Study Plan Manual

Master of Science in Mathematics
Department of Mathematics and Statistics
College of Science
King Faisal University

2022

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Curriculum

Study Plan Structure

The master program in Mathematics mainly consists of two tracks namely course track and thesis track. To obtain the degree of M. Sc in Mathematics, a candidate must successfully complete 42 units (24 credit hours in compulsory courses, 16 credit hours in electives courses, 2 credit hours for article and essay course) in Course Track and 32 units (24 credit hours in compulsory courses and 8 credit hours for thesis course) in Thesis Track. Complete detail's structure for both tracks is presented in below tables. Each courses are linked with a short description.

1. Study Plan Structure Courses Path

Program Structure		**No. of Courses**	**Credit Hours**	**Percentage**
Course	Required	**8**	**24**	**57.14%**
	Elective	**4**	**16**	**38.1%**
Graduation Project (if any)		**1**	**2**	**4.76%**
Thesis (if any)		**0**	**0**	**0**
Field Experience(if any)		**0**	**0**	**0**
Others (.....)		**0**	**0**	**0**
Total		**13**	**42**	**100%**

2. Study Plan Structure Courses with Thesis Path

Program Structure		**No. of Courses**	**Credit Hours**	**Percentage**
Course	Required	**8**	**24**	**75%**
	Elective	**0**	**0**	**0**
Graduation Project (if any)		**0**	**0**	**0**
Thesis (if any)		**Thesis**	**8**	**25%**
Field Experience(if any)		**0**	**0**	**0**
Others (.....)		**0**	**0**	**0**
Total		**8+Thesis**	**32**	**100%**

Program Courses

This section enlisted all courses in the program as its appearance. To have a clear view, the course is listed in tabular form according to Courses Path and Thesis path. It is to be noted here that both paths are further classified as Pure and Applied sections.

Courses Path (Pure Mathematics)

Level	Course Code	Course Title	Required or Elective	Pre-Requisite Courses	Credit Hours
Level 1	08171641	Real Analysis I	Required	-----	3
	08171631	Abstract Algebra I	Required	-----	3
	Total				6
Level 2	08171642	Real Analysis II	Required	08171641	3
	08171601	Numerical Analysis I	Required		3
	Total				6
Level 3	08171643	Complex Analysis I	Required		3
	08171632	Abstract Algebra II	Required	08171631	3
	Total				6
Level 4	08171644	Complex Analysis II	Required	08171643	3
	08171660	Topology	Required	-----	3
	Total				6
Level 5		Elective Course 1	Elective	-----	4
		Elective Course 2	Elective	-----	4
	Total				8
Level 6		Elective Course 3			4
		Elective Course 4	Elective	-----	4
	08171600	Essay and Article			2
	Total				10
	Grand Total				42

Courses Path (Applied Mathematics)

Level	Course Code	Course Title	Required or Elective	Pre-Requisite Courses	Credit Hours
Level 1	08171641	Real Analysis I	Required	-----	3
	08171631	Abstract Algebra I	Required	-----	3
	Total				6
Level 2	08171601	Numerical Analysis I	Required	-----	3
	08171604	Ordinary Differential Equations I	Required	-----	3
	Total				6
Level 3	08171643	Complex Analysis I	Required		3
	08171606	Partial Differential Equations	Required		3
	Total				6
Level 4	08171608	Mathematical Methods	Required	-----	3
	08171602	Numerical Analysis II		08171601	3
	Total				6
Level 5		Elective Course 1	Elective	-----	4
		Elective Course 2	Elective	-----	4
	Total				8
Level 6		Elective Course 3			4
		Elective Course 4	Elective	-----	4
	08171600	Essay and Article			2
	Total				10
	Grand Total				42

Thesis Path (Pure Mathematics)

Level	Course Code	Course Title	Required or Elective	Pre-Requisite Courses	Credit Hours
Level 1	08171641	Real Analysis I	Required	-----	3
	08171631	Abstract Algebra I	Required	-----	3
	Total				6
Level 2	08171642	Real Analysis II	Required	08171641	3
	08171601	Numerical Analysis I	Required		3
	Total				6
Level 3	08171643	Complex Analysis I	Required		3
	08171632	Abstract Algebra II	Required	08171631	3
	Total				6
Level 4	08171644	Complex Analysis II	Required	08171643	3
	08171660	Topology	Required	-----	3
	Total				6
Level 5,6,7,8	08171700	Thesis	Required	-----	8
	Total				8
	Grand Total				32

Thesis Path (Applied Mathematics)

Level	Course Code	Course Title	Required or Elective	Pre-Requisite Courses	Credit Hours
Level 1	08171641	Real Analysis I	Required	-----	3
	08171631	Abstract Algebra I	Required	-----	3
	Total				6
Level 2	08171601	Numerical Analysis I	Required	-----	3
	08171604	Ordinary Differential Equations I	Required	-----	3
	Total				6
Level 3	08171643	Complex Analysis I	Required		3
	08171606	Partial Differential Equations	Required		3
	Total				6
Level 4	08171608	Mathematical Methods	Required	-----	3
	08171602	Numerical Analysis II	Required	08171601	3
	Total				6
Level 5,6,7,8	08171700	Thesis	Required	-----	8
	Total				8
	Grand Total				32

Table1: Elective courses		
Course Code	Course Title	Credit Hours
08171611	Calculus of Variations	4
08171612	Ordinary Differential Equations II	4
08171613	Theory of Partial Differential Equations I	4
08171614	Theory of Partial Differential Equations II	4
08171615	Boundary Value Problems	4
08171616	Approximation Theory	4
08171617	Numerical Methods of Ordinary Differential Equations	4
08171618	Numerical Methods of Partial Differential Equations	4
08171621	Mathematical Logics I	4
08171622	Mathematical Logics II	4
08171623	Set Theory	4
08171624	Model Theory	4
08171625	Proof Theory	4
08171626	Theory of computation	4
08171633	Commutative Algebra	4
08171634	Arithmetic Algebra	4
08171635	Rings and Modules	4
08171636	Fields and Galois theory	4
08171637	Groups Theory	4
08171645	Introduction to Harmonic Analysis	4
08171646	Functional Analysis I	4
08171647	Functional Analysis II	4
08171648	Theory of Operators	4
08171649	Banach Algebra	4
08171651	Numerical Methods of Linear Algebra	4

08171653	Special Functions in Applied Mathematics	4
08171654	Integration Transforms and Operation Methods	4
08171655	Applied Functional Analysis I	4
08171656	Applied Functional Analysis II	4
08171657	Theory of Distributions	4
08171661	Algebraic Topology I	4
08171662	Algebraic Topology II	4
08171671	Differential Geometry I	4
08171672	Differential Geometry II	4
08171673	Algebraic Geometry	4

Table 2 – Special Topics in Mathematics

Course number	Course title	Lecture	tutorial	Lab	Prerequisites
08171695	Special Topics in Mathematics	4			

Thesis and Its Requirements

1. Registration of the thesis: (Requirements/conditions and procedures for registration of the thesis as well as controls, responsibilities and procedures of scientific guidance)

1- The admission requirements are established in accordance with the criteria set by the college council, the Unified Regulations for Postgraduate Studies in the Kingdom of Saudi Arabian, and the admission requirements of King Faisal University.

2 To be eligible for admission, the applicant must successfully pass twelve credit hours of required courses (4 courses) with a GPA with a minimum average 3.75 out of 5.

2. Scientific Supervision: (The regulations of the selection of the scientific supervisor and his/her responsibilities, as well as the procedures/ mechanisms of the scientific supervision and follow-up)

- The department assigns supervisors for the thesis.
- The student should prepare a thesis under supervision. This work requires the following main steps:
  - ✓ Choose the subject of the project.
  - ✓ Prepare a literature survey about the (project) topic.
  - ✓ Recognize the importance of library and internet in expansion of our knowledge.
  - ✓ Develop a research plan.
  - ✓ Investigate the area of interest.
  - ✓ Apply appropriate software and web resources.
  - ✓ Write up the thesis and defend it.

3.Thesis Defense/Examination:(The regulations for selection of the defense/examination committee and the requirements to proceed for thesis defense, the procedures for defense and approval of the thesis, and criteria for evaluation of the thesis)

The thesis should be characterized by originality and reviewed by internal and external reviewers.

