ODEs to simple harmonic and damped motions

Chapter 4: Series solutions

- 4.1 Review of power series, power series solutions
- 4.2 Ordinary points and singular points of a linear second order ODEs
- 4.3 Series solutions of linear second order ODEs about ordinary points
- 4.4 Series solutions of linear second order ODEs about singular points
- 4.5 Regular and irregular singular points of a second order ODEs
- 4.6 The Method of Frobenius linear
- 4.7 The Gamma function and its properties
- 4.8 Solutions of Bessel's equation
- 4.9 Legendre's equation

Chapter 5: Laplace transform

- 5.1 Definition of Laplace transform
- 5.2 Inverse Laplace transform
- 5.3 Translation Theorem and derivative

5.4 Application to IVP

Chapter 6: Systems of linear first order differential equations

- 6.1 Definition of nth-order system of linear ODE and examples
- 6.2 Matrix form of a system and solution vector
- 6.3 Initial value problem of a system and existence of a unique solution
- 6.4 Fundamental solutions of a homogeneous system
- 6.5 Nonhomogeneous system and general solution

Teaching –learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment methods

- Assignments/quizzes/ 20%
- Mid semester examination 30%
- Final examination 50%

Teaching materials

- Textbook: - Dennis G Zill, **A first course in differential equations**
- References: - W. E. Boyce & R. C. DiPrima, **Elementary differential equations and boundary value problems**, 7th ed. John Wiley & Sons, INC., 2001
- Nagel et al, **Fundamentals of differential equations**, 5th ed., Addison Wesley Longman, 2004
- Martin Braun, **Differential equations and their applications**, Springer-Verlag, 1993
- E. D. Rainville and P. E. Bedient, **Elementary differential equations**, MacMillan publishing company, 1999
- R. L. Ross, **Introduction to ordinary differential equations**, 4th ed., Wiley, 1989
- Erwin Kreyzing, **Advanced engineering mathematics**, 10th ed., Wiley, 2000
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Math 484

Course title: Partial Differential Equations

Course code: Math 484

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 481

Course category: Compulsory

Aims

The course introduces students to the concepts and analytical methods for solving partial differential equations. It builds on the previous core mathematics courses to develop more advanced ideas in differential and integral calculus.

Course description

This course discusses basic concepts of partial differential equations (PDE), some techniques of solutions of first order PDE, Fourier series, second order PDE and analytical methods of solutions.

Course objectives

On completion of the course, successful students will be able to:

- define Fourier series of periodic functions,
- expand periodic functions in terms of sine and cosine,
- compute Fourier series,
- determine the order and classification of PDEs
- solve PDEs,
- model some physical problems using PDEs,
- apply Fourier and Laplace transforms for solving PDEs,
- solve one dimensional heat flow and wave equations,
- solve Laplace equations,
- understand generalized functions,
- apply generalized functions.

Course outline

Chapter1: Fourier series and orthogonal functions

- 1.1 Orthogonal functions
- 1.2 Fourier series
 - 1.2.1 Fourier series of functions with period 2π
 - 1.2.2 Fourier series of functions with arbitrary period
 - 1.2.3 Fourier series of odd and even functions
- 1.3 Fourier integrals
- 1.4 Complex form of Fourier series

Chapter 2: Introduction to partial differential equations

- 2.1 Definitions and basic concepts

- 2.2 Classification of PDEs
- 2.3 Definition of initial/boundary value problems
- 2.4 Well-posedness of a problem
- 2.5 Modeling some physical problems using PDEs

Chapter 3: First order partial differential equations

- 3.1 Solution of first order PDEs with constant coefficients
- 3.2 Solution of a first order PDEs with variable coefficients
- 3.3 Charpit's method
- 3.4 Application of a first order PDEs to fluid flow problems

Chapter 4: Fourier transform

- 4.1 Fourier transform and its inverse
- 4.2 Properties of Fourier transform
- 4.3 Fourier sine and cosine transforms
- 4.4 Convolution

Chapter 5: Second order partial differential equations

- 5.1 Definition and classification of second order PDEs
- 5.2 Method of separation of variables
- 5.3 One dimensional heat and their solutions by using methods of Fourier transform
- 5.4 One dimensional wave equations and their solutions by using methods of Fourier transform
- 5.5 The potential(Laplace) equation
- 5.6 Fourier and Laplace transforms, applied to other PDEs

Teaching –learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment method:

- Assignments / quizzes / 20%
- Mid semester examination 30%
- Final examination 50%

Teaching materials

Textbook: - I.N. Sneddon, **Elements of partial differential equations**

- References: - R. C. Mcowen, **Partial differential equations, methods and applications**, Pearson education, INC, 2003
- H. M. Lieberstein, **Theory of partial differential equations**, Academic press, 1972
- R. B. Gunther & J. W. Lee, **Partial differential equations of physics**, Dover, 1996

12.2 Elective Mathematics Courses

Math 403

Course title: Logic and Set Theory

Course code: Math 403

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 321

Course category: Elective

Aims

The course intends to introduce students to the world of formal logics from the perspectives of truth, proof, and arguments. It presents the notion of sets axiomatically laying a foundation for classical mathematics.

Course description

This course covers propositional and predicate logic, intuitive and axiomatic set theory, relations and functions, the natural numbers, cardinal and ordinal numbers, transfinite arithmetic, the axioms of choice, and zorn's lemma.

Course objectives

On completion of the course, successful students will be able to:

- understand the statement calculus,
- apply rules of inferences,
- prove validity of arguments,
- understand the axiomatic approach to set theory,
- understand algebra of sets,
- determine equivalence classes,
- understand the construction of natural numbers,
- understand the notion of cardinal and ordinal numbers,
- apply counting principles in classification of sets,
- state the Well Ordering Principle,
- state the Axiom of Choice and Zorn's lemma.

Course outline

Chapter 1: Propositional and predicate logic

- 1.1 Sentential connectives and truth tables
- 1.2 The statement calculus
- 1.3 Validity
- 1.4 Consequence and Rules of Inference
- 1.5 Application
- 1.6 Symbolizing Everyday Language
- 1.7 Predicate Calculus
- 1.8 Consequence

Chapter 2: Introduction to set theory

- 2.1 Intuitive set theory
- 2.2 Axiomatic set theory
- 2.3 The primitive notions and axioms
- 2.4 Algebra of sets

Chapter 3: Relations and functions

- 3.1 Ordered pairs, Cartesian Products and relations
- 3.2 Functions
- 3.3 Equivalence and ordering relations

Chapter 4: The natural numbers

- 4.1 Construction of the natural numbers
- 4.2 Arithmetic and ordering on a set of natural numbers

Chapter 5: Cardinal and ordinal numbers

- 5.1 Cardinal numbers
- 5.2 Countable sets and cardinal arithmetic
- 5.3 Order types, well-ordered sets & ordinal numbers

Chapter 6: The Axiom of Choice, the Well Ordering theorem and alephs

- 6.1 The axiom of choice
- 6.2 The Well Ordering theorem

Teaching-learning methods

Three hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment methods

- | | |
|----------------------------|-----|
| - Assignment /quizzes/ | 20% |
| - Mid semester examination | 30% |
| - Final examination | 50% |

Textbook: - R. R. Stoll, **Set theory and logic**

- References:
- Ademe Mekonen, **Logic and Set theory**, Department of Mathematics, AAU, 2007
 - Yiannis Moschovakis, **Notes on set theory**, 2nd ed., Springer
 - Peter T. Johnstone, **Notes on logic and set theory**, Cambridge University press, 1987
 - George Tourlakis, **Lectures in logic and set theory**, Cambridge University press, 2003

- M. L. Bettinger, **Logic, Proof, and sets**, Adison-Wesley, 1982
 - I. Copi & C. Cohen: **Introduction to logic**, Maxwell Macmillan, 1990
 - R. S. Wolf: **Proof, logic and conjecture**, The mathematics toolbox, 1998
 - J. Barkley Rosser, **Logic and set theory**
 - P.R. Halmos, **Naïve Set theory**
 - H.B. Enderton, **Elements of set theory**
-

Math 408

Course title: History and philosophy of mathematics

Course code: Math 408

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: None

Course category: Elective

Aims

The course introduces students the development of mathematics and its role in the development of other science and technology. It helps them understand that there is a lot more facts to be invented and discovered in mathematics and science that would advance both in the future.

Course description

This course presents history and philosophy of mathematics in three eras: before, in and after the eighteenth century. The values of learning the history of mathematics and the roles of different mathematicians and countries in the development of mathematics are discussed. It helps students appreciate that mathematics is an open science, the frontiers of which are always widened through the interaction of theory and practice in different scientific relationships of physical quantities.

Course objectives

On completion of the course, successful students will be able to:

- understand the philosophy of mathematics,
- tell the history of mathematics,
- recognize the values and advantages of learning the history of mathematics,
- describe the roles that ancient mathematicians played in the development of mathematics and other advancement in science technology,
- appreciate the works and contributions of the ancient mathematicians just by looking at their discoveries and their

- inventions,
- state the roles played by Mathematics in the development process of countries.

Chapter 1: Historical Dimension of Mathematics

- 1.1 Introduction
- 1.2 Primitive origin
- 1.3 Babylonians' contribution
- 1.4 Egyptians' contribution
- 1.5 The Greeks contribution
- 1.6 The Alexandrian Hellenistic Greek mathematics
- 1.7 The Hindu mathematics
- 1.8 The Arab/ Islam contribution
- 1.9 The Renaissance- Golden age
- 1.10 The present age mathematics
- 1.11 The great mathematicians behind mathematics

Chapter 2: Philosophical dimension of mathematics

- 2.1 Introduction
- 2.2 What is philosophy?
- 2.3 What is knowledge?
- 2.4 Philosophy of mathematics
- 2.5 The Absolutist
- 2.6 Logicism
- 2.7 Formalism
- 2.8 Intuitionism
- 2.9 Fallibilism
- 2.10 Conventionalism
- 2.11 Empiricism
- 2.12 Quasi-Empiricism
- 2.13 Platonism

Chapter 3: Mathematics education

- 3.1 Introduction (Definition of mathematics and the scope of mathematics)
- 3.2 Mathematics and Logic
- 3.3 Values of mathematics education

Teaching –learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do reading assignments and write a report.

Assessment methods

- | | |
|---------------------|-----|
| • Assignments | 30% |
| • Term paper | 20% |
| • Final examination | 50% |

Teaching materials

- References:
- James Robert Brown, **Philosophy of Mathematics: A contemporary introduction to the world of proofs & pictures**, 2nd ed., 2008
 - W. S. Anglin, **Mathematics: A concise history and philosophy**, Springer, 1994
 - Matthias Schirm, **The philosophy of mathematics today**, Clarendon Press Oxford, 1998
 - William Ewald, **From Kant to Hilbert: A source book in the foundation of mathematics**, Oxford University press, 1996
 - Aspray, William, and Philip Kitcher, **History and philosophy of modern mathematics**, university of Minnesota, 1988
 - Philip Kitcher, **The nature of mathematical knowledge**, Oxford University press, 1984
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Math 411

Course title: Projective Geometry

Course code: Math 411

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 312

Course category: Elective

Aims

The course aims at building on earlier materials on geometry and linear algebra, and combining these areas to understand Euclidean and projective geometries.

Course description

This course covers introduction to projections, projective transformation, projective plane, analytic projective geometry and projective description of conics.

Course objectives

On completion of the course, successful students will be able to:

- comprehend the basic principles of projective geometry,
- understand some of the interrelations among various, geometries via projective geometry,
- understand the classical topics such as Desargues' theorem, and Pappus theorem harmonic sets, etc,
- write equations of projective lines,
- apply cross ratio,
- understand the basic geometric and algebraic properties,
- understand the interrelations between projective, transformations and conic sections,

- solve problems and prove theorems in projective geometry

Course outline

Chapter 1: Introduction to projections

- 1.1 Parallel projections of a line
- 1.2 The real projective plane
- 1.3 Central projections
- 1.4 Central projections of a line on intersecting lines
- 1.5 Central projections of a line on intersecting planes
- 1.6 The value of cross ratio of points, parallel and concurrent lines
- 1.7 Harmonic division

Chapter 2: Projective transformation

- 2.1 Definitions
- 2.2 Equations of projective transformations
- 2.3 Projective group
- 2.4 Projective transformations and projections
- 2.5 Projective transformations and conic sections

Chapter 3: The Projective Plane

- 3.1 The ideals definitions
- 3.2 Model of extended plane projective space
- 3.4 Projections in a broader sense
- 3.5 Duality: Co linearity and concurrence
- 3.6 Cross-Ratio and ideal element
- 3.7 Application of the cross ratio
- 3.8 Order on a projective line
- 3.9 Figures in a projective plane
- 3.10 Harmonic properties of complete figures

Chapter 4: Analytic projective geometry

- 4.1 Homogeneous coordinates of points
- 4.2 Equations of projective lines
- 4.3 Linear combination of points
- 4.4 Equations of tangents to projective conics
- 4.5 Homogeneous coordinates of lines
- 4.6 Equations of points
- 4.7 Linear combination of lines
- 4.8 The summation notation

Chapter 5: Projective description of conics

- 5.1 Introduction: Pascal and Brianchon's propositions
- 5.2 First projective view point of conics
- 5.3 Projective correspondence

Teaching –learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do reading assignments and write a report.

Assessment methods

- Assignments 30%
- Mid semester examination 20%
- Final examination 50%

Teaching materials

Textbook: - A. Tuller Van Nostrand Co., **A Modern introduction to geometry**, 1967
- C. F. Adler, **Modern geometry**, 2nd Ed., McGraw-Hill, 1967.