Course short description

Required Courses:

Course Name	Real Analysis 1				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1641**	**1st**	**3**	None
Course Track	☐ University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives				

Course Description:
This course deals with the measure theory in the Lebesgue sense ,Convergence theorems, Lebesgue spaces, Ascoli-Arzela theorem,. and Linear operators.

Course Objectives:
This course provides a clear understanding of the main concepts related to the Lebesgue measure theory and operators.

Courses Learning Outcomes:

1. State the basic definitions, concepts and some fundamental results in measure theory and real analysis such as measurability , integrability, absolutely continuous functions, function of bounded variation and linear operators.
2. Examine the measurability and integrability of function
3. Apply convergence theorems and Ascoli Ascoli-Arzela theorem
4. Distinguish the L^p -spaces and its properties.
5. Apply the closed graph and open mapping theorems, the uniform boundedness principle
6. Analyze the hypotheses of a given problem and apply the suitable results encounter it through a homework
7. Presentation a project on a subject related to the contents of the course.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• H. L. Royden. Real Analysis. Macmillan publishing company ,New-York1968 (Text book). • D.L.Cohn. Measure Theory. Birkhauser, Berlin.Basel.Stuttgart.1980.					
References	• P. R. Halmos. Measure Theory. D. Van Nostrand Co.Inc.Princeton.N.J.1950. • W. Rudin . Real and Complex Analysis. McGraw-Hill.1979. • R.L. Weeden and A. Zygmond .Measure and Integrals: An Introduction to Real Analysis. Marcel Dekker.Inc.1977					
Electronic Materials	http://www.math.math.com/					
Other Learning Materials						

Course Name	Abstract Algebra 1				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1631**	**1st**	**3**	None
Course Track	☐ University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives				

Course Description:

This course provides the basic knowledge of groups, group homomorphism, finitely generated abelian groups, group action, Sylow's theorems, normal series and solvable groups. Rings, ideals, ring homomorphism, rings of quotients, rings of polynomials, Principal ideal domains.

Course Objectives.

The aim of this course is to give a clear understanding of the main results about groups, finite abelian groups, the applications of Sylow's theorems and rings.

Courses Learning Outcomes:

1. State the basic definitions, concepts and some fundamental results in group theory.
2. Apply the orbit equation and Sylow's Theorems in some problems.
3. Recognize simple groups of given order
4. State the basic definitions, concepts and some fundamental results in ring theory.
5. Analyze the hypotheses of a given problem and apply the suitable results and the properties of rings and ring isomorphism to encounter it.
6. Form examples of groups.
7. Compare group structures.
8. Recognize simple groups and finite abelian groups.
9. Calculate the invariant factors and elementary divisors of a finite abelian group.
10. Examine the irreducibility of elements in an integral domain.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• I. N. Herstein, Topics in Algebra; John Wiley and sons, New York, 1977.					
References	• D. Saracino, Abstract Algebra: A first course, Waveland Press, 2008. • P.B. Bhattacharya, S.K. Jain, S.R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, 1994. • Jonathan. D. H. Smith, Introduction to Abstract Algebra, CRC Press, Taylor and Francis Group, 2008.					
Electronic Materials						
Other Learning Materials						

Course Name	Real Analysis 2				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1642**	**2nd**	**3**	08171641
Course Track	☐ University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives				

Course Description:

Abstract measure space, measurable function, Borel functions, The integral of a real function with respect to a measure and the convergence theorems, Signed measure and Radon Nikodym 's theorem, Outer measure, Jordan decomposition . Lebesauge stieltijes integral, Product measure, Tonnili and Fubbini theorems, Linear functional, Borel measure and the conjugate of the space of real continuous functions. The Daniel integral

Course Objectives.

At the end of the course, students are expected to have a clear understanding the properties of measure spaces and integrable functions. Moreover Understanding how we can generate a measure and product measures.

Courses Learning Outcomes:

1. State the basic definitions, concepts, and some fundamental results on measure theory
2. Apply the theoretical methods to create a measure
3. Examine the measurability and integrability of function with respect to any measure.
4. Distinguish the signed measure and its properties.
5. Apply Jordan decomposition.
6. Conduct a measure from an outer measure
7. To recognize the product measure and apply Tonelli and Fubini theorems
8. Analyze the hypotheses of a given problem and apply the suitable results encounter it
9. Act in a group to solve diverse problem related to the contents of the course.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• H. L. Royden. Real Analysis. Macmillan publishing company ,New-York1968 (Text book). • D.L.Cohn. Measure Theory. Birkhauser, Berlin.Basel.Stuttgart.1980.					
References	• P. R. Halmos. Measure Theory. D. Van Nostrand Co.Inc.Princeton.N.J.1950. • W. Rudin . Real and Complex Analysis. McGraw-Hill.1979. • R.L. Weeden and A. Zygmond .Measure and Integrals: An Introduction to Real Analysis. Marcel Dekker.Inc.1977					
Electronic Materials	http://www.math.math.com/					
Other Learning Materials						

Course Name	Abstract Algebra 2				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0 817	**1632**	**3rd**	**3**	08171631
Course Track	☐ University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives				

Course Description:

To have knowledge in commutative rings with chain conditions such as Noetherian, Artinian rings, principal ideals domains, primary ideals and primary decomposition, simple and primitive rings, field extensions, degree, simple extensions, algebraic, transcendental and finite extensions, splitting fields, normal extensions and separable extensions, the primitive element theorem, Galois group of a field extension and of a polynomial, the Fundamental Theorem of Galois Theory and its Applications, solvability by radicals, insolvability of the quintic

Course Objectives.

The aim of this course is to give a clear understanding of the main results about Commutative rings with chain conditions such as Noetherian, Artinian rings, Principal ideals domains. Primary ideals and Primary decomposition. Simple and primitive rings, algebraic extensions Splitting fields of polynomials, Normal and separable extensions, and the Galois group.

Courses Learning Outcomes:

1. State the basic definitions, concepts and some fundamental results in ring theory and field theory.
2. Describe some classes of commutative rings with chain conditions.
3. Classify finite field extensions and determine the degree of an extension and the minimal polynomial.
4. Construct Splitting fields of polynomials over a field.
5. Apply the Primitive element theorem and the fundamental theorem of Galois Theory.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• Steven Roman, Field Theory, Second Edition, Graduate Texts in Mathematics, Springer, 1995.					
References	• Iain T. Adamson, Introduction to field theory, Second edition, Cambridge University Press, 1982. • M. M. Postnikov, Foundations of Galois Theory, Dover Publication, INC, Mineola, New York, 2004. • Morandi, Patrick, Field and Galois Theory, Graduate texts in Mathematics, Springer, 1996. • Stewart, Galois Theory – (Chapman and Hall 2003); Library reference 512.4 STE.					
Electronic Materials						
Other Learning Materials						

<table>
<tr><td>Course Name</td><td colspan="5">Complex Analysis 1</td></tr>
<tr><td rowspan="2">Course Information</td><td>Course Code</td><td>Course No.</td><td>Course Level</td><td>Credit Hour</td><td>Prerequisite(s)</td></tr>
<tr><td>Math0 817</td><td>1643</td><td>3rd</td><td>3</td><td>None</td></tr>
<tr><td>Course Track</td><td colspan="5">☐University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives</td></tr>
<tr><td colspan="6">Course Description:
To grasp the basic knowledge of complex numbers and functions, analytic and harmonic functions, power series representation of analytic and meromorphic functions, Cauchy's theorem, applications of Cauchy's Integral Formula, zeros of Analytic function, Maximum Modulus Principal, conformal maps, Residue Calculus and its applications, Rouche's theorem.</td></tr>
<tr><td colspan="6">Course Objectives.
At the end of the course, students are expected to have a clear understanding of analytic and meromorphic functions, conformal maps and the applications of Residue Calculus</td></tr>
<tr><td colspan="6">Courses Learning Outcomes:
1. State the basic definitions, concepts, and some fundamental results.
2. Describe the geometric and algebraic representations of complex objects.
3. Test the analyticity and harmonicity of functions
4. Evaluate complex and improper integrals with a variety of methods.
5. Construct a solution of a given problem using appropriate mathematical argument.
6. Test the analyticity and harmonicity of functions.
7. Act in a group to solve diverse problem related to Complex analysis</td></tr>
<tr><td rowspan="2">Assessment Policy</td><td>Assignments, Quizzes, Presentations Project/ Report</td><td colspan="3">20%</td><td>Lab</td><td>NA</td></tr>
<tr><td>Midterm</td><td>30%</td><td>Final</td><td>50%</td><td>Others</td><td>NA</td></tr>
<tr><td>Textbook</td><td colspan="5">• J. B. Conway. Functions of One Complex Variable. Springer. 2002.</td></tr>
<tr><td>References</td><td colspan="5">• Serge Lang, Complex Analysis, 4th edition, Springer Science., 2003.</td></tr>
<tr><td>Electronic Materials</td><td colspan="5"></td></tr>
<tr><td>Other Learning Materials</td><td colspan="5"></td></tr>
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<table>
<tr><td>Course Name</td><td colspan="5">Topology</td></tr>
<tr><td rowspan="2">Course Information</td><td>Course Code</td><td>Course No.</td><td>Course Level</td><td>Credit Hour</td><td>Prerequisite(s)</td></tr>
<tr><td>Math0817</td><td>1660</td><td>4th</td><td>3</td><td>----</td></tr>
<tr><td>Course Track</td><td colspan="5">☐University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives</td></tr>
<tr><td colspan="6">Course Description:
Topological spaces. Continuous functions, open and closed mappings. Product and quotient spaces. Convergence of sequences nets and filters. The separation axioms, regularity and complete regularity, normal spaces. Countability properties. Compactness and local compactness. Connectedness, local connectedness, path wise connectedness, continua. Metrizable spaces. Complete metric spaces and the Baire theorem</td></tr>
<tr><td colspan="6">Course Objectives.
To know the basic concepts of ordinary differential equation and to study the stability of linear and quasi-linear equations.</td></tr>
<tr><td colspan="6">Courses Learning Outcomes:
1. To recognize and state some of the basic definitions of concepts concerning topological spaces such as compactness, connectedness, completeness and Countability properties
2. To examine the Convergence of sequences, nets and filters
3. To recognize the product and quotient spaces
4. To recognize compact space, local compactness, metrizable spaces and Complete metric spaces
5. To examine Connectedness, local connectedness, pathwise connectedness
6. to use the Baire theorem
7. Act in a group to solve diverse problem related to Topology</td></tr>
<tr><td rowspan="2">Assessment Policy</td><td colspan="2">Assignments, Quizzes, Presentations Project/ Report</td><td colspan="2">20%</td><td>Lab</td><td>NA</td></tr>
<tr><td>Midterm</td><td>30%</td><td>Final</td><td>50%</td><td>Others</td><td>NA</td></tr>
<tr><td>Textbook</td><td colspan="5">• J. L. Kelley: “General Topology”
• Stephen Willard: “ General Topology”</td></tr>
<tr><td>References</td><td colspan="5">• John G. Hocking and Gail S. Young:”Topology”</td></tr>
<tr><td>Electronic Materials</td><td colspan="5"></td></tr>
<tr><td>Other Learning Materials</td><td colspan="5"></td></tr>
</table>

Course Name	Complex Analysis 2				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1644**	**4th**	**3**	0817-1643
Course Track	☐ University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives				

Course Description:

To grasp the basic knowledge of The Riemann mapping theorem, infinite product, Harmonic functions, subharmonic functions, Dirichlet problem and Shotcky's and Picard's thoerems.

Course Objectives.

At the end of the course, students are expected to demonstrate theoretical knowledge and to have practical skills in advanced complex analysis.

Courses Learning Outcomes:

1. State the basic definitions and fundamental results related to the main concepts of complex analysis
2. Apply the method of infinite products and the Weierstrass factorization.
3. Test the Harmonicity and subharmonicity of functions.
4. Recognize applications of relevant results such as: theorems of Mittag-Leffler, Shotcky, Picard and Riemann.
5. Construct a solution of a given problem using appropriate mathematical argument.
6. Act in a group to solve diverse problem related to Complex analysis

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA

Textbook	• John B. Conway: "Functions of One Complex Variable" first volume • Lars V. Ahlfors:" Complex Analysis
References	• E. Hille: "Analytic Function Theory"(2 vols) • C. Caratheodory: "Theory of a Function of a Complex Variable" (2vols
Electronic Materials	
Other Learning Materials	

Course Name	Numerical Analysis 1				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1601**	**2nd**	**3**	None
Course Track	☐ University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives				

Course Description:

This deals with basic understanding of numerical methods and skills to implement algorithms to approximate problems of root-finding of nonlinear equations, approximation of functions, interpolation, numerical differentiation and numerical integration.

Course Objectives.

This course aims to give a clear understanding of the main concepts related to error analysis, numerical methods for root-finding of nonlinear equations, approximation of functions, interpolation, numerical differentiation and numerical integration

Courses Learning Outcomes:

1. State the basic definitions, concepts, and some fundamental results in numerical analysis
2. Calculate numerical solutions of nonlinear equations with appropriate numerical methods
3. Write polynomial interpolation for functions
4. Estimate approximations of derivatives and integrals of functions with numerical algorithms and methods.
5. Calculate approximations for functions and data with several numerical methods
6. Use a numerical method in physical applications
7. Implement numerical algorithms in a modern scientific computing programming language.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	-Kendall.E.Atkinson,An Introduction to Numerical Analysis " John Wiley(1989) -Burden R.L., Faires J.D. Numerical analysis (9ed., Brooks Cole, 2010)					
References	-P.Henrici,"Elements of Numerical Analysis" .John Wiley&Sons Inc (1966). -A Raloston, "A First Course in Numerical Analysis". Mc Grow-Hill Book					
Electronic Materials	http://ocw.mit.edu/courses/mathematics/18-330-introduction-to-numerical-analysis-spring-2004/ http://ocw.mit.edu/courses/mechanical-engineering/2-993j-introduction-to-numerical-analysis-for-engineering-13-002j-spring-2005/					
Other Learning Materials	MATLAB Software					

<table>
<tr><td>Course Name</td><td colspan="5">Numerical Analysis 2</td></tr>
<tr><td rowspan="2">Course Information</td><td>Course Code</td><td>Course No.</td><td>Course Level</td><td>Credit Hour</td><td>Prerequisite(s)</td></tr>
<tr><td>Math0817</td><td>1602</td><td>4th</td><td>3</td><td>08171601</td></tr>
<tr><td>Course Track</td><td colspan="5">☐University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives</td></tr>
<tr><td colspan="6">Course Description:
This course deals with numerical methods for solving initial value problems and boundary value problems for ordinary differential equations, direct methods for solving linear systems, iterative methods for solving linear systems and numerical methods for approximating eigen values.</td></tr>
<tr><td colspan="6">Course Objectives.
At the end of the course, students are expected to understand the main concepts of solving initial value problems and boundary value problems for ordinary differential equations and the main concepts for numerical linear algebra.</td></tr>
<tr><td colspan="6">Courses Learning Outcomes:
1. State the basic concepts of numerical linear algebra and numerical methods for Initial Value problems and Boundary value problems.
2. Apply a numerical method in other fields.
3. Calculate approximations solutions of Initial Value Problems and Boundary Value Problems using appropriate numerical method.
4. Solve linear systems with direct methods and iterative methods.
5. Estimate approximate eigenvalues and eigenvectors for appropriate methods.
6. Implement numerical algorithms in a modern scientific computing programming language</td></tr>
<tr><td rowspan="2">Assessment Policy</td><td colspan="2">Assignments, Quizzes, Presentations Project/ Report</td><td colspan="2">20%</td><td>Lab</td><td>NA</td></tr>
<tr><td>Midterm</td><td>30%</td><td>Final</td><td>50%</td><td>Others</td><td>NA</td></tr>
<tr><td>Textbook</td><td colspan="5">-Kendall.E.Atkinson,An Introduction to Numerical Analysis ” John Wiley(1989)
-Burden R.L., Faires J.D. Numerical analysis (9ed., Brooks Cole, 2010)</td></tr>
<tr><td>References</td><td colspan="5">-P.Henrici,“Elements of Numerical Analysis” .John Wiley&Sons Inc (1966).
-A Raloston, “A First Course in Numerical Analysis”. Mc Grow-Hill Book</td></tr>
<tr><td>Electronic Materials</td><td colspan="5">http://ocw.mit.edu/courses/mathematics/18-330-introduction-to-numerical-analysis-spring-2004/
http://ocw.mit.edu/courses/mechanical-engineering/2-993j-introduction-to-numerical-analysis-for-engineering-13-002j-spring-2005/</td></tr>
<tr><td>Other Learning Materials</td><td colspan="5">MATLAB Software</td></tr>
</table>

Course Name	Ordinary Differential Equations I				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1604**	**2nd**	**3**	-----
Course Track	☐ University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives				

Course Description:

The course covers core topics for ordinary differential equations such that the existence and the unicity of solutions, properties of linear systems of differential equations with constants and periodic coefficients, and the Lyapunov stability direct method.