References: - Judith N. Cedrberg, **Course in Modern Geometries**, 2nd, 2001, ed.
- Divid A. Thomas, **Modern geometry**, 2002
- James W. Anderson, **Hyperbolic Geometry**, 2005, 2nd ed.
- College Geometry: **A problem solving approach with applications**, 2008, 2nd Ed.
- Edward C. Wallace Stephen F., **Roads to Geometry**, West, 3rd ed, 2004.

Math 412

Course title: Introduction to Differential Geometry

Course code: Math 412

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 366, Math 312

Course category: Elective

Aims

The course is intended to introduce students with the classical differential geometry of curves and surfaces using calculus and linear algebra.

Course description

This course covers calculus on Euclidean spaces, frame fields, Euclidean geometry, and calculus on a surface and shape operators.

Course objectives

On completion of the course, successful students will be able to:

- comprehend the basic principles of differential geometry,
- analyze calculus on general spaces,
- understand the properties of curves and surfaces,
- find covariant derivatives,
- define orientation,

- comprehend topological properties of surfaces and manifolds,
- compute curvature integral forms.

Course outline

Chapter 1: Calculus on Euclidean space

- 1.1 Euclidean space
- 1.2 Tangent vectors
- 1.3 Directional derivatives
- 1.4 Curves in \mathbb{R}^3
- 1.5 Forms
- 1.6 Differential forms
- 1.7 Mappings

Chapter 2: Frame fields

- 2.1 Dot product
- 2.2 Curves
- 2.3 The Frenet formulas
- 2.4 Arbitrary-speed curves
- 2.5 Covariant derivatives
- 2.6 Frame fields
- 2.7 Connection forms
- 2.8 The structural equations

Chapter 3: Euclidean geometry

- 3.1 Isometries of \mathbb{R}^3
- 3.2 The Derivative map of an isometry
- 3.3 Orientation
- 3.4 Euclidean geometry
- 3.5 Congruence of curves
- 3.6 Summary

Chapter 4: Calculus on a surface

- 4.1 Surfaces in \mathbb{R}^3
- 4.2 Patch computations
- 4.3 Differentiable functions and tangent vectors
- 4.4 Differential forms on a surface
- 4.5 Mappings of surfaces
- 4.5 Integration of forms
- 4.6 Topological properties of surfaces
- 4.7 Manifolds

Chapter 5: Shape operators

The shape operator of $M \subset \mathbb{R}^3$
 Normal curvature
 Gaussian curvature

Computational techniques
Special curves in a surface
Surfaces of revolution

Teaching –learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do assignments.

Assessment methods

- Assignments / quizzes/ 20%
- Mid semester examination 30%
- Final examination 50%

Teaching materials

- Textbook: - Barrett O'Neill, **Elementary differential geometry**, Academic press, 1966
- References: - Gabriel Lugo, **Differential geometry in physic**, Dept. of mathematical science Universty of North Carolina at Wilmington, 1998
- Do Carmo, M. P., **Differential geometry of curves and surfaces**, Prentice-Hall, New Jersey, USA
 - Guggenheimer, H. W., **Differential geometry**, Dover Pub., New York, USA.
 - Judith N. Cedrberg, **Course in Modern Geometries**, 2001, 2nd ed.
 - Divid A. Thomas, **Modern Geometry**, 2002
 - James W. Anderson, **Hyperbolic Geometry**, 2005, 2nd ed.
 - College Geometry: **A problem solving approach with applications**, 2008, 2nd Ed.
 - Edward C. Wallace Stephen F. West, **Roads to Geometry**, 2004, 3rd ed.
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Math 424

Course title: Modern Algebra II

Course code: Math 424

Credit hours: 3

Contact hrs: 3

Tutorial hrs: 2

Prerequisite: Math 423

Course category: Elective

Aims

The course is a continuation of modern algebra I. It intends to deepen the knowledge and skills of students in Galois and Module theories, which prepare them for graduate study.

Course description

This course covers introduction to Galois theory, module theory, modules over principal ideal domains and commutative rings.

Course objectives

On completion of the course, successful students will be able to:

- comprehend the concepts in Galois theory,
- state the fundamental theorem of Galois theory,
- solve polynomials by radical,
- compute the Galois group of a polynomial,
- define and give an example of a module,
- understand the concept of modules and their properties,
- state and prove the main theorems of Galois theory,
- state and prove the main theorems of Module theory,
- determine the isomorphism of two modules,
- define a module over PID,
- define different types of rings,
- define exact sequences,
- determine the Jordan and canonical forms.

Course outline

Chapter 1: Galois theory

- 1.1 Basic definitions
- 1.2 The fundamental theory of Galois theory
- 1.3 The Galois group
- 1.4 Properties of the Galois group
- 1.5 Galois group of a polynomial
- 1.6 Solvability by radicals

Chapter 2: Module theory

- 2.1 Definition and examples of a module
- 2.2 Basic properties of modules
- 2.3 Submodules
- 2.4 Quotient modules and module homomorphisms
- 2.5 Generation of modules, direct sums, and free modules
- 2.6 Exact sequences, projective, injective and flat modules

Chapter 3: Modules over PID

- 3.1 The basic theory
- 3.2 The rational canonical form
- 3.2 The Jordan canonical form

Chapter 4: Introduction to commutative rings

- 4.1 Primary decomposition of ideals
- 4.2 Integral dependence and valuation
- 4.3 Noetherian rings
- 4.4 Artinian rings

Teaching-learning methods

Three hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment methods

- | | |
|----------------------------|-----|
| - Assignment /quizzes/ | 20% |
| - Mid semester examination | 30% |
| - Final examination | 50% |

Teaching materials

Teaching materials

Textbook: - B. Fraleigh John, **A First Course in Abstract Algebra**, 2nd ed, Addison-Wesley publishing Company, Reading

References:

- J. J Gerald, **Introduction to modern algebra(revised)**, 4th ed; University Book Stall, Reading, 1989
 - D. S. Dummit and R. M. Foote, **Abstract algebra**, 3rd ed, John Wiley and Sons, 2004.
 - P. B. Bhattachara *et-al*, **Basic abstract algebra**, 2nd ed, Cambridge University press, 1995
 - N. H. Ma-Coy *et-al*, **Introduction to abstract algebra**, Academic Press, 2005
 - C. C. Pinter, **A book of abstract algebra**, McGraw Hill, 1986
 - T. A. Whitelaw, **Introduction to abstract algebra**, Chapman and Hall, 2000
 - J. A. Gallian, **Contemporary abstract algebra**, D. C. Heath & Comp., 1994
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Math 426

Course title: Introduction to Algebraic Geometry

Course code: Math 426

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 423

Course category: Elective

Aims

The course intends to introduce undergraduates to the basic concepts and techniques in algebraic geometry, which treats by using algebra. It provides algorithms for manipulating systems of polynomial equations that are useful in computer science and engineering.

Course description

This course covers polynomial and affine varieties, Groebner basis, elimination theory, the algebra-geometry dictionary, polynomial, and rational functions on a variety.

Course objectives

On completion of the course, successful students will be able to:

- comprehend the concept of algebraic geometry,
- understand the relationship between algebra and geometry
- solve problems in algebraic geometry,
- perform parameterization of affine varieties,
- understand Groebner bases and their properties,
- apply Groebner bases,
- find sums, products, and intersections of ideals
- decomposition of a variety into irreducibles.

Course outline

Chapter 1: Geometry, algebra, and algorithms

- 1.1 Polynomials and affine space
- 1.2 Affine varieties
- 1.3 Parametrizations of affine varieties
- 1.4 Ideals
- 1.5 Polynomials of one variable

Chapter 2: Groebner bases

- Introduction
- 2.2 Orderings on the monomials in $k[x_1, \dots, x_n]$
- 2.3 A division algorithm in $k[x_1, \dots, x_n]$
- 2.4 Monomial ideals and Dickson's Lemma
- 2.5 The Hilbert basis theorem and Groebner bases
- 2.6 Properties of Groebner bases

- 2.7 Buchberger's algorithm
- 2.8 First Applications of Groebner bases
- 2.9 Improvements on Buchberger's algorithm (Optional)

Chapter 3: Elimination theory

- 3.1 The elimination and extension theorems
- 3.2 The geometry of elimination
- 3.3 Implicitization
- 3.4 Singular points and envelopes
- 3.5 Unique factorization and resultants
- 3.6 Resultants and the extension theorem

Chapter 4: The algebra–geometry dictionary

- 4.1 Hilbert's Nullstellensatz
- 4.2 Radical ideals and the ideal–variety correspondence
- 4.3 Sums, products, and intersections of ideals
- 4.4 Zariski closure and quotients of ideals
- 4.5 Irreducible varieties and prime ideals
- 4.6 Decomposition of a variety into irreducibles
- 4.7 Primary decomposition of ideals (Optional)

Chapter 5: Polynomial and rational functions on a variety

- 5.1 Polynomial mappings
- 5.2 Quotients of polynomial rings
- 5.3 Algorithmic computations in $k[x_1, \dots, x_n]/I$
- 5.4 The coordinate ring of an affine variety
- 5.5 Rational functions on a variety
- 5.6 Proof of the closure theorem (Optional)

Teaching-learning methods

Three hours of lectures and two hours of tutorials per week. Students do home assignments and presentations.

Assessment methods

- Assignment	20%
- Mid semester examination	30%
- Final examination	50%

Teaching materials

Textbook: - David Cox , John Little, Donal O'Shea , **Ideals Verities and Algorithms: An Introduction to Computational Algebraic Geometry and Commutative Algebra**, 3rd ed Springer, 2007.

- References: - Miles Reid, **Undergraduate algebraic geometry**, Cambridge University press, 1998.
- William Fulton, **Algebraic curves: An introduction to algebraic geometry**, Addison Wesley, 1974.
- George R. Kempf, **Algebraic varieties**, Cambridge University press, 1993
-

Math 440

Course title: Numerical Analysis II

Course Code: Math 440

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 343

Corequisite: Math 481

Course category: Elective

Aims

This course aims at introducing numerical method for solving mathematical problems that can not be solved analytically. It is a cross road of several discipline of mathematics that have great relevance in modern applied sciences.

Course Descriptions

The course deals with a review of interpolation and numerical integration, approximation theory, numerical methods for initial value and boundary value problems and methods for solving eigenvalue problems.

Course objectives

On completion of the course, successful students will be able to:

- use numerical methods for approximating functions,
- derive numerical methods for solving initial and boundary value problems,
- investigate the stability and convergence properties of numerical methods,
- identify the numerical methods that preserve the quantitative behavior of solution,
- solve eigenvalue problems,
- translate complex algorithms into computer programming format.

Course outline

Chapter 1: Revision of numerical integration

- 1.1 Interpolation
- 1.2 Trapezoidal and Simpson's rules, Gaussian quadrature
- 1.3 Multiple integration

Chapter 2: Approximation theory

- 2.1 Least-square approximation
- 2.2 Approximation of functions by orthogonal polynomials (such as Chebyshev, Legendre and Fourier series)

Chapter 3: Numerical methods for ordinary differential equations

3.1 The initial value problem

- 3.1.1 Taylor's method of order n
- 3.1.2 Euler's methods
- 3.1.3 Runge-Kutta methods
- 3.1.4 Multistep methods
- 3.1.5 Higher-order equations and system

3.2 Boundary value problems

- 3.2.1 The Linear shooting method
- 3.2.2 The Shooting method for non linear problems
- 3.2.3 Finite Difference method for linear problems
- 3.2.4 Finite-Difference method for non linear problems

Chapter 4: Eigenvalue problems

- 4.1 Basic properties of eigen values and eigen vectors
- 4.2 The power method for finding dominant eigen values
- 4.3 Householder's method and the QL algorithm

Teaching- learning methods

Three contact hours of lectures and two hours of computer lab per week. Students do home assignment.

Assessment methods

Computer lab assignment	20%
Mid semester examination	30%
Final examination	50%

Teaching Materials

- Textbook: - Gerald C. F. and Wheatly P. O., **Applied numerical analysis** 5th ed, Edsion Wesley,Co
- References: - P.A. Strock, Richard L. Burden, **Numerical Analysis-** 2nd Ed 1981.
- Volkov, Numerical methods 1986

- Frank Ayres, Theory and Differential Equations Schuam's outline series, 1981
 - Robert Ellis and Denny Glick, Calculus with Analytical Geometry, 3rd Ed.
 - Murry R. Advanced Calculus, Spiegel Advanced Calculus for Engineering and Scientists- Murry R. Spiegel
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Math 442

Course title: Fluid Mechanics

Course code: Math 442

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 343, Math 481

Course category: Elective

Aims

The course aims at providing the fundamental concepts of fluid mechanics, which is one of the major modern areas for the successful practical applications of mathematics.

Course description

This course discusses Kinematics of fluid flow, equation of continuity, flow and circulation, motion in two dimensions, applications (Navier's and Stoke's equation and their solution, Prandtl's boundary layer theory, energy equation, solution of particular case studies).

Course objectives

On completion of the course, successful students will be able to:

- understand basic concepts of fluid dynamics,
- understand the kinematics of fluid flow,
- identify body and surface forces,
- understand pressure in fluid,
- understand Reynold's transportation theorem,
- comprehend the equations of motion of the fluid,
- comprehend Navier-Stokes equation,
- describe potential problems using complex number,
- solve fluid flow problems and interpret the results.