Course Objectives. To know the basic concepts of ordinary differential equation and to study the stability of linear and quasi-linear equations.

Courses Learning Outcomes:

7. State and recognize the main theorems related to theory of differential equations.
8. Examine the existence and uniqueness of solutions to some ODE
9. Study the properties of solutions of some linear systems of differential equations.
10. Classify the singularities of a linear systems with variable coefficients to apply the Frobenius method.
11. Apply the Poincare-Bendixson theory
12. Investigate the stability of solutions by the Lyapunov direct method.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• E. A. Coddington and N. Levinson:" Theory of Ordinary Differential Equations" Krieger Pub Co 1984. • K. Yosida: "Lectures on Differential and Integral Equations", Interscience publisher 1991. • Guckenheimer and P. Holmes:" Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields" Springer 2002. • P. Hartman: "Ordinary Differential Equations" Society for industrial and applied mathematics 2002					
References						
Electronic Materials						
Other Learning Materials						

Course Name	Partial Differential equations				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1606**	**3rd**	**3**	
Course Track	☐ University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives				

Course Description:

This course covers core for partial differential equations such as calculate the integral curves and surfaces of a vector field, solve quasi-linear and linear equations of the first order using suitable different method and apply to the Equations of Mathematical physics.

Course Objectives.

This course provides a clear understanding of the main concepts related to partial differential equations and to solve certain equations of mathematical physics

Courses Learning Outcomes:

1. State and recognize the main theorems related partial differential equation
2. Apply to the Equations of Mathematical physics.
3. Calculate the integral curves and surfaces of a vector field.
4. Solve quasi-linear and linear equations of the first order using suitable different method.
5. Apply to the Equations of Mathematical physics.
6. Solve given problems through a homework

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	1. I. G. Petrovsky. Lectures on Partial Differential Equations, Dover Publications, 1992. 2. E. Zauderer. Partial Differential Equations of Applied Mathematics, Wiley-Interscience; 3rd 2006. 3. R. Courant, D. Hilbert. Methods of Mathematical Physics, vol. 2, Wiley-VCH, 1989. 4. Lawrence C. Evans. Partial Differential Equations, American Mathematical Society; 2nd edition, 2010.					
References						
Electronic Materials						
Other Learning Materials						

Course Name	Mathematical Methods				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1608**	**4th**	**3**	None
Course Track	☐ University Requirement ☐ College Requirement ☒ Specialized Core ☐ Electives				

Course Description:

This course deals with Laplace and Fourier transformations and its applications. Integral operators and Fredholm alternative, Green's functions. Sturm- Liouville expansion, Bessel and Legendre functions. Special Functions of Applied Mathematics.

Course Objectives.

This course provides a clear understanding of the main concepts related to the common mathematical methods such as: Laplace and Fourier transformations, Integral operators and Fredholm alternative…etc and their applications.

Courses Learning Outcomes:

1. To realize some concepts in mathematical methods such as Laplace and Fourier transformations. Green's functions, integral operators
2. To derive Sturm- Liouville expansion
3. To write research or a report about the relation between concepts of the course.
4. To apply some special Functions
5. To solve problems related to the concepts of the course
6. Presentation a project on a subject related to the contents of the course.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	-R. Courant and D. Hilbert: "Methods of Mathematical Physics"					
References	1- G. Arfken: "Mathematical Mathods for Physicists" 2- J. Mathews and R. L. Walker: "Mathematical Methods of Physics"					
Electronic Materials						
Other Learning Materials						

Elective Courses

<table>
<tr><td>Course Name</td><td colspan="5">The Calculus of Variation</td></tr>
<tr><td rowspan="2">Course Information</td><td>Course Code</td><td>Course No.</td><td>Course Level</td><td>Credit Hour</td><td>Prerequisite(s)</td></tr>
<tr><td>Math0817</td><td>1611</td><td>5th/6th</td><td>4</td><td>None</td></tr>
<tr><td>Course Track</td><td colspan="5">☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives</td></tr>
<tr><td colspan="6">Course Description:
Gateaux and Frechet differentials. Classical calculus of variations. Necessary conditions. Sufficient conditions for extremals. Jacobi and Legendre conditions. Natural boundary conditions. Broken extrema, Erdmann-Weierstrass condition. Multiple integral problems. Constrained extrema. Hamilton principle with application to mechanics and theory of small oscillations. Direct method, including the Galerkin and Ritz methods. Variational methods for eigenvalue problems.</td></tr>
<tr><td colspan="6">Course Objectives.
The aim in this course is to provide students with a good background in the calculus of variations and optimal control. It will make them learn how to derive from first principles many important results such as Euler-Lagrange equation, Pontryagin maximum principle and the Hamilton-Jacobi –Bellman equation to cite a few, and solve such problems in specific special cases. Our plan is to incorporate a computer program, such as Matlab/Python/Julia in order to go beyond these well selected academic problems</td></tr>
<tr><td colspan="6">Courses Learning Outcomes:
1. Show a good understanding on how to formulate a variational problem and an optimal control problem.
2. Model variational and optimal control problems
3. Derive the main results in the calculus of variations and optimal control.
4. Solve analytically and/or numerically variational and optimal control problems
5. Work professionally and ethically individually and in a team
6. Communicate mathematics orally and in written form.
7. Use mathematical reasoning and proof techniques to formulate, analyze and solve analytically and/or numerically variational and optimal control problems and communicate the results orally and in written form professionally
8. Show good knowledge of software tools available to solve real life variational and optimal control problems</td></tr>
<tr><td rowspan="2">Assessment Policy</td><td colspan="2">Assignments, Quizzes, Presentations Project/ Report</td><td colspan="2">20%</td><td>Lab</td><td>NA</td></tr>
<tr><td>Midterm</td><td>30%</td><td>Final</td><td>50%</td><td>Others</td><td>NA</td></tr>
<tr><td>Textbook</td><td colspan="5">I. M. Gelfand and S. V. Fomin, Calculus of VariationsPrentice-Hall, Inc., 1963; Dover Publications, Inc., 2000.</td></tr>
<tr><td>References</td><td colspan="5">• J. L. Troutman, Variational Calculus and Optimal Control, (2nd edition), , Springer 1996 2)
• Weinstock, Calculus of Variations: With Applications to Physics and Engineering. Dover Publications, Inc., 1974 3)
• George M. Ewing.Calculus of Variations with Applications. Dover Publications,New York, NY, 1985 4)
• Daniel Liberzon,Calculus of Variations and Optimal Control Theory: AConcise Introduction, Princeton, 2012</td></tr>
<tr><td>Electronic Materials</td><td colspan="5"></td></tr>
<tr><td>Other Learning Materials</td><td colspan="5"></td></tr>
</table>

Course Name	Ordinary Differential Equations II				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1612**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:

This course deals with the Self-adjoint and non Self-adjoint boundary-value problems, behavior of the solution and related theorems like as Sturm-Liouville theory. Oscillation and comparison theorems

Course Objectives.

This course provides a clear understanding of the main concepts related to the Self-adjoint and non Self-adjoint boundary-value problems

Courses Learning Outcomes:

1. State the basic definitions and fundamental results related to the boundary value problems
2. Apply Sturm-Liouville theory in studying the asymptomatic properties of eigenvalues and eigenfunctions.
3. Use Sturm-Liouville theory in studying the hypergeometric and similar special functions
4. Apply Oscillation and comparison theorems in finding number of eigenvalues
5. Make a presentation on a topic in Mathematics.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• E. A. Coddington and N. Levinson: "Theory of Ordinary Differential Equations					
References	• K. Yosida: "Lectures on Differential and Integral Equations" Dover Publications (April 1, 1991) • Guckenheimer and P. Holmes:"Nonlinear Oscilation, Dynamical Systems, and Bifurcations of Vector Fields Springer-Verlag New York"					
Electronic Materials						
Other Learning Materials						

Course Name	Theory Of Partial Differential Equations I				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1613**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:

This course is mainly concerned with the following topics: Distributions, Fourier transforms, Green's functions. Sobolev spaces, the Embedding theorem, compactness properties, the Trace theorem, duality. Operator theory, the spectral theory of a compact operator, Sturm-Liouville boundary value problems

Course Objectives.

At the end of the course, students are expected to apply distributions like Fourier Transform to solve IVPs, and to understand Greens functions. Moreover, to use the Embedding and Trace theorems as well as use properties of Sobolev spaces to solve some boundary value problems including Sturm-Liouville BVP.

Courses Learning Outcomes:

1. To state the basic definitions, concepts and some fundamental results in partial differential equations theory related to initial and boundary value problems
2. To discuss Distributions like Fourier transforms, and to admit Green's functions.
3. To discuss Sobolev spaces and to apply Embedding theorem, and understand compactness properties.
4. To use the Trace theorem, and admit duality and operator theory.
5. To adopt the spectral theory of a compact operator
6. To treat the Sturm-Liouville boundary value problems
7. Analyze the hypotheses of a given problem and apply the suitable results encounter it through a homework

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• I. G. Petrovsky. Lectures on Partial Differential Equations, Dover Publications, 1992. • E. Zauderer. Partial Differential Equations of Applied Mathematics, Wiley-Interscience; 3rd 2006. • R. Courant, D. Hilbert. Methods of Mathematical Physics, vol. 2, Wiley-VCH, 1989. 4. Lawrence C. Evans. Partial Differential Equations, American Mathematical Society; 2nd edition, 2010					
References	• K. Yosida: "Lectures on Differential and Integral Equations" Dover Publications (April 1, 1991) • Guckenheimer and P. Holmes:"Nonlinear Oscilation, Dynamical Systems, and Bifurcations of Vector Fields Springer-Verlag New York"					
Electronic Materials	http://www.math.math.com					
Other Learning Materials						

Course Name	Theory Of Partial Differential Equations II				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1614**	**5th/6th**	**4**	08171614
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:

This course is mainly concerned with the following topics:
- Dirichlet problem of linear elliptic equations: Existence and uniqueness of solutions, Lax-Milgram theorem, Garding's Inequality and existence of weak solutions.
- Eigenfunction expansions, Fredholm theory.
- General Linear elliptic problems: Neuman problem, Adjoint Boundary-value problem, Agmon's condition and coercive problems.
- Interior and boundary regularities: Difference quotients, second-order scalar equations and boundary regularity.

Applications on classical Partial differential equations

Course Objectives.

At the end of the course, students are expected to have a clear understanding of some methods that uses properties of Sobolev spaces to solve some boundary problems related to some partial differential equations. Moreover, students are expected to apply all what they have learnt in Math613 (Theory of Partial Differential Equations I). Furthermore, students should be aware of the modern and current directions and applications of initial value problems

Courses Learning Outcomes:

1. To state the basic definitions, concepts and some fundamental results in partial differential equations theory related to boundary value problems
2. To discuss the existence and uniqueness of solutions to Dirichlet problem of PDE.
3. To apply some fundamental theorems: Lax-Milgram lemma and Garding's Inequality in resolution of PDE.
4. To use Fredholm theory to determine Eigenfunctions.
5. To adopt some techniques to general linear elliptic equations
6. To treat the interior and boundary regularities of solutions of PDE.
7. Analyze the hypotheses of a given problem and apply the suitable results encounter it through a homework

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• F. Treves. Basic Linear Partial Differential Equations, Dover Publications , 2006. • M. Renardy, R. C. Rogers. An Introduction to Partial Differential Equations, Springer; 2nd edition, 2004. • V. P. Mikhailov. Partial Differential Equations, Central Books Ltd, 1979. • J. Rauch. Partial Differential Equations, Springer, 1991. • J. Jost. Partial Differential Equations, Springer, 2010.					
References						
Electronic Materials	http://www.math.math.com					

Other Learning Materials					
Course Name	Boundary Value Problems				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1615**	**5th/6th**	**4**	08171614
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:

This course deals with boundary value problems using methods such as Green's functions, the theory of distributions, linear integral equations, and the Neumann series. In addition, finding the solution of the inhomogeneous equation with symmetric Hilbert-Schmidt kernel, approximation methods, Nonsymmetric Hilbert-Schmidt operator, spectral theory of second order differential operator, the regular boundary value problem and the general singular problem

Course Objectives.

This course provides a clear understanding of the main methods related to the boundary value problems such as Green's functions, the theory of distributions, linear integral equations, and the Neumann series.

Courses Learning Outcomes:

1. State the basic definitions and fundamental results related to the main concepts of boundary value problems
2. Apply the Green's functions, the theory of distributions, linear integral equations, and the Neumann series of boundary value problems
3. Compute the solution of the inhomogeneous equation with symmetric Hilbert-Schmidt kernel
4. Apply the approximation methods and Nonsymmetric Hilbert-Schmidt operator
5. Use the spectral theory of second order differential operator, the regular boundary value problem and the general singular problem
6. Make a presentation on a topic in Mathematics.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• Stakgold:"Boundary Value Problems of Mathematical Physics"					
References	• M. A. Pinsky:"Partial Differential Equations and Boundary Value Problems with Applications" • A. Tikhonov and A. A. Samarski: "Equations of Mathematical Physics"					
Electronic Materials						
Other Learning Materials						

Course Name	Approximation Theory				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1616**	**5th/6th**	**4**	08171614
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:

This course is mainly concerned with uniform approximation, best approximation, least square approximation, interpolation piecewise-polynomial approximation and splines, and applications to the solutions of differential equations

Course Objectives.

This course provides understanding of fundamental methods and theoretical basis of approximation, to provide students with the technical tools enabling them to solve practical problems including interpolation piecewise-polynomial and differential equations.

Courses Learning Outcomes:

1. To state notions of best approximation in different norms and be able to find the best approximation.
2. To compute weak and classical solutions of elliptic boundary value problems
3. To apply piecewise polynomial approximation in two dimensions.
4. To estimate errors analysis.
5. To apply the approximation theory on the solutions of differential equations
6. Make a presentation on a topic in Mathematics.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• P. J. DAVIS. Interpolation And Approximation, General Publishing Company, Ltd., Canada, 1975. • N. K. Govil, H. N. Mhaskar, Ram N. Mohapatra, Zuhair Nashed and J. Szabados, Frontiers in Interpolation and Approximation , Taylor & Francis Group, LLC, 2007. • G. G. Lorentz. Approximation of Functions, AMS Cheilsea Publishing, 2nd Ed.,1986 . • M. J. D. Powell. Approximation Theory and Methods, Dover Publications, 1981.					
References	Mathematical program as Maple program					
Electronic Materials	http://www.math.math.com					
Other Learning Materials						

Course Name	Numerical Methods For Ordinary Differential Equations				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1617**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:

This course is mainly concerned with numerical methods for solving ordinary differential equations (ODEs). The course begins with a discussion of some numerical methods for solving initial value problems and boundary value problems. It covers topics such as stability and instability, linear systems and nonlinear differential equations. The course concludes with some projection methods

Course Objectives.

This course provides a clear understanding of various numerical methods and their applications to solve ordinary differential equations (ODEs).