Course outline

Chapter1: Background of fluid mechanics

- 1.1 The continuum concept
- 1.2 Density, forces (body and surface)
- 1.3 Pressure in a fluid

Chapter 2: Kinematics and mass conservation

- 2.1 Brief description of Euler and Lagrange descriptions
- 2.2 Velocity
- 2.3 Streamlines, particle paths and streaklines
- 2.4 Vorticity and circulation
- 2.5 Material time derivative
- 2.6 Derivatives of material integrals, Reynold's transportation theorem
- 2.7 Mass conservation, incompressibility, vector potential, streamfunction for plane flow
- 2.8 Boundary conditions

Chapter 3: Equation of motion of a fluid

- 3.1 Euler equation
- 3.2 Balance laws in integral form
- 3.3 Bernoulli's theorem
- 3.4 Examples (such as jet hitting plate, venture tube, open-channel flow)

Chapter 4: Viscous flows

- 4.1 The coefficient of viscosity, laminar flow
- 4.2 The Navier-Stokes' equation of motion
- 4.3 Application of Navier-Stokes' for variety of practical problems (with simplifying assumptions and a solution strategies)

Teaching –learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment methods

- | | |
|----------------------------|-----|
| • Assignments / quizzes / | 20% |
| • Mid semester examination | 30% |
| • Final examination | 50% |

Teaching materials

- Textbooks:
- White, F.M., **Viscous Fluid Flow**, 2nd McGraw Hill 1991.
- References:
- Paterson A. R., **A first course in fluid dynamics**, Cambridge, UK, 1983
 - Street R. L. et al., **Elementary fluid mechanics**, John Wiley and Sons: New Work, 1996
 - Kundu P. K. et al, **Fluid mechanics**, Academic Press, Amsterdam, 2004
 - J. N. Kapoor, **Mathematical Modeling**, Wiley 2000.
-

Math 451

Course title: Operations Research

Course code: Math 451

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 356

Course category: Elective

Aims

The course intends to equip students with some of the basic techniques, methodologies, and models used in operational research and make rational decisions in solving variety of optimization problems using computers.

Course description

This course covers integer programming, deterministic dynamic programming, inventory models, forecasting models, decision theory, queuing systems, and simulation modeling.

Course objectives

On completion of the course, successful students will be able to:

- identify the problems that can be solved using quantitative methods, explain steps in quantitative analysis,
- use computers to perform quantitative analysis, apply quantitative analysis in modeling and solving decision making problems,
- formulate a decision making problem,
- develop the use of probability in decision making,
- apply the method of depicting a series of decisions and outcomes of decisions,
- use computers to aid decision making,
- analyze solutions,
- identify different types of forecast,
- measure forecast accuracy,
- apply time-series forecasting models,
- formulate different types of inventory models,
- formulate different types of queuing models,
- relate queuing problems to simulation,
- apply inventory models to material requirement planning,
- formulate problems that can be solved using integer programming
- check feasibility of solutions of an integer programming problem.

Course outline

Chapter 1: Integer programming

- 1.1 Introduction
- 1.2 Problem formulation
- 1.3 Optimal feasible solution

Chapter 2 : Deterministic dynamic programming

- 2.1 Bellman principle
- 2.2 Forward and backward recursion
- 2.3 Dynamic programming for Knapsack problem

Chapter 3 : Inventory models

- 3.1 Elements of inventory analysis
- 3.2 Inventory control systems

Chapter 4: Forecasting

- 4.1 Introduction
- 4.2 Types of forecast
- 4.3 Scatter diagram
- 4.3 Measures of forecasting accuracy

Chapter 5: Decision theory

- 5.1 Decision making without probabilities
- 5.2 Decision making with probabilities
- 5.3 Utility in decision making
- 5.4 Solving problems using computer software

Chapter 6: Queuing systems

- 6.1 Single server model
- 6.2 Multi-server models
- 6.3 Machine repair models
- 6.4 Queues in series
- 6.5 Queues in Priorities
- 6.6 Queuing simulation
 - 6.6.1 Types of simulation
 - 6.6.2 Elements of discrete event simulation
 - 6.6.3 Manual simulation of a single server model

Chapter 7: Simulation modeling

- 7.1 Random variable
- 7.2 Monte Carlo simulation
- 7.3 Different types of simulation
- 7.4 Applications

Teaching-learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignment. Some topics of some of the chapters will be given as reading assignments.

Assessment methods

- Assignments/quizzes/ 25%
- Mid semester examination 30%
- Final examination 45%

Teaching materials

References:

- F. S. Hillier and G. J. Lieberman, **Introduction to operations research**, Holde-day, 2001
 - H. A. Taha, **Operations research, an introduction**, Macmillan publishing company, 2002
 - W. L. Winston, **Operations research: Applications and algorithms**, Duxbury Press, Belmont, 1994
 - Eric V. Denardo, **The science of decision making: a problem-based approach using Excel**, John Wiley & Sons, Inc., 2002
 - Walter C. Giffin, **Queuing Theory and applications**, Grid Inc, 1978
 - Rechar J. Terssine (1994) **Principles of inventory and materials management**, 4th edn. Prentice-Hall 1994
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Math 456

Course title: Nonlinear Optimization

Course code: Math 456

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 356

Course category: Elective

Aims

The course intends to introduce students to both theoretical and algorithmic aspects of nonlinear optimization.

Course description

This course covers basic notions of convex analysis, nonlinear optimization, discrete optimization, graph theory, and network optimization.

Course objectives

On completion of the course, successful students will be able to:

- define convex sets and convex functions,
- determine continuity and differentiability of convex functions,
- understand the fundamental principles of nonlinear programming,
- formulate a problem statement as a mathematical model,
- test necessary and sufficient optimality conditions,

- understand Kuhn-Tucker conditions,
- solve nonlinear programming problems,
- apply penalty method,
- apply Lagrange method,
- apply iterative methods for solving convex optimization problems,
- solve discrete optimization problems,
- understand the scope and limitation of modeling practical problems as nonlinear programs,
- apply graph theory to solve network oriented problems.

Course outline

Chapter 1: Basic notions of convex analysis

- 1.1 Affine and convex sets
- 1.2 Convex functions
- 1.3 Continuity and differential property of convex functions

Chapter 2: Nonlinear optimization

- 2.1 Convex optimization problems
- 2.2 Necessary and sufficient optimality conditions
- 2.3 Penalty methods
- 2.4 Lagrange-method and the Kuhn-Tucker conditions
- 2.5 Quadratic optimization problems
- 2.6 Separable optimization problems
- 2.7 Iterative methods for solving convex optimization problems

Chapter 3: Discrete optimization

- 3.1 Dynamic optimization
- 3.2 The Knapsack problem
- 3.3 Branch-and-Bound method

Chapter 4: Graph theory and network optimization

- 4.1 Basic notions of graph theory
- 4.2 Paths and circuits
- 4.3 Trees and forests
- 4.4 Directed graphs
- 4.5 Network flow
- 4.6 Minimum and critical path problems
- 4.7 Maximal flow problems

Teaching-learning methods

Three contact hours of lectures and two contact hours of tutorials per week. The students do graded home assignments individually or in small groups.

Assessment methods

- Assignment and quizzes 20%
- Mid semester examination 30%
- Final examination 50%

Textbook: - Bazaraa, Sherali and Shetty, **Nonlinear programming**, 3rd Edition, Wiley 2006

- References: - R. Deumlich, **Lecture note for theory of optimization**, Dept. of mathematic AAU
- P. Whittle, **Optimization under constraints**
 - Bertsekas, **Nonlinear programming**, Athena Scientific, 1999
 - Fletcher, **Practical methods of optimization**, Wiley 2000
 - Rockafellar, **Convex analysis**, Princeton, 1970
 - Mangasarian, **Nonlinear programming**, SIAM, 1994
 - Boyd and Vandenberghe, **Convex optimization**, Cambridge, 2004
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Math 463

Course title: Advanced Calculus of Several Variables

Course code: Math 463

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 366

Course category: Elective

Aims

This course intends to offer a careful and rigorous treatment of the theory of functions of several variables. The main results in this course help students in the study of higher courses of mathematics and applied sciences.

Course description

This course covers the topics in Euclidean n -space and transformation, the topology on \mathbb{R}^n , limit and continuity, differentiation, inverse function theorem, implicit function theorem, integration, and Fubini's theorem.

Course objectives

On completion of the course, successful students will be able to:

- understand basic properties of the Euclidean space and linear transformations on \mathbb{R}^n ,
- understand the various topological aspects in \mathbb{R}^n ,
- understand and apply the notion of convergence of sequences of points in \mathbb{R}^n in terms of sequences in \mathbb{R} ,
- apply the concepts of limit and continuity of functions in one

- variable to functions defined on \mathcal{R}^n ,
- evaluate limits of functions defined on \mathcal{R}^n ,
- understand the concept of differentiability of a function on \mathcal{R}^n ,
- find derivatives and partial derivatives,
- apply the implicit function theorem,
- understand the theory of integration on \mathcal{R}^n ,
- apply Fubini theorem to compute integrals
- exhibit core skills in proofs.

Course outline

Chapter 1: Euclidean n-space and transformation

- 1.1. Euclidean n – Space
- 1.2. Norm in \mathcal{R}^n
- 1.3. Inner product in \mathcal{R}^n
- 1.4. Linear transformation
- 1.5. Dual space of \mathcal{R}^n

CHAPTRE 2: Topology on \mathcal{R}^n

- 2.1. Interior, exterior, boundary and points of a Set.
- 2.2. Sequences
- 2.3. Product of sets
- 2.4. Open and closed sets
- 2.5. Compact sets
- 2.6. Connectedness

CHAPTER 3: Limit and continuity of functions on \mathcal{R}^n

- 3.1. Vector valued functions
- 3.2. Limit and continuity of vector and real valued functions
- 3.3. Connectedness and continuity
- 3.4. Compactness and continuity

CHAPTER 4: Differentiation in \mathcal{R}^n

- 4.1. The chain rule
- 4.2. Partial derivatives
- 4.3. Directional derivatives
- 4.4. Mean value theorem
- 4.5. Surjective function theorem and open mapping theorem
- 4.6. The inverse and the implicit functions theorem

CHAPTER 5: Integration in \mathcal{R}^n

- 5.1. Basic definition
- 5.2. Measure zero and content zero
- 5.3. Integrable functions
- 5.4. Fubini's theorem

Teaching –learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignment.

Assessment methods

- | | |
|----------------------------|-----|
| • Assignments/quizzes/ | 25% |
| • Mid semester examination | 35% |
| • Final examination | 40% |

Teaching materials

- References:
- W. H. Fleming, **Functions of several variables**, Addison-Wesley publishing company, INC, 1965
 - Bisrat Dilnesahu, **Advanced calculus of several variables**, Department of Mathematics, AAU
 - R. C. Werde & M. Spiegel, **Advanced calculus**, 2nd ed., McGraw-Hill, 2002
 - Ian Craw, **Advanced calculus and analysis**, University of Aderdeen, 2000
 - Michael Spivak, **Calculus of manifolds**
 - C. H. Edwards, **Calculus of several variables**
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Math 465

Course title : Introduction to Topology

Course code: Math465

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math461

Course category: Elective

Aims

The course intends to lay the foundation to advanced study in analysis and related fields of mathematics.

Course Description

This is an introductory course in topology dealing with metric spaces treating topics such as open sets, closed sets, continuity, convergence and completeness, and it extends the ideas to general topological spaces.

Course Objectives

On completion of the course, successful students will be able to:

- understand the definition of a metric space,
- distinguish between open balls and closed balls in a metric space,
- understand the definition and properties of open set in a metric space,
- understand the definition of continuity of a mapping from one metric space into another,
- know the conditions for equivalent metrics,
- understand the definition of a topology and topological space,
- determine whether a collection of subsets of a set is topology,
- distinguish the open and closed sets in a topological space,
- understand the definitions and properties of compact space,
- recognize compact subsets of a topological space,
- understand the definitions and properties of connected space,
- recognize connected subsets of a topological space,
- prove that two topological spaces are homeomorphic.

Course outline

Chapter 1. Metric spaces

- 1.1 Definition and examples of a metric space
- 1.2 Open sets and closed sets in metric spaces
- 1.3 Interior, closure and boundary
- 1.4 Continuous functions
- 1.5 Equivalence of metric spaces
- 1.6 Complete metric spaces

Chapter 2. Topological spaces

- 2.1 Definition and some examples of a topological space
- 2.2 Interior, closure and boundary
- 2.3 Basis and subbasis
- 2.4. Continuity and topological equivalence
- 2.5 Subspaces

Chapter 3. Connectedness

- 3.1 Definition and theorems on connectedness
- 3.2 Connectedness and continuity
- 3.2 Connected subspaces of the real line
- 3.3 Applications of connectedness.

Chapter 4. Compactness

- 4.1 Compact spaces and subspaces
- 4.2 Compactness and continuity

- 4.3 Properties related to compactness
- 4.4 One-point compactification
- 4.5 The Cantor set

Teaching-learning methods

Three contact hours of lecture and two hours of tutorial per week. Students do home assignment.

Assessment methods

- Assignments/quizzes/ 25%
- Mid semester examination 35%
- Final examination 40%

Teaching materials

- Text book: - Fred H. Croom, **Principles of Topology**
 - S. Lipschutz, **Theory and problems of general topology**, McGraw-Hill 1965
- References: - James R. Munkers, **Topology a first course**
 - George F. Simmons, **Introduction to Topology and Modern Analysis**
 - Bert Mendelson, **Introduction to topology**, 3rd ed.,
 John D. Baum, **Elements of point-set topology**,
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Math 472

Course title: Graph Theory

Course code: Math 472

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 325

Course category: Elective

Aims

This course intends to introduce students the basic concepts of graph theory. It has a wide variety of applications, both to other branches of mathematics and to real-world problems.