Courses Learning Outcomes:

1. Recognize the basic definitions and fundamental results related to the numerical methods for ODEs
2. Apply several of the most important numerical methods for solving initial value problems
3. Discuss the stability and error estimates of ODEs
4. Apply numerical methods for solving boundary value problems
5. Compute numerical solutions for some ODEs using computer programs
6. Make a presentation on a topic in Mathematics.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• G. H. Golub and J. M. Ortega," Scientific Computing and Differential Equations: An Introduction to Numerical Methods", Academic Press, New York,1992, (text book).					
References	• J.C. Butcher, Numerical Methods for Ordinary Differential Equations , John Wiley & Sons, Ltd, 2003. • A. H. Stroud. Numerical Quadrature and Solution of Ordinary Differential Equations , Springer, 1974. • J. D. Lambert . Computational Methods in Ordinary Differential Equations, UK, Wiley, 1974. • G. Sewell. The Numerical Solution of Ordinary and Partial Differential Equations , 2nd Ed. John Wiley & Sons, Inc. , 2005.					
Electronic Materials	http://www.math.math.com					
Other Learning Materials						

Course Name	Numerical Methods for Partial Differential Equations				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1618**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:

This course is mainly concerned with numerical methods for partial differential equations . The course begins with a discussion of stability and convergence of numerical schemes. Then, initial and boundary value problems for partial differential equations is studied . The course concludes with various finite element and difference methods and their applications for solving partial differential equations of applied mathematics

Course Objectives.

This course provides a clear understanding of various numerical methods ,such as finite difference and finite element methods, and their applications to solve partial differential equations of applied mathematics.

Courses Learning Outcomes:

1. To recognize the basic definitions and concepts relating to numerical methods of partial differential equations.
2. To apply numerical solution methods, finite difference and finite element methods, for various partial differential equations with associated boundary/ initial conditions
3. To analyze finite difference methods for various partial differential equations.
4. To analyze finite element methods for various partial differential equations .
5. To compute numerical solution for various partial differential equations using computer programs.
6. Make a presentation on a topic in Mathematics.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• L. Lapidus, G. F. Pinder. Numerical Solution of Partial Differential Equations in Science and Engineering , Wiley-Interscience; 1st Ed, 1999					
References	• G. D. Smith. Numerical Solution of Partial Differential EquationsFinite Difference Methods , Oxford University Press, 1985 • S.S. Rao, The finite element methods In Engineering, 4th Ed. Elsevier Inc. , 2005 • L. A. Hageman and D. M. Young. Applied Iterative Methods , Dover Publications ,2004. • T. Meis, T Meis, U. Marcowitz. Numerical Solutions of Partial Differential Equations , Springer, 1981. • C. Grossmann H. Roos. Numerical Treatment of Partial Differential Equations , Springer-Verlag Berlin Heidelberg 2007					
Electronic Materials						

Other Learning Materials	

Course Name	Mathematical Logic I				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1621**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
This course is mainly concerned with the propositional logic, connectives and truth value, proofs, axiom systems, completeness. First order logic, quantifiers and interpretations, structures, first order theories, proof systems for first order logic, completeness and decidability, normal forms, categoricity, ultraproducts and nonstandard analysis. Axioms for arithmetic, primitive recursive and recursive functions, Goedel's incompleteness, recursive undesirability

Course Objectives.
At the end of the course, students are expected to have a clear understanding of the basic notions in Mathematical Logic.

Courses Learning Outcomes:

1. To recognize and state some of the basic definitions of concepts concerning Mathematical logic.
2. To express a logic sentence in terms of predicates, quantifiers, and logical connectives
3. To construct abstract mathematical proofs.
4. To use Goedel's First and Second incompleteness Theorem and related technical results.
5. To evaluate the development of 20th century Mathematical Logic in terms of its relation to the foundations of mathematics.
6. Act in a group to solve diverse problem related to the contents of the course.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• E. Mendelson, Introduction to Mathematical Logic, Fourth Edition, CRC Press, 1997 • J. D. Monk, Mathematical Logic, Springer Science & Business Media, 2012 • J. L. Bell and M. Machover, A Course in Mathematical Logic, Elsevier, 1977.					
References						
Electronic Materials						
Other Learning Materials						

Course Name	Mathematical Logic II				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1622**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
This course is mainly concerned with axiomatic set theory, an axiom system for set theory, ordinals, ordinal arithmetic, the axiom of choice , the axiom of regularity, alternative axiom systems for set theories. Recursion theories, models for computation, partial recursive functions, unsolvable problems, recursively enumerable sets, decision problems.

Course Objectives.
This course provides a clear understanding of the main concepts related to the basic notions in Mathematical Logic.

Courses Learning Outcomes:

1. To recognize and state some of the basic definitions of concepts concerning Mathematical logic.
2. To understand, Explain and interpret a general knowledge of sets.
3. To write and analyze axiomatic set theory.
4. To prove some theory of initial and arithmetic ordinals.
5. To Determine properties Computable, recursive functionals and functions, a stockiples of examples.
6. Act in a group to solve diverse problem related to the contents of the course
7. Presentation a project on a subject related to the contents of the course

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• E. Mendelson, Introduction to Mathematical Logic, Fourth Edition, CRC Press, 1997 • J. D. Monk, Mathematical Logic, Springer Science & Business Media, 2012 • J. L. Bell and M. Machover, A Course in Mathematical Logic, Elsevier, 1977.					
References						
Electronic Materials						
Other Learning Materials						

Course Name	Set Theory				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1623**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
This course starts by presenting the basic concept of set theory, the ZF axioms of set theory, group theory, the realization of calculation of ordinals and original numbers, cardinals, and absoluteness, reflection theorems, constructible sets and groups and the axiom of constructability and forcing.

Course Objectives.
At the end of the course, the students are expected to have a clear understanding of the fundamentals concept of set theory, group theory, the ZF axioms of set theory, the realization of calculation of ordinals and original numbers, cardinals, and absoluteness, reflection theorems, constructible sets and groups and the axiom of constructability and forcing.

Courses Learning Outcomes:

1. State the basic definitions, concepts and some fundamental results in set theory.
2. Recognize the notion of infinity and arithmetic of the cardinals and ordinals.
3. To understand the Axiom of Choice, Zorn's Lemma and well-ordering principle, the theories of reflection
4. State the Axiom of Choice, Zorn's Lemma and well-ordering principle
5. Interpret Constructible Sets and the axiom of constructability.
6. Analyze the hypotheses of a given problem
7. Apply the postulates of ZF of group theory
8. Work effectively and constructively in group or team situations, whether in a leadership role or as a member of a group.
9. Take responsibility for continuing learning, take initiative in identifying issues requiring attention and benefit from opportunities for personal and career development.
10. Express understanding or conclusion by writing an essay or a thesis
11. Collect information from a variety of sources in order to gain a coherent understanding of the subject area and produce a concise summary of the information
12. Communicate effectively, lucidly, accurately, relevantly, succinctly, and engagingly both orally and in writing.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• K. Devlin, "The Joy of sets: Foundation of Centemporary Set Theory", Undergraduate Text in Mathematics, Second edition, Springer-Verlag (1994).					
References	• T. Jech, "Set Theory", Springer Monograph in Mathematics, Springer-Verlag (2006). • K. Kunen, "Set Theory: An Introduction to Independence Proofs", Studies in Logic and the Foundation of Mathematics-North Holland (1983).					

Electronic Materials	
Other Learning Materials	

Course Name	Model Theory				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1624**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
This course deals with the relation between a formal language and its interpretations, or models.

Course Objectives.
This course provides a clear understanding of the main concepts related to shows how to apply logic to the study of structures in pure mathematics.

Courses Learning Outcomes:

1. State the basic notions and definitions of model theory and fundamental results related to the main concepts of model theory.
2. Recall and refine some definitions from the entries on classical logic and model theory for sentential logic, languages, theories and examples of theories.
3. Demonstrate models constructed from constants to analyze compactness-like properties of sets in partial metric spaces and obtain the equivalence of several forms of the compactness for partial metric spaces. Generalizations of omitting type's theorem and interpolation theorem.
4. Apply model-theoretic constructions such as elementary extensions, elementary chains and their applications, indiscernible and model completeness.
5. Demonstrate ultra products fundamental theorem and measurable cardinals.
6. Use saturated and special models for applications to field theory.
7. Make a presentation on a topic in Mathematics

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• Chang and Keisler: “Model Theory”					
References	• W. Hodges: “A Shorter Model Theory”					
Electronic Materials						
Other Learning Materials						

Course Name	Proof Theory				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1625**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
To grasp the basic understanding of proof theory and its relation to other parts of logic and computer science.