Course description

This course covers graphs and their matrix representation, paths and circuits, trees and forests, planar graphs, graph coloring, digraph, networks, and flows.

Course objectives

On completion of the course, successful students will be able to:

- understand the basic concepts of graphs and their types,
- formulate problems in terms of graphs,

- represent graphs and digraphs by matrices,
- understand the concepts of paths and circuits,
- identify Eulerian and Hamiltonian graphs,
- comprehend the Greedy algorithm,
- find the minimal spanning tree,
- distinguish planar graphs,
- find chromatic numbers,
- apply graph coloring in scheduling and shortage problems.

Course outline

Chapter 1: Introduction

Basic definitions and examples

Degree of a vertex

The incidence and adjacency matrices

Isomorphism of graphs

Subgraphs

Chapter 2: Paths and circuits

2.1 Walks, paths and circuits

2.2 Connectedness

2.3 Eulerian graphs

2.4 Hamiltonian circuits

2.5 Weighted graphs

2.6 Applications

Chapter 3: Trees and forests

3.1 Characterization of trees

3.2 Distances and centers

3.3 Cut-edges and cut-vertices

3.4 Spanning trees

3.5 Rooted and binary trees

3.6 Applications

Chapter 4: Planar graphs

4.1 Plane and planar graphs

4.2 Plane duality

4.3 Kuratowski's theorem

4.4 Thickness and crossing numbers

4.5 Applications

Chapter 5: Graph coloring

5.1 The chromatic number

5.2 Edge coloring

5.3 Vertex coloring

- 5.4 Coloring of maps
- 5.5 Chromatic polynomials
- 5.6 Applications

Chapter 6: Networks and flows

- 6.1 Directed graphs
- 6.2 Eulerian digraphs and tournaments
- 6.3 Minimal and critical path problems
- 6.4 Flows and cuts
- 6.5 The max-flow min-cut theorem

Teaching –learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do home assignments.

Assessment methods

- Assignments / quizzes / 20%
- Mid semester examination 30%
- Final examination 50%

Teaching materials

Textbooks: - J. A. Bondy and U. S. R. Murthy, **Graph Theory with Applications**, Elsevier Science Publishing Co. Inc. New York, 1976.

- References: - F. Harary, **Graph Theory**, Addison-Wesely, 1969.
- R. Diestel, **Graph Theory**, Springer-Verlag New York, 2000.
 - R. J. Wilson, **Introduction to Graph theory**, 3rd ed., Longmann Inc. New York, 1985.
 - B. Harris, **Graph Theory and its applications**, Academic press, 1970
 - Oystein Ore, **Theory of graphs**, American Mathematical Society, 1974
-

Math 493

Course title: Introduction to Cryptography

Course code: Math 493

Credit hours: 3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 392

Course category: Elective

Aims

The course is intended to provide a foundation of cryptography in an applied manner so that students can grasp its importance in relation to the rest of information security.

Course description

This course covers cipher system, methods and types of attack, information theory, stream ciphers, block ciphers, public key ciphers, authentication, identification, and digital signatures.

Course objectives

On completion of the course, successful students will be able to:

- have an overview of some of the classical cryptosystems,
- understand the basic mathematics behind private-key and public-key cryptography,
- describe several well known techniques for cryptography, security and authentication,
- understand secure hashes,
- understand digital signatures,
- understand the method of encryption and decryption of ciphers,
- understand how to use private and public keys,
- know how to construct or extend a key,
- understand the algorithms that arise in the study of cryptology and error control codes,
- know the algebraic method involved in decoding or correcting a code.

Course outline

Chapter 1: Introduction to modern cryptography

- 1.1 Encryption: Historical glance
- 1.2 Modern encryption
- 1.3 Security definition
- 1.4 The model of adversary
- 1.5 Road map to encryption
- 1.6 Mathematical background (Introduction to finite field theory)

Chapter 2: One-way and trapdoor functions

- 2.1 One way functions: Motivation and definition
- 2.2 Hard-core predicate of a one way function
- 2.3 One-way and trapdoor predicates

Chapter 3: Block ciphers

- 3.1 Definition of a block cipher
- 3.2 Data encryption standard (DES): Brief history, construction and speed
- 3.3 Key recovery attacks on block ciphers
- 3.4 Iterated-DES and DESX
- 3.5 Advanced encryption standard (AES)
- 3.6 Limitations of key-recovery based security

Chapter 4: Pseudo-random functions

- 4.1 Function families
- 4.2 Random functions and permutations
- 4.3 Pseudorandom functions and permutations
- 4.4 Modeling block ciphers
- 4.5 Example attacks, security key recovery, the birth day attack
- 4.6 The PRP/PRF switching lemma
- 4.7 Some applications of PRFs

Chapter 5: Private-key encryption

- 5.1 Symmetric encryption schemes
- 5.2 Some symmetric encryption schemes, stream ciphers
- 5.3 Issues in privacy
- 5.4 Indistinguishability under chosen-plaintext attack
- 5.5 Examples chosen-plaintext attacks
- 5.6 IND-CPA implies PR-CPA
- 5.7 Security of CTR modes
- 5.8 Security of CBC with random IV
- 5.9 Indistinguishability under chosen-ciphertext attack
- 5.10 Examples of chosen-ciphertext attacks
- 5.11 Other methods for symmetric encryption

Chapter 6: Public-key encryption

- 6.1 Definition of public-key encryption
- 6.2 Simple examples of PKC: The trapdoor function model
- 6.3 Defining security
- 6.4 Probabilistic public key encryption
- 6.5 Exploring active adversaries

Chapter 7: Hash functions

- 7.1 The hash function SHA1

- 7.2 Collision-resistant hash functions
- 7.3 Collision-finding attacks
- 7.4 One-wayness of collision-resistant hash functions
- 7.5 The MD transfer
- 7.6 Collision-resistance under hidden-key attack

Chapter 8: Message authentication

- 8.1 Definition of security for MACs
- 8.2 Construction from pseudorandom functions
- 8.3 The CBC MACs (The basic CBC MAC, birthday attack on the CBC MAC)
- 8.4 MACing with cryptographic hash functions
- 8.5 Combining encryption and authentication

Chapter 9: Digital signatures

- 9.1 The ingredients of digital signature
- 9.2 Digital signatures: the trapdoor model
- 9.3 Attack against digital signatures
- 9.4 The RSA digital signature schemes
- 9.5 ElGamal's scheme, Rabin's scheme
- 9.6 Probabilistic signatures
- 9.7 Concrete security and practical RSA based signatures

Teaching-learning methods

Three hours of lectures and two hours of tutorials per week. Students do home assignments. Some chapter topics are assigned for reading.

Assessment methods

Assignments/quizzes/	25%
Mid semester examination	30%
Final examination	45%

Teaching materials

- References:**
- Neal Koblitz, **A course in number theory and cryptography**, 2nd ed; Springer, 1994
 - J. A. Buchmann, **Introduction to cryptography**, Springer-Verlag, 2000
 - Alferd J. Menezes, Paul C. Van Oorschot and Scott S. Vanstone, **Handbook of applied cryptography**; CRC Press, 1996
 - Alferd J. Menezes, Paul C. Van Oorschot and Scott S. Vanstone, **Introduction to modern cryptography**, 2008

Math 494

Course title: Computational Number Theory

Course code: Math 494

Credit hours:3 Contact hrs: 3 Tutorial hrs: 2

Prerequisite: Math 392

Course category: Elective

Aims

The course intends to provide an introduction to many methods currently used for testing/proving primality and for factorization of composite integers. It develops the mathematical theory that underlines these methods, and describes the methods themselves. It is useful in the study of applied mathematics fields such as cryptography.

Course description

This course covers quick review of number theory, primality test, primality proofs, and factorization.

Course objectives

On completion of the course, successful students will be able to:

- understand the variety of methods for testing/proving primality,
- understand the factorization of composite integers,
- understand the theory of binary quadratic forms, elliptic curves and quadratic number fields sufficient to understand the principles behind state-of-the art factorization methods,
- analyze the complexity of some fundamental number-theoretic algorithms,
- conduct primality test,
- analyze the primality proofs,
- understand factorization methods.

Course outline

Chapter 1: Number theory background

- 1.1 Complexity analysis
- 1.2 Revision of Euclid's algorithm
- 1.3 Continued fractions
- 1.4 The prime number theory
- 1.5 Smooth numbers
- 1.6 Elliptic curves over a finite field
- 1.7 Square roots modul a prime
- 1.8 Quadratic number fields
- 1.9 Binary quadratic forms and fast polynomial evaluation

Chapter 2: Primality test

- 2.1 Fermat Test
- 2.2 Miller-Rabin test
- 2.3 Carmichael numbers
- 2.4 Euler test
- 2.5 Euler-Jacobi test
- 2.6 Lucas test
- 2.7 Mersenne numbers
- 2.8 Prime number generation (random search, strong primes)

Chapter 3: Primality proofs

- 3.1 Succinct certificates
- 3.2 Elliptic curve method

Chapter 4: Factorization

- 4.1 Trial division
- 4.2 Parallelization
- 4.2 Fermat's method and extensions
- 4.3 Methods using binary quadratic forms
- 4.4 Pollard's p-1 method
- 4.5 Pollard's rho and roo method
- 4.6 Factor-base methods
- 4.7 Quadratic sieve
- 4.8 Number field sieve

Teaching-learning methods

Three hours of lectures and two hours of tutorials per week. Students do home assignments.

Teaching materials

Textbook: - David M. Bressoud and Stan Wagon, **A course in computational number theory**, Springer-Verlag, 2000

References: - R. Crandall, **Prime Numbers: A computational perspective**, Springer, 2001.
- Neal Koblitz, **A course in number theory and Cryptography**, Springer-Verlag, 2nd ED 1994.

13. Supportive Course Specifications

(All the course specifications included in this section are directly pasted as presented by the course offering departments)

Stat 270

Course title: Introduction to Statistics
Course code: Stat 270
Credit hours: 3
Contact Hours: Lecture 3 hours per week, Tutorial 2 hours per week
Pre-requisite:

Course description

Meaning of statistics; Methods of data collection; Methods of data presentation; Measures of location; Measures of variation; Moments, skewness and kurtosis; Counting Techniques; Concepts of Probability (classical approach); Probability distributions: Binomial, Poisson, Normal, t and Chi-square; Sampling and Sampling Distribution of the mean and proportion; Elementary description of the tools of statistical inference: Basic concepts; Estimation: (Point and Interval) for the population mean and proportion; Hypothesis testing on the population mean and proportion; Chi-square test of association. Each topic should begin with motivating examples.

Objectives

- to introduce students the basic statistical knowledge on data collection and presentation methods, Measures of Central Tendency and Variation, probability and probability distributions, one sample inference, regression and correlation;
- introduces the basic concepts of statistical thinking and reasoning;
- to enable students apply the methods of statistics in scientific research, decision making and future career;
- to demonstrate the importance and practical usefulness of probability in real life;
- to show how probability is a necessary foundation for understanding statistics;
- to demonstrate the importance and usefulness of statistics in real life and on real data;
- to show how to present data informatively and clearly;

- to equip students to apply probability and statistical methods to solve standard problems from a wide range of disciplines;
- to give students an appreciation of the limitations of these standard techniques;
- to enable students to communicate the results of their analyses in clear non-technical language;

Learning outcomes

At the end of the course students are expected to:

- have a broad knowledge of the basic understanding of statistical techniques demonstrated through principles of data collection, descriptive statistics, probability, probability and sampling distributions, statistical inference and linear regression.
- understand the methods of data collection, organization, presentation, analysis and interpretation;
- know what is meant by sample space, event, relative frequency, probability, conditional probability, independence, random variable, probability distribution, probability density function, expected value and variance;
- be familiar with some standard discrete and continuous probability distributions;
- be able to use standard statistical tables for the Normal t, chi-square distributions;
- be able to differentiate between common types of data, and display them appropriately;
- learn some desirable properties of point estimators;
- recognize the additional benefits of calculating interval estimates for unknown parameters;
- understand the framework of hypothesis testing for carrying out statistical inference;
- be able to produce and interpret interval estimates and tests of hypotheses correctly in some simple cases;
- be able to present their results correctly and in non-technical language;
- have basic skills in exploratory data analysis.