Course Objectives.
At the end of the course, students are expected to have a clear understanding of Proof theory for sentential and first order logic and its role in logic, the resolution systems for proof, the cut elimination theorem and the use of logic as a programming language.

Courses Learning Outcomes:

1. State the logical structure of proofs.
2. Perform set operations on finite and infinite collections of sets and be familiar with properties of set operations
3. Write solutions to problems and proofs of theorems that meet rigorous standards based on content, organization and coherence, argument and support, and style and mechanics.
4. Determine equivalence relations on sets and equivalence classes.
5. To understand the nature of a formal system
6. Create intuition-forming examples or counterexamples, and prove conjectures.
7. Analyze resolution and its use in proofs.
8. Interpret the theoretical underpinning of logic programming
9. Make a presentation on a topic in Mathematics

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• Jean H. Gallier, Logic for computer science: Foundation of automatic theorem proving, Courier Dover Publications, 2015. • Zbigniew Stachniak, resolution proof systems: An algebraic theory, Springer Science & Business Media, 2012. • A. S. Troelstra, and H. Shwichtenberg: 'Basic proof theory, Cambridge University Press, 2000.					
References	•					
Electronic Materials						

Other Learning Materials	

Course Name	Theory of computation				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1626**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
This course deals with various models of computation such as Turing machines, recursive functions, Markov algorithm, Lambda calculus. It concerned also with undecidable problems, strong reducibility and weak reducibility.

Course Objectives.
This course provides a clear understanding of the main concepts related to the concepts of computation, and solvability of problems

Courses Learning Outcomes:

1. State the logical structure of proofs.
2. Perform set operations on finite and infinite collections of sets and be familiar with properties of set operations
3. Write solutions to problems and proofs of theorems that meet rigorous standards based on content, organization and coherence, argument and support, and style and mechanics.
4. Determine equivalence relations on sets and equivalence classes.
5. To understand the nature of a formal system
6. Create intuition-forming examples or counterexamples, and prove conjectures.
7. Analyze resolution and its use in proofs.
8. Interpret the theoretical underpinning of logic programming
9. Make a presentation on a topic in Mathematics

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• Jean H. Gallier, Logic for computer science: Foundation of automatic theorem proving, Courier Dover Publications, 2015. • Zbigniew Stachniak, resolution proof systems: An algebraic theory, Springer Science & Business Media, 2012. • A. S. Troelstra, and H. Shwichtenberg: 'Basic proof theory, Cambridge University Press, 2000.					
References	•					
Electronic Materials						
Other Learning Materials						

Course Name	Commutative Algebra				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1633**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:

This course deals with the commutative rings and modules, prime ideals, localization, noetherian rings, primary decomposition, integral extensions and Noetherian normaliztion, the Nullstellensatz, dimension , flatness , Hensel's lemma, graded rings, Hilbert polynomials, valuations, regular rings, singularities, unique factorization , homological dimension , depth ,completion.

Course Objectives:

This course provides a clear understanding of the main concepts related to commutative rings and modules.

Courses Learning Outcomes:

1. State the basic definitions and fundamental results related to the commutative rings and modules, prime ideals, and localization
2. State the basic definitions and fundamental results related to the dimension , flatness , Hensel's lemma, graded rings, Hilbert polynomials
3. Classify the primary decomposition.
4. Apply the some basic theorem valuations, regular rings, singularities, unique factorization , homological dimension , depth ,completion
5. Apply some basic theorem in integral extensions and Noetherian normalization
6. Make a presentation on a topic in Mathematics.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• M. P. Atiyah. and I. G. MacDonald:"Introduction to Commutative Algebra"					
References	• I. Kaplansky: "Commutative Rings" • O. Zariski and P. Samuel: "Commutative Algebra" (2 vols)					
Electronic Materials						
Other Learning Materials						

<table>
<tr><td>Course Name</td><td colspan="5">Arithmetic algebra</td></tr>
<tr><td rowspan="2">Course Information</td><td>Course Code</td><td>Course No.</td><td>Course Level</td><td>Credit Hour</td><td>Prerequisite(s)</td></tr>
<tr><td>Math0817</td><td>1634</td><td>5th/6th</td><td>4</td><td>None</td></tr>
<tr><td>Course Track</td><td colspan="5">☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives</td></tr>
<tr><td colspan="6">Course Description:
The course is mainly concerned with: the Properties of affine and projective varieties on algebraically closed field, compatibility (harmonic) of Ideals and localization, measurable map, measurable Paired geometry, Division on curves and surfaces, Introduction to schemes, The Riemann-Roch theorem for projective curves.</td></tr>
<tr><td colspan="6">Course Objectives:
At the end of the course, students are expected to have a clear understanding of varieties on algebraically closed field, and algebraic geometry.</td></tr>
<tr><td colspan="6">Courses Learning Outcomes:
1. State the basic definitions and fundamental results related to compatibility (harmonic) of Ideals and localization..
2. Classify measurable map, and measurable Paired geometry.
3. Apply the properties of affine and projective varieties on algebraically closed field.
4. Apply Riemann-Roch theorem for projective curves.
5. Make a presentation on a topic in Mathematics.</td></tr>
<tr><td rowspan="2">Assessment Policy</td><td>Assignments, Quizzes, Presentations Project/ Report</td><td colspan="2">20%</td><td>Lab</td><td>NA</td></tr>
<tr><td>Midterm</td><td>30%</td><td>Final</td><td>50%</td><td>Others</td><td>NA</td></tr>
<tr><td>Textbook</td><td colspan="5">• R. Mines, F. Richman, W. Ruitenburg: “ A Course in Constructive Algebra”</td></tr>
<tr><td>References</td><td colspan="5">• W. V. Vasconcelos:” Computational Methods in Commutative Algebra and Algebraic Geometry”
• D. Cox, J. Little, and D. O’Shea” Ideals Varieties and Algorithms”</td></tr>
<tr><td>Electronic Materials</td><td colspan="5"></td></tr>
<tr><td>Other Learning Materials</td><td colspan="5"></td></tr>
</table>

Course Name	Rings and Modules				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1635**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
This course deals with Artinian and Noetherian modules. Schreier theorem and the JordanHolder theorem. The Krull-Schmidt theorem. Completely reducible modules. Invariance of dimension. Tensor products, and the Hom functor. Projective modules, Injective modules and the injective hull. Primitivity and semiprimitivity. The radicals of a ring. Density theorems. Artinian rings. The Wedderburn-Artin theorem. Special rings.

Course Objectives:
At the end of the course, students are expected to understand Artinian and Noetherian modules, Projective modules, Injective modules and the injective hull, and the main theorem that are related to Modules

Courses Learning Outcomes:

1. State the basic definitions, concepts and some fundamental results in Module theory.
2. Understand the definition of Artinian rings and their basic property
3. Become familiar with the tensor product and the Hom functor and use their properties in proofs of properties of injective and projective modules
4. Understand the Weederburn-Artin theorem for simple rings
5. Understand the concept of radical of a ring and appreciate its importance
6. Become familiar with the structure theory of algebras and apply it to the study of Clifford algebras
7. Analyze the hypotheses of a given problem and apply the suitable results encounter it through a homework

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• F. W. Anderson, and K. R. Fuller: Rings and categories of Module, Springer-Verlag, 1973. • T. W. Hungerford: Algebra, Springer-Verlag, 1974					
References	• K. R. Goodearl: Ring Theory, non-singular rings and modules, Marcel Dekker inc., 1976 • R. Wisbauer: Foundation of modules, and Ring theory, Gordon and Breach London, 1991 • J. Lambek: “Lectures on Rings and Modules”					

	• M. Gray.: "A Radical Approach to Algebra" • N. J. Divinsky:" Rings and Radicals" • I. N. Herstein.:" Noncommutative Rings"
Electronic Materials	
Other Learning Materials	

Course Name	Fields and Galois Theory				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1636**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
It is mainly concerned with discussing Fields, Fields extensions, transcendental extensions and transcendental basis. Algebraic extensions, separable and radical extensions, normal and Galois extension. Classical Galois theory, the Galois correspondence, norm and trace, cyclotomic extensions, solvable extensions, the theory of equations. Introduction to algebraic functions

Course Objectives:
At the end of the course, students are expected to have a clear understanding of normal and Galois extension, cyclotomic extensions and solvable extensions.