Course Outline

1. Introduction (3 lecture hours)

1.1 Definition and classification of Statistics

- 1.2 Stages in statistical investigation
- 1.3 Definition of Some Basic terms
- 1.4 Applications, uses and limitations of Statistics
- 1.5 Types of variables and measurement scales

2. Methods of Data Collection and Presentation (4 lecture hours)

- 2.1 Methods of data collection
 - 2.1.1 Sources of data
 - 2.1.2 Methods of collection
- 2.2 Methods of Data Presentation
 - 2.2.1 Motivating examples
 - 2.2.2 Frequency Distributions: qualitative, quantitative: absolute, relative and Percentage.
 - 2.2.3 Tabular presentation of data
 - 2.2.4 Diagrammatic presentation of data: Bar charts, Pie-chart, Cartograms
 - 2.2.5 Graphical presentation of data: Histogram, and Frequency Polygon

3. Measures of Central Tendency (5 lecture hours)

- 3.1 Motivating example
- 3.2 Objectives of measures of central tendency
- 3.3 Summation notation
- 3.4 Important Characteristics of a good average
- 3.5 Mean
 - 3.4.1 Arithmetic Mean
 - 3.4.2 Geometric Mean
 - 3.4.3 Harmonic Mean
- 3.6 Median
- 3.7 Mode

4. Measures of variation (Dispersion), Skewness and Kurtosis (5 lecture hours)

- 4.1 Motivating examples
- 4.2 Objectives of measures of central tendency
- 4.3 Measures of Dispersion (Variation)
 - 4.3.1 Range
 - 4.3.2 Variance, Standard Deviation and coefficient of variation
 - 4.3.3 Standard scores
- 4.4 Moments

- 4.5 Skewness
- 4.6 Kurtosis
- 5. Elementary Probability (5 lecture hours)**
 - 5.1 Introduction
 - 5.2 Definition & some concepts (Experiment, sample, event, equally likely outcomes, mutually exclusive events, independent events)
 - 5.3 Random experiments
 - 5.4 Counting rules: addition, multiplication rules, permutation and combination
 - 5.5 Definitions of probability (probability of an event)
 - 5.6 Some rules of probability
- 6. Probability Distributions (7 lecture hours)**
 - 6.1 Definition of random variables (discrete and continuous) and probability distributions
 - 6.2 Introduction to expectation: mean and variance of random variable
 - 6.3 Common discrete distributions: binomial and Poisson
 - 6.4 Common continuous distributions: Normal, t, and chi-square distribution
- 7. Sampling and Sampling Distributions of the Mean (3 lecture hours)**
 - 7.1 Basic concepts (population, sample, parameter, statistic, sampling frame, Sampling unit, sampling error, sample size)
 - 7.2 Reasons for Sampling
 - 7.3 Different types of Sampling (Probability vs Non probability Sampling Techniques)
 - 7.4 Simple random sampling (lottery method, table or computer generated random numbers)
 - 7.5 Sampling distribution of the sample mean and proportion
 - 7.6 Central limit theorem
- 8. Estimation and Hypothesis Testing (10 lecture hours)**
 - 8.1 Estimation
 - 8.1.1 Motivating examples
 - 8.1.2 Point estimation: mean and proportion
 - 8.1.3 Interval estimation: mean and proportion
 - 8.2 Hypothesis Testing
 - 8.2.1 Motivating examples
 - 8.2.2 Important concepts in testing a statistical hypothesis

- 8.2.3 Steps in testing a hypothesis
- 8.2.4 Hypothesis testing about the population mean
- 8.2.5 Hypothesis testing about the population proportion
- 8.2.6 Chi-square test of association

9. Simple Linear Regression and Correlation (6 lecture hours)

- 9.1 Motivating examples
 - 9.1 Introduction: regression and correlation
- 9.2 Simple Linear Regression
- 9.3 Correlation Coefficient

Textbook

Bluman, A.G. (1995). Elementary Statistics: A Step by Step Approach (2nd edition). Wm. C. Brown Communications, Inc.

References

1. Coolidge, F.L.(2006). Statistics: A Gentle Introduction (2nd edition).
2. David, S.M., McCabe, P. and Craig, B. (2008). Introduction to the Practice of Statistics (6th edition). W.H. Freeman.
3. Eshetu Wencheke (2000). Introduction to Statistics. Addis Ababa University Press.
4. Freund, J.E and Simon, G.A. (1998). Modern Elementary Statistics (9th Edition).
5. Gupta, C.P.(.). Introduction to Statistical Methods (9th Revised Edition).
6. Snedecor, G.W and Cochran, W.G. (1980). Statistical Methods (7th edition).
7. Spiegel, M.R. and Stephens, L.J. (2007). Schaum's Outline of Statistics, Schaum's Outline Series (4th edition). McGraw-Hill.
8. Woodbury, G. (2001). Introduction to Statistics. Duxbury press.

Teaching and learning methods

Lectures, tutorials, discussions, demonstration and assignments.

Modes of Assessment

Two or more tests and assignments	20%
Mid Semester Examination	30%
Final Examination	50%
Total	100%

Stat 276

Course title: **Introductory Probability**

Course code: **Stat 276**

Credit hours: **3**

Pre-requisite:

Course description

Review of elementary probability; Random variables; Probability distributions; Common Discrete Probability Distributions: Binomial, Poisson, Geometric and Hypergeometric; Common Continuous Distributions: Uniform, Normal, exponential, t, chi-square, and F; Two-dimensional random variables, Definition of distribution functions, Marginal distributions, Conditional distributions, Expectation, Covariance and Correlation.

Objectives

- to introduce students to fundamental concepts in probability theory;
- to introduce the basic principles and methods of quantification of uncertainty;
- to introduce the basics of random variables, common probability distributions and expectation;
- to introduce two dimensional random variables their probability distributions including marginal and conditional distributions and independence;
- to introduce one and two dimensional functions and computing their probability distribution, expectation, variance and correlation;
- to demonstrate the importance and usefulness of probability in real applications.

Learning outcomes

At the end of the course students are expected to:

- have equipped with basic concept of probability and a good appreciation of the laws of probability;
- know what is meant by random variable, probability distribution, cumulative distribution function, probability density function, expectation, variance and correlation;
- have the skills to tackle simple problems on probability distributions;
- understand conditional probability and independence;
- know what is meant by joint, marginal and conditional distribution and independent random variables;

- be familiar with one and two dimensional random variables and their functions and deriving their probability distributions and computing their expectation, variance and correlation;
- be familiar with standard discrete and continuous probability distributions, how they arise in practice and their elementary properties.

Course Outline

1. Review (2 lecture hours)

- 1.1 Deterministic and non-deterministic models
- 1.2 Random experiments, sample space and events
- 1.3 Review of set theory: sets, union, intersection, complementation, De Morgan's rules
- 1.4 Finite sample spaces
- 1.5 Equally likely outcomes
- 1.6 Counting techniques
- 1.7 Axioms of probability
- 1.1 Derived theorems of probability

2. Conditional Probability and Independence (3 lecture hours)

- 2.1. Conditional Probability
- 2.2 Multiplication rule
- Partition Theorem, Bayes' Theorem and Applications
- Independent Events

3. One-dimensional Random Variables (3 lecture hours)

- 3.1 Random variable: definition and distribution function
- 3.2 Discrete random variables
- 3.3 Continuous random variables
- 7.1 Cumulative distribution function and its properties

4. Functions of Random Variables (6 lecture hours)

- 4.1 Equivalent events
- 4.2 Functions of discrete random variables and their distributions
- 4.3 Functions of continuous random variables and their distributions

5. Two-Dimensional Random Variables (8 lecture hours)

- 5.1 Two-dimensional random variables
- 5.2 Joint distributions for discrete and continuous random variables

- 5.3 Marginal and conditional probability distributions
- 5.4 Independent random variables
- 5.5 Distributions of functions of two random variables

6. Expectation (5 lecture hours)

- Expectation of random variable
- Expectation of a function of a random variable
- Properties of expectation
- Variance of a random variable and its Properties
- Chebyshev's Inequality
- Covariance and Correlation Coefficient
- Conditional Expectation

7. Common Discrete Distributions and their Properties (10 lecture hours)

- 7.1 Binomial distribution
- 7.2 Poison distribution
- 7.3 Hypergeometric distribution
- 7.4 Geometric distribution
- 7.5 Multinomial distribution

8. Common Continuous Distributions and their Properties (11 lecture hours)

- 1.1 Uniform distribution
- 1.2 Normal distribution
- 1.3 Exponential distribution
- 1.4 Chi - square distribution
- 1.5 t distribution
- 1.6 F distribution
- 1.7 Bivariate normal distribution

Textbook

Ross S. (2006). A First Course in Probability (7th Edition). Prentice-Hall, Upper Saddle Rivel, New Jersey.

References

1. Cheaffer, R.L. and McClave, J.T (1994). Probability and Statistics for Engineers (4nd Edition). Duxbury Press.

2. Lipschutz, S. and Schiller, J. (1998). Introduction to Probability and Statistics. Schaum's Outline Series, Mc Graw-Hill.
3. Mendenhall, W., Beaver, R.J. and Bearer, B.M. (2008). Introduction to Probability and Statistics (13th Edition). Duxbury Press.
4. Mendenhall, W., Beaver, R.J. and Bearer, B.M. (2005). Student Solutions Manual for Introduction to Probability and Statistics (12th Edition). Duxbury Press.
5. Walpole, R. E., Myers, S.L. and Ye, K. (2006). Probability and Statistics for Engineers and Scientists (6th Edition). Prentice Hall.
6. Roussas, G. G. (2006). Introduction to Probability. Academic Press.
7. Bertsekas, D. P. and Tsitsiklis, J. N. (2008). Introduction to Probability (2nd Edition). Athena Scientific.
8. Suhov, Y. and Kelbert, M. (2005). Probability and Statistics by Examples. Cambridge University Press.

Teaching and learning methods

Lectures, tutorials and assignments.

Mode of Assessment and Evaluation

Two or more tests and assignments	20%
Mid-Semester Examination	30%
Final Examination	50%
Total	100%

Comp 201

Course Title: Introduction to Computer Science

Course Number: Comp 201

Credit Hours: 4

Contact Hours:

Lecture: 3

Lab: 2

Prerequisites: None

Course description

An overview of Computer Science, the development of computers, data representation in computers, logical organization of a computer system, computer software and hardware, computer number system and arithmetic, computer system architecture, computer networks and communications with description of modern networking technologies, introduction to computer security.

Course objectives

This course introduces the students with fundamentals of Computer Science by furnishing them with a broad oversight of the discipline of formal computer science.

At the end of the course students should be able to:

- explain what Computer Science is, its characteristics and applications
- explain the historical development, generations and types of computers
- get familiar with the computer system, data representation techniques, and computer arithmetic
- get familiar with the different coding methods
- explain Boolean logic, logic elements, etc.
- define computer networks and types
- get familiar with the Internet and its services

Course outline

Chapter 1: Overview of Computer Science (5 hours)

- 1.1 Introduction to Information and Communication Technology (1/2 hour)
- 1.2 Definition of Computer and Computer Science (1/2 hour)
- 1.3 Characteristics of computers (1 hour)
 - Speed, accuracy, capacity, versatility, durability and reliability
- 1.4 Types of computers (1 hour)
 - Analog, digital, special purpose, general purpose
 - Super computers, mainframe computers, minicomputers, microcomputers (desktop, laptop or notebook, PDA or palmtop, handheld)

- 1.5 Applications of computers (2 hours)
- Learning aid
 - Entertainment
 - Commercial and business applications
 - Information utility
 - Engineering and research applications
 - Public service

Chapter 2: Development of computers (3 hours)

- 2.1 History of computing (1 hour)
- Abacus
 - Pascal's Calculator
 - The difference engine and the analytical engine
 - Herman Hollerith's tabulating machine
 - Mark I
 - ENIAC - Electronic Numerical Integrator And Computer
 - The Von Neumann Machine
 - Commercial computers
- 2.2 Generations of computers (2 hours)
- First, second, third, and fourth generations
 - Current Trends

Chapter 3: Organization of a computer system (8 hours)

- 3.1 Introduction to Computer Systems (1/2 hour)
- 3.2 Computer hardware (3 hours)
- The Central Processing Unit (CPU)
 - Purposes of the Central Processing Unit
 - Control Unit
 - Arithmetic and Logic Unit (ALU)
 - RAM and ROM
 - The bus system (address bus, data bus, and control bus)
 - Input/Output units

- Input units (pointing devices, game controllers, keyboard, scanner, camera, microphone)
- Output units (monitor, printer, speaker)
- Storage units
- Sequential access media (tape)
- Random access media (magnetic disk, optical storage media, flash memory cards)

3.3 Computer software

- System software (3 hours)
- Operating systems
- What is an operating system?
- Functions of an operating system (controlling operations, input/output management, command processing)
- Types of operating systems (single/multi tasking, single/multi user, real-time, command driven vs GUI-based)
- Example operating systems (Windows, UNIX, Solaris, MacOS)
- Language software
- Translators (assemblers, compilers, interpreters), and editors
- Applications software (1 1/2 hours)
- Word processing
- Spreadsheet
- Database management systems
- Graphics
- Software suites
- Enterprise application software

Chapter 4: Data representation in computers (12 hours)

4.1 Units of data representation (1 1/2 hours)

- Bit, Byte, Word

4.2 Concept of number systems and binary arithmetic (4 hours)

- Binary, Octal, and Hexadecimal number systems
- Conversion from one number system to another
- Binary arithmetic

4.3 Coding method (2 1/2 hours)

- EBCDIC (Extended Binary Coded Decimal Interchange Code)
- BCD 4 and 6 (Binary Coded Decimal)
- ASCII 7 and 8 (American Standard Code for Information Interchange)

- UNICODE
- 4.4 Representation of negative numbers and arithmetic (3 hours)
 - Signed magnitude, One's complement, Two's complement
- 4.5 Floating-point representation (1 hour)

Chapter 5: Computer System architecture (12 hours)

- 5.1 Hierarchical structure of computer system architecture (1 hour)
- 5.2 Logic elements and Boolean algebra (3 hours)
 - Logic gates and Boolean algebra
- 5.3 Implementation of Boolean algebra (3 hours)
 - Boolean functions and truth tables
 - Construction of logic circuits
- 5.4 Types of circuits (2 hours)
 - Combinational and sequential circuits

Chapter 6: Computer networks and communications (4 hours)

- 6.1 Introduction to computer networking and its applications (2 hours)
- 6.2 Types of networks
 - LANs (Local Area Networks) and WANs (Wide Area Networks)
- 6.3 Introduction to the Internet (2 hours)
 - Services of the Internet (e-mail, World Wide Web, file transfer/access, remote login/ execution, video conferencing)

Chapter 7: Computer security (1 hour)

- Introduction to computer security
- Encryption
- Backup
- Viruses and worms

Evaluation

Reading assignment class)	10% (depending on the number of students per
Lab:	20%
Mid exam:	20%
Final exam:	50%

Textbook

Introduction to Computer Science, IITL Education Solutions Ltd, Pearson Education, 2004

References

Dida Midekso , **Introduction to Computer Science** , Ethiopia, AAU, 1994
Computer Science: An Overview: International Edition, (10th ed.), Pearson Higher Education, 2007.

Comp 231

Course Title: Fundamentals of Programming I

Course Number: Comp 231

Credit Hour: 4

Contact Hour:

Lecture: 3

Laboratory: 2

Prerequisites: None

Course description

Problem solving using computers, algorithms, program structure, constants, types, variables, reserved words, syntax diagram, identifiers, numbers, character strings and constant declarations; basic data types, statements (assignment, I/O, control).

Course objective

This course is designed to introduce students to problem solving techniques using computers.

On completion of this course students should be able to:

- describe the problem solving process as applied in programming
- describe the basics of C++ programming – syntax and semantic elements of the programming
- describe and exercise the Arithmetic and Logic operations implemented in C++
- implement the program flow control in software
- describe and implement the basic data structure elements in C++ that serve as holding homogenous data primitives

Course outline

Chapter 1: Introduction to Programming (12 hrs)

- 1.1 General Introduction to computer and programming
- 1.2 Software Development Life Cycle (SDLC)
- 1.3 Feasibility study
- 1.4 Requirement Analysis
- 1.5 Designing Solution
- 1.6 Testing Designed Solution
- 1.7 Implementation(Coding)
- 1.8 Unit Testing
- 1.9 Integration and System Testing
- 1.10 Maintenance
- 1.11 Algorithm development and representation
 - 1.11.1 Structured Chart
 - 1.11.2 Pseudocode
 - 1.11.3 Flow chart

Chapter 2: C++ Basics (4 hrs)

- 2.1 Structure of C++ Program
- 2.2 C++ IDE
- 2.3 Showing Sample program
- 2.4 Keywords, Identifiers, Inputs, Outputs, Comments, Parts of a program
- 2.5 Data Types, Variables, and Constants
- 2.6 Operators
 - 2.6.1 Assignment Operators
 - 2.6.2 Compound Assignment Operators
 - 2.6.3 Arithmetic Operators
 - 2.6.4 Relational Operators
 - 2.6.5 Increment and Decrement Operators
 - 2.6.6 Infix and postfix types
- 2.7 Precedence of Operators

Chapter 3: Control Statements (16 hrs)

- 3.1 If statements: If...else, nested if
- 3.2 Switch Statements: Multiple cases, break, Default
- 3.3 Looping: for, while, do, break, continue
- 3.4 Nested Loops

Chapter 4: Arrays and String Manipulation (12 hrs)

- 4.1 Array Definition
- 4.2 Array referencing
- 4.3 One dimensional and multidimensional arrays

4.4 Strings: Definition, accessing Strings

Chapter 5: Pointers (4 hrs)

5.1 Definition of Pointers

5.2 Pointer and address of operator

Evaluation Schemes

Lab Assessment	20%
Mid Term Examination	30%
Final Examination	50%

Textbook

1. Dietel & Dietel, "**C How To Program**", Third Edition, Prentice-Hall, 2003
2. Robert Lafore, "**The Waite Group's C Programming Using Turbo C++**", Techmedia, 1993

References

1. Walter Savitch, "**Problem solving with C++ – The Object of Programming**", Menlo Park: Addison-Wesley, 1996
2. John R. Hubrard, "**Fundamentals of Computing with C++**", Shuam's Outline, 1997
3. Jess Liberty, "**An Introduction to C++**", 1995
4. Robert Lafore, "**The Wait Group Object Oriented Programming With C++**", 1994

Comp 351

Course Title: Fundamentals of Database Systems

Course Number: Comp 351

Credit Hours: 4

Contact Hours:

Lecture: 3

Laboratory: 2

Prerequisite: Comp 231

Course description

Database systems concepts: definition of a database and benefits of database systems. Database Systems Architecture: Internal, conceptual and External level architectures. Relational data model: Conceptual data model- entity, attribute, relationship, and integrity constraints rules. Database design: ER-model, functional dependencies, avoidance of redundancy and normalization. Mapping ER-models to relational tables. Structured Query language- Data Definition Language, Data Manipulation Language; Basics of Relational Algebra and operation;

Course objectives

This course introduces the students to the overview, design and implementation of database systems.

At the end of the Course students should be able to:

- understand what a Database System is, and be able to identify its characteristics and applications,
- explain the Different models of database,
- design ER models from specifications and interpret them into relational tables,
- write SQL statements for data creation and manipulation purposes,
- know how to optimize databases to the most efficient form,
- distinguish and use relational model and relational algebra,
- identify and fix the possible problems that may occur in securing data,

Course outline

Chapter 1: Introduction (4 hours)

- 1.1 Overview
- 1.2 Basics of Database
- 1.3 File organization verses Database approach
- 1.4 Users and actors of Database system

Chapter 2: Database System Architecture (5 hours)

- 2.1 Data models, Schemas, and Instances
- 2.2 Over view of data models
- 2.3 Architecture and Data Independence

Chapter 3: The ER Model (10 hours)

- 3.1 The high-level conceptual model
- 3.2 Entities, Attributes, and Keys
- 3.3 Relationships, Associations, and Constraints
- 3.4 The ER Diagrams
- 3.5 Mapping ER-models to relational tables

Chapter 4: Functional Dependency and Normalization (6 hours)

- 4.1 Functional Dependency
- 4.2 Normal Forms

Chapter 5: The SQL Language (9 hours)

- 5.1 Data Definition Language
- 5.2 Data Manipulation Language
- 5.3 Basic Queries in SQL
- 5.4 Views

Chapter 6: The Relational Data Model and the Relational Algebra (7 hours)

- 6.1 The Relational Model Concepts
- 6.2 The Relational Constraints and Relational Database Schemas
- 6.3 The Relational Operations

Chapter 7: Data Protection (4 hours)

- 7.1 Data recovery
- 7.2 Concurrency
- 7.3 Data Security

Evaluation Schemes

(This may vary on the number of students per class, but general evaluation scheme is as below)

Quiz	10%
Mid Exam	30%
Lab Evaluation and Project Work	20%
Final Exam	40%

Textbook:

Ramez Elmasri, Shamkant B. Navathe, **Fundamentals of Database Systems**, Addison-Wesley, 2000

References

- Abraham Silberschatz, Henry F. Korth, S. Sudarshan, **Database System Concepts**, 4th Ed., McGraw Hill, 2002
- Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom, **Database Systems: The Complete Book**, Prentice Hall, 2002
- Introduction to Database systems, C.J.DATE

Phys 207

Course Title: Mechanics and Heat (Phys 207)

Credits: 4 **Lecture:** 4 hrs **Tutorial:** 2 hrs

Lab: _____ hrs

Prerequisite:

Co requisite:

Course Rationale

At the end of this course students are expected to be acquainted with basic concepts in mechanics, identify the connection between them and explain the common phenomena. They will also develop skills of solving problems.

Course Description

Vector algebra, Particle Kinematics and Dynamics, Work and Energy, Conservation forces and Potential Energy Dynamics of systems of Particles, Collision, Rotational Kinematics, Dynamics and Static of a Rigid Body, Oscillations, Gravitation and Planetary Motion, Heat, Kinetic Theory of Gases, Thermodynamics.

Learning Outcomes

Upon Completion of this course students should be able to:

- compute average and instantaneous values of velocity, speed and acceleration
- derive the Kinematic equations for uniformly accelerated one-dimensional motion
- solve problems involving bodies moving in one-dimensional and two-dimensional using the concepts in calculus and trigonometry
- explain some implementations of Newton's laws of motion
- derive the work-energy theorem
- solve mechanics problem using impulse, momentum and the conservation of linear momentum
- apply the law of conservation of linear momentum of collisions
- repeat the procedure followed in rectilinear motion for rotational motion
- explain basic laws of heat and thermodynamics

Course Outline

1. Vectors (2 hrs)

Vector Algebra

Geometrical and algebraic representation of vectors

Vector addition

Vector multiplication

2. One and two dimensional motions (5 hours)

Average and instantaneous velocities
Average and instantaneous accelerations
Motion with constant acceleration
Projectile motion
Uniform circular motion

3. Particle dynamics (6 Hours)

Newton's law of motion
Friction force
Applications of Newton's laws
Velocity dependent forces

4. Work and Energy (7 hrs)

Work done by constant and variable forces
The work energy theorem
Conservative and non-conservative forces, conservative force and potential forces
Conservation of mechanical energy
Power

5. Dynamics of system of particles (8 hrs)

Linear momentum and impulse
Conservation of momentum
Systems of particles
Center of mass
Center of mass of a rigid body
Motion of system of particles
Elastic and inelastic collision(1 & 2-D)
Elastic collisions in one dimension
Two-dimensional elastic collisions
Inelastic collisions
Systems of variable mass

6. Rotation of rigid bodies (7 hrs)

Rotational motion with constant and variable angular accelerations
Rotational kinetic energy
Momentum of inertia
Rotational dynamics
Torque and angular momentum
Work and power in rotational motion
Conservation of angular momentum
Relation between linear and angular motions

7. Simple harmonic motion (4hrs)

Energy in simple harmonic motion
Equations of simple harmonic motion
Pendulum
Damped and simple oscillations
Resonance

8. Temperature and thermometry (2 hrs)

Temperature scale
Thermometry, the fixed points
Thermocouple

9. Heat and energy (4 hrs)

Heat energy
Heat capacity and specific heat capacity
Specific latent heat
Heat losses

10. Gas laws and basic laws of thermodynamics (6 hrs)

The gas laws
Internal energy
The first law of thermodynamics
Isothermal and adiabatic changes
Work done by gas

11. Kinetic theory of gases (6 hrs)

Ideal gas
Temperature and kinetic theory
Boltzmann's constant
Graham's law of diffusion
Maxwell's distribution of molecular speeds

12. The second law of thermodynamics(4 hrs)

Heat energies and thermodynamic efficiency
The Carnot cycle
The second law of thermodynamics
The Kelvin temperature scale
Entropy

Methods of teaching

Presentation of the course is through lecture, a related guided problems section with demonstrator assistance and additional assessed course work. Online learning resources.

Assessment

- Homework will consist of selected of end of chapter problems: 15%
- In-class participation(asking questions, discussing homework, answering questions): 5 %
- Two tests (40%)
- Mid-semester and semester final tests (40%)

Recommended References

Course Textbook

Raymond A. Serway, **Physics: For Scientists & Engineers**, 6th ed., Thomson Bruke, 2004

References:

1. Hugh D. Young and Roger A. Freedmann, **University physics with modern physicscs**, 12th ed. 2008
2. Douglas C. Giancoli, **Physics for scientists and engineer**, Prentice Hall 4th ed., 2005
3. Robert Resnick and David Halliday, **Fundamentals of physics extended**, HRW 8th ed. 2008
4. Paul M. Fishbane, Stephene Gasiorowicz, Stephen T. Thornton, **Physics for scientists and engineers**, 3rd ed., 2005

14. General Courses

Course Title: Environmental Science

Staff Responsible: -----
Course Code: Geol 200
Credit Hours: 3
Course Category: Core course
Year and Semester: Year 1 Semester 1
Pre-requisite(s): None
Co-requisite(s): None

Course Aim/Rationale: The course aims to introduce students to the broader issues of global environmental challenges facing the human society.

Learning Outcomes: After successful completion of the course students will have an understanding of the interactions between humans and the global environment; develop skills and insight into critical thinking and situational awareness of their surrounding environment; gain an understanding of the physical processes that operate in and on earth, will be aware of environmental issues of international or global scale.

Course Content: Fundamental concepts of the Environmental Science: Population-resource-environment; Development and environment; Sustainability; Earth materials, systems and cycles. Natural hazards: geologic and hydroclimatic hazards. Water resources: surface water process, supply and use, factors affecting surface runoff, managing water use; groundwater process, supply and use, groundwater/surface water interaction, water pollution; Oceans ocean pollution and ocean resources. Environmental Pollution: Air and Water, global warming, green house effect, ozone layer depletion. Mineral and energy resource: minerals (metallic and non-metallic deposits), fossil fuels, renewable sources of energy, environmental impacts of resource exploitation and use. Deforestation, land degradation and desertification, reclamation of degraded land. Megacities and associated challenges: waste disposal sites and waste management. Other environmental concerns of global scale: food and nutrition, biodiversity, international conflicts.

Course Outline

1. Introduction [4 hrs]

- Global environmental issues and challenges
- Population-resource-environment linkage
- Population size as global environmental challenge and opportunity
- Development-resources-sustainability
- Earth materials, systems and cycles

2. Natural Hazards [10 hrs]

- Earthquakes and Earthquake hazards
 - Internal structure and composition of the earth
 - Origin and distribution of earthquakes, tsunamis
 - Measurement of earthquakes, earthquake magnitude, Earthquake Intensity
 - Effects of Earthquakes, Predicting earthquakes and earthquake risks
 - The response to earthquake hazards, mitigation measures
 - Earthquake hazard in Ethiopia
- Volcanism and Volcanic hazards
 - Volcanoes, volcano types, volcano origins
 - Forecasting volcanic activity
 - Predicting volcanic hazards and mitigation measures
 - Adjustment to and perception of volcanic hazards
 - Volcanic hazards in Ethiopia
- Landslides and Landslide hazards
 - Introduction to Landslides, slope processes and types of landslides, slope stability
 - Landslide hazards
 - Minimizing the landslide hazard, perception of the landslide hazard
 - Landslide hazard in Ethiopia
- Hydro-climatic hazards
 - Climatic hazards: El Nino, La Nina, cyclones, drought, climate change, hurricanes, floods

- Hydro-climatic hazards vs geologic hazards global inventory
 - Hydrologic hazards: flooding, magnitude and frequency, urbanization and flooding
 - Adjustments to flood hazards, perception of flooding, flooding hazards in Ethiopia
- 3. Global water resources [6 hrs]**
- The hydrologic cycle, global water balance, global water supply and demand
 - Global Water Scarcity
 - Physical
 - Technical water scarcity
 - International waters and conflict on water resources
 - Groundwater
 - Occurrence and zones of groundwaters
 - Groundwaters as resources
 - Groundwater as environmental, social and economic good
 - Concepts of integrated water resources management
 - Oceans and the environment
 - Ocean resources, ownership of oceans, international laws on oceans
 - Oceans as sinks of global CO₂
 - Interaction between ocean waters and adjacent lands
- 4. Environmental pollution sources and processes [8 hrs]**
- Atmosphere of the Earth
- Composition of the Atmosphere
 - Structure of the Atmosphere: troposphere, stratosphere, mesosphere, thermosphere
 - The solar Energy balance of the Atmosphere: vertical and horizontal flows
- Air pollution and sources
- Green house gases, green house effect, global warming
 - The Ozone layer and its depletion
 - Pollution of the lower Atmosphere
- Water pollution and sources
- Landfills
 - Nitrate pollution
 - Lake Eutrophication
 - Oil spills
 - Acid Mine drainage
- 5. Mineral and energy resources and their link to the environment [6 hrs]**
- Environmental impact of mineral exploitation
 - Non petroleum energy sources
 - Petroleum and natural gas
 - Alternative energy resources
 - Energy resources of the 21st century
- 6. Soils and environment [3 hrs]**
- Soils as regulators of global climate changes

- Formation and types of soils
- Soil Erosion and degradation
- Deforestation and desertification
- Soil preservation approaches
- Soil pollution
- 7. Megacities and solid waste management [4 hrs]**
 - Type and classification of wastes
 - Megacities and various development challenges
 - Solid waste management in cities
 - Waste management challenges in cities/towns of Ethiopia
- 8. Other Environmental challenges of international scale [5 hrs]**
 - Food and nutrition
 - Biodiversity and species extinction
 - International conflicts
 - Foresight capability

Course Delivery: Lecture

Course Assessment: Midterm exam (50 %), essay type written exam at the end of the semester (50%).

Textbooks and Reference Materials

- Edward Keller, Introduction to Environmental Geology 4th edition.
- Montgomery, Carla W., 2008, Environmental Geology, [8th Ed.], McGraw Hill.

14. Service Courses

Math 233

Course title: Calculus I for Chemists

Course code: Math 233

Credit hours: 3 **Contact hrs:** 3 **Tutorial:** 2 hrs

Prerequisite: None

Aims

The course is designed for applied science students. It equips students with basic concepts and techniques of functions and their graphs, differential and integral calculus that are useful for solving chemical problems.

Course Description

This course covers functions and their graphs, concepts and applications of differential and integral calculus of one variable, sequences.

Course objectives

On completion of the course successful students will be able to:

- Understand the concepts of limit and continuity
- Evaluate derivatives,
- Apply derivatives,
- Understand the concepts of integration,
- Evaluate integrals,
- Apply integrals,
- understand the concept of sequence
- determine convergence and divergence of sequence

Course outline

Chapter 1: Limits and continuity

- 1.1. Revision of functions and their graphs
- 1.2. Formal definition of limit
- 1.3. Basic limit theorems
- 1.4. One-sided limits
- 1.5. Infinite limits
- 1.6. Limit at infinity
- 1.7. Formal definition of continuity
- 1.8. One-sided continuity
- 1.9. The intermediate value theorem

Chapter 2: Derivatives

- 2.1. Definition of derivatives
- 2.2. Geometric interpretation of derivative as a slope
- 2.3. Differentiable functions
- 2.4. Derivatives of combinations of functions
- 2.5. The chain rule
- 2.6. Application of chain rule; Related Rates and Implicit Differentiation
- 2.7. Higher order derivatives
- 2.8. Implicit differentiation

Chapter 3: Application of derivatives

- 3.1. Extreme values of functions
- 3.2. The mean value theorem and its application
- 3.3 Monotonic functions
- 3.4. First and second derivative tests
- 3.5. Concavity and inflection points
- 3.6. Curve sketching
- 3.7. Tangent line approximation
- 3.8. Indeterminate forms and L' Hopital's rule

Chapter 4: Integration

- 4.1. Antiderivatives
- 4.2. Partitions, lower sum, upper sum, Riemann sum
- 4.3. Definite integrals;
- 4.4. Basic properties of definite integral
- 4.5. Techniques of integration (Substitution, by part, partial fraction)
- 4.6. Fundamental theorem of calculus
- 4.7. Indefinite integral and their properties
- 4.8. Application of integration (Area, Volume of solid figure, work)

Chapter 5: Sequence

- 5.1. Definition and examples of sequences
- 5.2. Convergence properties
- 5.3. Bounded and monotonic sequences
- 5.4. Subsequences

Teaching- Learning methods

Three contact hours of lectures and two hours tutorials per week. Students do reading assignments.

Assessment Method

- Assignment /quizzes/	20%
- Mid term exam	30%
- Final Exam	50%

Teaching Materials

Textbook: - R. Ellis, **Calculus with analytic geometry**

Reference: - Johnson and Kiokemeister, **Calculus with analytic geometry**
- Harvey and Greenspan: **An introduction to applied Mathematics**

Math 234

Course title: Calculus II for Chemists

Course code: Math 234

Credit hours: 3 Contact hrs: 3 Tutorial: 2 hrs

Prerequisite: Math 233

Aims

The course builds on the knowledge and skills gained in the first course with an extension to multi dimensional problems.

Course description

This course covers series; power series; differential and integrals calculus of functions of several variables and their applications.

Course objectives

On completion of the course successful students will be able to:

- Decide on convergence or divergence of a wide class of series,
- Find radius of convergence of a power series,
- Find the limit of convergent power series,
- Represent a wide class of functions by a Taylor's series,
- Apply Taylor's polynomial,
- Find domain and range of a function of several variables,
- Understand Fourier series
- Apply Fourier series
- Understand functions of several variables,
- Find partial derivatives,
- Apply partial derivatives,
- Find directional derivatives and gradients,
- Use tangent plane approximation,
- Evaluate double and triple integrals,
- Change rectangular coordinate systems to polar, cylindrical and spherical coordinate systems,
- Apply different coordinate systems to evaluate multiple integrals.

Course outline

Chapter 1: Series of real numbers

Definition of infinite series

Convergence and divergence, properties of convergent series

Nonnegative term series

Tests of convergence (integral, comparison, ratio and root tests)

Alternating series and alternating series test
Absolute and conditional convergence
Generalized convergence tests

Chapter 2. Power series

- 2.1 Definition of power series at any x_0 and $x_0 = 0$
- 2.2 Convergence and divergence, radius and interval of convergence
- 2.3 Algebraic operations on convergent power series
- 2.4 Differentiation and integration of power series
- 2.5 Taylor series; Taylor polynomial and application

Chapter 3: Differential calculus of function of several variables

- 3.1 Notations, examples, level curves and graphs
- 3.2 Limit and continuity
- 3.3 Partial derivatives; tangent lines, higher order partial derivatives.
- 3.4 Directional derivatives and gradients
- 3.5 Total differential and tangent planes
- 3.6 Applications: tangent plane approximation of values of a function
- 3.7 The chain rule, implicit differentiation
- 3.8 Relative extrema of functions of two variables
- 3.9 Largest and smallest values of a function on a given set
- 3.10 Extreme values under constraint conditions: Lagrange's multiplier

Chapter 4: Multiple integrals

- 4.1 Double integrals and their evaluation by iterated integrals
- 4.2 Double integrals in polar coordinates
- 4.3 Application: Area, center of mass of plane region, surface area
- 4.4 Triple integrals in cylindrical and spherical coordinates
- 4.5 Application: Volume, center of mass of solid region

Teaching- learning methods

Three contact hours of lectures and two hours tutorials per week. Students do assignments.

Assessment method

-	Assignment/quizzes	20%
-	Mid term exam	30%
-	Final Exam	50%

Teaching materials

Textbook: - R. Ellis, **Calculus with Analytic Geometry**.
Reference: - Johnson and Kiokemeister, **Calculus with Analytic Geometry**

Math 231A

Course title: Applied Mathematics IA

Course code: Math 231A

Credit hours: 4

Contact hrs: 4

Tutorial hrs: 2

Prerequisite: None

Aims

The course is designed for applied science students. It equips students with basic concepts and techniques of linear algebra, differential and integral calculus that are useful for solving engineering and science problems.

Course description

This course covers basic elements of vectors, vector spaces, matrices, determinants, solving systems of linear equations, concepts and applications of differential and integral calculus of one variable.

Course objectives

On completion of the course successful students will be able to:

- understand the basic ideas of vector algebra,
- understand matrix algebra,
- determine the determinants,
- determine linear independence of vectors,
- apply scalar and vector products,
- write equations of lines and planes,
- determine direction angles and direction cosines of a vector,
- apply the basic techniques of matrix algebra,
- determine inverse of a matrix,
- apply elementary row operations,
- solve systems of linear equations,
- understand the concepts of limit and continuity
- evaluate derivatives,
- apply derivatives,
- understand the concepts of integration,
- evaluate integrals,
- apply integrals,

Course outline

Chapter 1: Vectors and vector spaces

- 1.1 Scalars and Vectors in \mathfrak{R}^2 and \mathfrak{R}^3
- 1.2 Addition and scalar multiplication
- 1.3 Scalar product
 - 1.3.1 Magnitude of a vector
 - 1.3.2 Angle between two vectors

- 1.3.3 Orthogonal projection
- 1.3.4 Direction angles
- 1.3.5 Direction cosines
- 1.4 Cross product
- 1.5 Lines and planes
- 1.6 Vector space; Subspaces
- 1.7 Linear Dependence and independence; Basis of a vector space

Chapter 2: Matrices and determinants

- 2.1. Definition of matrix and basic operations
- 2.2. Product of matrices and some algebraic properties; Transpose of a matrix
- 2.3. Elementary operations and its properties
- 2.4. Inverse of a matrix and its properties
- 2.5. Determinant of a matrix and its properties
- 2.6. Solving system of linear equations
 - 2.6.1 Cramer's rule
 - 2.6.2 Gaussian's method
 - 2.6.3 Inverse matrix method
- 2.7. Eigenvalues and Eigenvectors

Chapter 3: Limit and continuity

- 3.1. Definition of limit
- 3.2. Basic limit theorems
- 3.3 One sided limits
- 3.4. Infinite limits, limit at infinity and asymptotes
- 3.5. Continuity; one sided continuity
- 3.6. Intermediate value theorem

Chapter 4: Derivatives and application of derivatives

- 4.1. Definition of derivatives; basic rules
- 4.2. Derivatives of inverse functions
 - 4.2.1 Inverse trigonometric functions
 - 4.2.2 Hyperbolic and inverse hyperbolic functions
- 4.3. Higher order derivatives
- 4.4. Implicit differentiation
- 4.5. Application of derivatives
 - 4.5.1 Extrema of a function
 - 4.5.2 Mean value theorem
 - 4.5.3 First and second derivative tests
 - 4.5.4 Concavity and inflection point
 - 4.5.5 Curve sketching
- 4.6. Velocity, acceleration and rate of change
- 4.7. Indeterminate Forms (L'Hopital's Rule)

Chapter 5: Integration

- 5.1. Antiderivatives; indefinite integrals
- 5.2. Techniques of integration
 - 5.2.1 Integration by substitution, by parts and by partial fraction
 - 5.2.2 Trigonometric integrals
 - 5.2.3 Integration by trigonometric substitution
- 5.3. Definite integrals; Fundamental Theorem of Calculus
- 5.4. Improper integrals

Chapter 6: Application of integrals

- 6.1. Area
- 6.2. Volume
- 6.3. Arc Length
- 6.4. Surface Area

Teaching- learning methods

Three contact hours of lectures and two hours of tutorials per week. Students do reading assignments.

Assessment methods

- Assignment /quizzes/	20%
- Mid semester examination	30%
- Final examination	50%

Teaching materials

Textbook: - Robert Ellis and Denny Gulick, **Calculus with analytic geometry**, 6th ed, Harcourt Brace Jovanovich, Publishers, 5th ed, 1993.

References:

- Leithold, **The calculus with analytic geometry**, 3rd Edition, Herper & Row, publishers.
 - R. T. Smith and R. B. Minton, **Calculus concepts and connections**, McGraw-Hill book company, 2006
 - D. V. Widder, **Advanced calculus**, Prentice-Hall, 1979
 - Ross L. Finney et al, **Calculus**, Addison Wesley, 1995
 - E. J. Purcell and D. Varberg, **Calculus with analytic geometry**, Prentice-Hall INC., 1987
 - Adams, **Calculus: A complete course**, 5th ed, Addison Wesley, 2003
 - R. Wrede and M. R. Spiegel, **Theory of advanced calculus**, 2nd ed., McGraw-Hill, 2002.
 - A. E. Taylor and W. R. Mann, **Advanced calculus**, 3rd ed, John-Wiley and Son, INC, 1995.
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Math 232A

Course title: Applied Mathematics IIA

Course code: Math 232A

Credit hours: 4 Contact hrs: 4 Tutorial hrs: 2

Prerequisite: Math 231A

Aims

The course builds on the knowledge and skills gained in the first course with an extension to multi dimensional problems and introduction to differential equations.

Course description

This course covers sequences, series, power series, differential and integrals calculus of functions of several variables and their applications, introduction to differential equations.

Course objectives

On completion of the course successful students will be able to:

- find limit of a wide class of sequences,
- decide on convergence or divergence of a wide class of series,
- find radius of convergence of a power series,
- find the limit of convergent power series,
- represent a wide class of functions by a Taylor's series,
- apply Taylor's polynomial,
- find domain and range of a function of several variables,
- understand functions of several variables,
- find partial derivatives,
- apply partial derivatives,
- find directional derivatives and gradients,
- use tangent plane approximation,
- evaluate double and triple integrals,
- change rectangular coordinate systems to polar, cylindrical and spherical coordinate systems,
- apply different coordinate systems to evaluate multiple integrals,
- distinguish various classes of differential equations,
- understand the underlying theory of linear ODEs,
- understand various techniques of solving ODEs,
- apply the techniques to solve ODEs problems.

Course outline

Chapter 1: Sequence and series

- 1.1 Definition and types of sequence
- 1.2 Convergence properties of sequences
- 1.3 Subsequence and limit points
- 1.4 Definition of infinite series

- 1.5 Convergence and divergence, properties of convergent series
- 1.6 Nonnegative term series
- 1.7 Tests of convergence (integral, comparison, ratio and root tests)
- 1.8 Alternating series and alternating series test
- 1.9 Absolute and conditional convergence
- 1.10 Generalized convergence tests

Chapter 2. Power series

- 2.1 Definition of power series at any x_0 and $x_0 = 0$
- 2.2 Convergence and divergence, radius and interval of convergence
- 2.3 Algebraic operations on convergent power series
- 2.4 Differentiation and integration of power series
- 2.5 Taylor series; Taylor polynomial and application

Chapter 3: Differential calculus of function of several variables

- 3.1 Notations, examples, level curves and graphs
- 3.2 Limit and continuity
- 3.3 Partial derivatives; tangent lines, higher order partial derivatives.
- 3.4 Directional derivatives and gradients
- 3.5 Total differential and tangent planes
- 3.6 Applications: tangent plane approximation of values of a function
- 3.7 The chain rule, implicit differentiation
- 3.8 Relative extrema of functions of two variables
- 3.9 Largest and smallest values of a function on a given set
- 3.10 Extreme values under constraint conditions: Lagrange's multiplier

Chapter 4: Multiple integrals

Double integrals and their evaluation by iterated integrals
 Double integrals in polar coordinates
 Application: Area, center of mass of plane region, surface area
 Triple integrals in cylindrical and spherical coordinates
 Application: Volume, center of mass of solid region

Chapter 5: Ordinary Differential Equations

- 5.1 Ordinary differential equations of 1st order
- 5.2 Separation of variables multiplying factor, homogenous right-hand side Bernoulli- equation
- 5.3 Linear differential equation of 1st order
- 5.4 Linear differential equation of nth order, Cauchy problem
- 5.5 Method of undetermined coefficients
- 5.6 variation of parameters

Teaching- learning methods

Three contact hours of lectures and two hours tutorials per week. Students do assignments.

Assessment method

- | | | |
|---|--------------------|-----|
| - | Assignment/quizzes | 20% |
| - | Mid semester exam | 30% |
| - | Final examination | 50% |

Teaching materials

Textbook: - Robert Ellis and Denny Gulick, **Calculus with analytic geometry**, 6th ed, Harcourt Brace Jovanovich, Publishers, 5th ed, 1993.

References:

- Leithold, **The calculus with analytic geometry**, 3rd Edition, Herper & Row, publishers.
- R. T. Smith and R. B. Minton, **Calculus concepts and connections**, McGraw-Hill book company, 2006
- D. V. Widder, **Advanced calculus**, Prentice-Hall, 1979
- Ross L. Finney et al, **Calculus**, Addison Wesley, 1995
- E. J. Purcell and D. Varberg, **Calculus with analytic geometry**, Prentice-Hall INC., 1987
- Adams, **Calculus: A complete course**, 5th ed, Addison Wesley, 2003
- R. Wrede and M. R. Spiegel, **Theory of advanced calculus**, 2nd ed., McGraw-Hill, 2002.
- A. E. Taylor and W. R. Mann, **Advanced calculus**, 3rd ed, John-Wiley and Son, INC, 1995.

Math 335

Course title: Calculus II for Statistics

Course code: Math335

Credit hours: 3 **Contact Hours:** 3 **Tutorial:** 2 hours

Prerequisite: Math 264

Aims

This course is designed for statistics students. It intends to introduce students with the fundamental properties of indeterminate forms, sequences and series, and familiarize them with the theory and methods for differentiation and integration of functions of several variables.

Course description

The course deals with indeterminate forms, improper integral and Taylor's formula; sequence and series of real numbers, power series; limit, continuity, differentiation of functions of several variables and multiple integral

Course Objectives

On the completion of the course, successful students will be able to:

- apply L' Hopitals rule to find limits of a function
- approximate functions by Taylor's polynomial,
- determine convergence or divergence of a sequence,
- determine the convergence or divergence of a series
- apply the ratio and root tests
- find interval of convergence of a power series
- approximate a function by using its power series,
- find the Taylor's series expansion of a function
- find partial derivatives of functions
- evaluate double and triple integrals

Course outline

Chapter 1: Indeterminate forms, improper integrals and Taylor's formula

- 1.1 Cauchy's formula
- 1.2 Indeterminate forms (L' Hopital's Rule)
- 1.3 Improper integrals

Chapter 2: Sequence and series

- 2.1 Sequences
 - 2.1.1 Convergence and divergence of sequences
 - 2.1.2 Properties of convergent sequences
 - 2.1.3 Bounded and monotonic sequences
- 2.2 Infinite series
 - 2.2.1 Definition of infinite series
 - 2.2.2 Convergence and divergence of series
 - 2.2.3 Properties of convergent series
 - 2.2.5 Alternating series
 - 2.2.6 Absolute convergence, conditional convergence
 - 2.2.7 Generalized convergence tests
- 2.3 Power series
 - 2.3.1 Definition of power series
 - 2.3.2 Convergence and divergence, radius and interval of convergence
 - 2.3.3 Algebraic operations on convergent power series
 - 2.3.4 Differentiation and integration of a power series
 - 2.3.5 Taylor & Maclaurin series
 - 2.3.6 Binomial Theorem

Chapter 3: Differentiation of functions of several variables

- 3.1 definition and example of functions of several variables
- 3.2 limit and continuity
- 3.3 Partial derivatives and its geometrical interpretation

- 3.4 Differentiability of functions of several variables
- 3.5 The Chain rule

Chapter 4: Multiple integrals

- 4.1 Double integrals
- 4.2 Double integrals in polar coordinates
- 4.3 Surface area
- 4.4 Triple integrals
- 4.5 Triple integrals in cylindrical and spherical coordinates
- 5.6 Change of variables in multiple integrals

Teaching-learning methods

Three contact hours of lectures and two contact hours of tutorials per week. The students do graded home assignments individually or in small groups.

Assessment methods

- | | |
|----------------------------|-----|
| • Assignment and quizzes | 20% |
| • Mid semester examination | 30% |
| • Final examination | 50% |

Textbook:

- Robert Ellis and Denny Gulick, **Calculus with analytic geometry**, 6th ed, Harcourt Brace Jovanovich, Publishers.
 - **References:** Leithold, **The calculus with analytic geometry**, 3rd Edition, Herper & Row, publishers.
 - R. T. Smith and R. B. Minton, **Calculus concepts and connections**, McGraw-Hill book company, 2006
 - D. V. Widder, **Advanced calculus**, Prentice-Hall, 1979
 - Ross L. Finney et al, **Calculus**, Addison Wesley, 1995
 - E. J. Purcell and D. Varberg, **Calculus with analytic geometry**, Prentice-Hall INC., 1987
 - Adams, **Calculus: A complete course**, 5th ed, Addison Wesley, 2003
 - R. Wrede and M. R. Spiegel, **Theory of advanced calculus**, 2nd ed., McGraw-Hill, 2002.
 - A. E. Taylor and W. R. Mann, **Advanced calculus**, 3rd ed, John-Wiley and Son, INC, 1995.
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Math 339

Course title: Numerical methods for Statistics

Course code: Math 339

Credit hours: 3 **Contact hours:** 3 **Computer Lab:** 2 hours

Prerequisite: Math 264, Math 325

Aims

The course intends to introduce students with finding numerical solutions to statistical problems for which analytical solution can not easily be obtained. It also aims to help students develop programming skills.

Course description

This course covers basic concepts in error estimation, solutions of non-linear equations, solutions of system of linear equations and non-linear equations, finite differences, numerical interpolations, numerical differentiation and integration, introductory first order initial value problems (IVP), Taylor's method and Euler's method.

Course Objectives

At the end of accomplishment of the course, successful students will be able to:

- understand concept of errors
- understand a range of iterative methods for solving linear and non-linear systems of equations
- understand the roles of finite differences
- understand the concept of IVP
- grasp the practical knowledge of interpolation in numerical solving of IVP
- develop skills in translating numerical algorithms into computer programming

Course outline

Chapter 1: Basic concepts in error estimation

- 1.1 Sources of errors
- 1.2 Approximation of errors
- 1.3 Rounding off errors
- 1.4 Absolute and relative errors
- 1.5 Propagation of errors
- 1.6 Instability

Chapter 2: Nonlinear equations

- 2.1 Locating Roots
- 2.2 Bisection Method
- 2.3 Interpolation and Secant methods
- 2.4 Iteration Method
- 2.5 Conditions for convergence
- 2.6 Newton Raphson's Method

Chapter 3: System of equations

- 3.1 Direct methods for system of linear equations
 - 3.1.1 Gaussian's method
 - 3.1.2 Gaussian's method with Partial Pivoting
 - 3.1.3 Jordan's method
 - 3.1.4 Matrix inversion using Jordan's method
 - 3.1.5 Matrix decomposition
 - 3.1.6 Tri diagonal matrix method
- 3.2 Indirect methods for system of linear equations
 - 3.2.1 Gauss Jacobi method
 - 3.2.2 Gauss Seidel method
- 3.3 Solving systems of non-linear equations using Newton's method.

Chapter 4 Finite differences

- 4.1 Shift operators
- 4.2 Forward difference operators
- 4.3 Backward difference operators

Chapter 5: Interpolation

- 5.1 Linear interpolation
- 5.2 n^{th} degree interpolation
- 5.3 Lagrange's interpolation formula
- 5.4 Newton interpolation formula (forward and backward difference formulas)
- 5.5 Application of interpolation
 - 5.5.1 Differentiation
 - 5.5.2 Integration (Trapezoidal & Simpson's Rules)

Chapter 6: First order initial value problems

- 6.1 Definition of ODE and examples
- 6.2 Order of a differential equation, linear and nonlinear ODE

- 6.3 Nature of solutions of ODE: particular and general solutions
- 6.4 Initial value problem
- 6.5 Existence of a unique solution (Picards theorem)
- 6.6 Method of separable of variables
- 6.7 Homogeneous equations
- 6.8 Exact equations, non-exact equations and integrating factor
- 6.9 Linear equations
- 6.10 Orthogonal trajectories

Chapter 7: Numerical methods for initial value problems

- 7.1 Taylor’s method of order n
- 7.2 Euler’s method
- 7.3 Euler’s modified method

Teaching- Learning Process

Three contact hours of lectures and two hours of computer lab per week. Students do home assignment.

Assessment methods

- Computer lab assignment 20%
- Mid term examination 30%
- Final examination 50%

Teaching materials

- Textbook:
- Gerald C. F. and Wheatly P. O., **Applied numerical analysis** 5th ed, Edsion Wesley, Co
 - Dennis G.Zill, **A first course in Differential Equations**
- References:
- Richard L. Burden, **Numerical Analysis**, 1981, 2nd Ed.
 - P.A. Strock, **Introduction to numerical analysis**
 - Volkov, **Numerical methods** 1986
 - Frank Ayres, **Theory and Differential Equations** (Schuam’s outline series, 1981)
 - Robert Ellis and Denny Glick, **Calculus with Analytical Geometry**- 3rd Ed.
 - Murry R. Spiegel, **Advanced Calculus for Engineering and Scientists**, Murry R. Spiegel

15. Appendix course coding

All mathematics courses are coded “Math” followed by three digits, where

- The first digit indicates a second year course if it is 2, a third year course if it is 3, a fourth year course if it is 4.
- ii) The middle digit indicates the subject area of the course, that is if it is
- 0 the course is related to general mathematics;
 - 1, the course is related to geometry;
 - 2, the course is related to algebra;
 - 3 the course is related to service courses;
 - 4, the course is related to numerical analysis and related courses;
 - 5, the course is related to optimization and related courses;
 - 6, the course is related to pure analysis;
 - 7, the course is related to discrete mathematics;
 - 8, the course is related to differential equations, and
 - 9, the course is related to number theory and related courses.
- iii) The last digit indicates the semester in which the course is offered. If it is odd, the course is offered during the first semester, if it is even, the course is offered during the second semester.