Courses Learning Outcomes:

1. State the basic definitions, concepts and some fundamental results in Fields and Fields extensions.
2. Interpret transcendental extensions and transcendental basis. Algebraic extensions, separable and radical extensions,
3. Discuss concepts of normal and Galois extension
4. Apply Classical Galois theory, the Galois correspondence, norm and trace,
5. Judge concepts of cyclotomic extensions, solvable extensions, the theory of equations. Introduction to algebraic functions
6. Solve given problems through a homework

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• H. M. Edwards: " Galois Theory" • I. Steward: "Galois Theory"					
References	• D. Winter: " The Structure of Fields" • E. Artin: " Galois Theory					
Electronic Materials						
Other Learning Materials						

Course Name	Group Theory				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1637**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:

It is mainly concerned with discussing groups, Sylow theorems, normal series , Jordan-Holder theorem , solvable groups , nilpotent groups. Extensions and semidirect products, factor sets, the Schur-Zassenhaus lemma, some simple groups, the general linear group, the special linear group, groups of projective transformations. Free groups, generators and relations. Representations of groups and the group algebras, characters. Induced representations. Representations of Sn

Course Objectives:

At the end of the course, students are expected to have a clear understanding of representations of groups and the group algebras, characters. Induced representations and representations of Sn

Courses Learning Outcomes:

1. State the basic definitions, concepts and some fundamental results in groups and basic group theory
2. Discuss concepts of Sylow theorems, Normal series , Jordan-Holder theorem , solvable groups nilpotent groups. solvable groups , Extensions and semidirect products, factor sets.
3. Apply the Schur-Zassenhaus lemma
4. Interpret the Some simple groups, the general linear group , the special linear group, groups of projective transformations Free groups, generators and relations
5. Representations of groups and the group algebras, characters. Induced representations. Representations of Sn
6. Solve given problems through a homework

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• 1. J. Rotman: “The Theory of Groups”					
References	• J. S. Rose: “A Course in Group Theory” • M. Hall: “ The Theory of Groups					
Electronic Materials						

Other Learning Materials	

Course Name	Introduction To Harmonic Analysis				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1645**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
This course deals Fourier transforms on locally compact abelian groups, Haar measure, PaleyWiener and Tauberian theorems, dual groups, commutative Banach algebra.

Course Objectives:
At the end of the course, students are expected to have a clear understanding of Harmonic analysis on the torus, on the real line, on R^d, and on finite abelian groups.

Courses Learning Outcomes:

1. State the basic definitions, concepts and some fundamental results in Harmonic Analysis.
2. State the basic Formulate and prove main propositions related to Fourier series and Fourier transform.
3. Apply Paley-Wiener and Tauberian Theorems.
4. Apply Fourier analysis on uncertainty principles.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA

Textbook

- Y. Katznelson: An Introduction to Harmonic Analysis. Cambridge Press, 2004.Third edition (Textbook).
- R. E. Edwards, Fourier Series: A Modern Introduction. Inc. New York, 1967.
- H. Reieter and J. D. Stegeman: Classical Harmonic Analysis on Locally Compact Groups. Oxford Science Publications, 1968.
- W. Rudin: Fourier Analysis on Groups. Interscience Publishers.Inc.1962.
- Robert Strichartz: A Guide to Distribution Theory and Fourier Transforms (Studies in Advanced Mathematics) 1994.

References	• Y. Katznelson. An Introduction to Harmonic Analysis. Cambridge Press, 2004.Third edition (Textbook).
Electronic Materials	
Other Learning Materials	

Course Name	Functional Analysis(I)				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1646**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
Normed linear spaces. Bounded and unbounded linear operators. Linear functionals. Duality. Hilbert spaces. Open mapping theorem. Closed graph theorem. Uniform boundedness principle. Bilinear forms and the Lax-Milgram lemma. Adjoints and closed range theorem. Banach algebras. Maximal ideals and multiplicative functionals. Commutative Banach algebras. The spectral theory of normal operators on Hilbert spaces

Course Objectives:
This course provides a clear understanding of the main concepts related to Banach and Hilbert spaces, spectral theory and Banach algebra.

Courses Learning Outcomes:

1. To state the basic definitions, concepts and some fundamental results on Banach and Hilbert spaces, spectral theory and Banach algebra.
2. Identify normed spaces and examine linearity, boundedness of operators
3. Apply Functional theorems (Baire-theorem, Uniform boundedness theorem, closed graph theorem and Lax Milgram Theorem).
4. Identify Hilbert spaces and show the familiarity with the basic notions defined on Hilbert spaces.
5. Identify Banach algebra and show the familiarity with the basic notions of maximal ideals and multiplicative functionals
6. Apply the theoretical results to find the spectrum of a linear bounded operator
7. Analyze the hypotheses of a given problem and apply the suitable results encounter it through a homework

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• W. Rudin .Functional Analysis. McGraw-Hill Science, Second edition 1991. • K. Yosida. Functional Analysis. Berlin .Springer-Verlag. third edition 1971.					

	• - E. Kreyszig. Introductory Functional Analysis with Applications. John Wiley&Sons,Inc. Second edition 1989.(Text book). • F. Riesz and B. Sz-Nagy . Functional Analysis. New-York. Ungar 1955
References	• A. P. Robertson and W. Robertson. Topological Vector Spaces. Cambridge University Press.1964. • H.H.Schaefer and M.P.Wolff. Topological vector spaces. Berlin. Springer-Verlag Second edition 1991. • A.N.Kolmogorov and S.V.Fomin. Introductory Real Analysis.Dover Publications,Inc.New York.1970.
Electronic Materials	
Other Learning Materials	

Course Name	Functional Analysis(II)				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1647**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
Topological vector spaces. Locally convex spaces. The Hahn-Banach theorem. Duality. Topologies on the dual space. The spaces of test functions and distributions. Generalized derivatives. Sobolev spaces. Applications to partial differential equations.

Course Objectives:
This course provides a clear understanding of the main concepts related to topological spaces and Sobolev spaces.

Courses Learning Outcomes:

1. State the basic definitions, concepts and some fundamental results in topological vector
2. Realize basic properties of topological vector spaces
3. Realize basic properties of locally convex spaces
4. Realize the properties the Sobolev spaces
5. Apply Hann Banah Theorem
6. Analyze the hypotheses of a given problem and apply the suitable results encounter it through a homework

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• W. Rudin .Functional Analysis. McGraw-Hill Science, Second edition 1991. • K. Yosida. Functional Analysis. Berlin .Springer-Verlag. third edition 1971. •					
References	• A. P. Robertson and W. Robertson. Topological Vector Spaces. Cambridge University Press.1964.					

Electronic Materials	
Other Learning Materials	

Course Name	Theory of Operators				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1648**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
Brief idea on the spectral of a bounded linear operator, Hilbert-adjoint of linear bounded operator, spectral theory of bounded linear operators, spectral properties of compact operators in Hilbert spaces, operator equations involving compact operators, Fredholm alternative, spectral properties of self-adjoint linear operators. Spectral theory in Banach algebra.

Course Objectives:
At the end of the course, students are expected to have a clear understanding the spectral theory of different kind of linear bounded operators such as self-adjoint and compact operators. Moreover, the properties of unbounded linear operators

Courses Learning Outcomes:

1. To state the basic definitions, concepts and some fundamental results in spectral theory for different kind of operators
2. To recognize some properties of linear bounded or unbounded operators
3. To realize the spectrum of different kind of operators.
4. To apply the properties of compact operators. in studying the solutions of equations involving compact operators
5. Solve given problems through a homework.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• Gohberg and S. Goldberg. Basic Operator Theory. Birkhauser. Boston sel.Stuttgart.1981 • E. Keyszig: Introductory; Functional Analysis with Applications. John Wiley &Sons (1978).					
References	S. Goldberg. Unbounded Linear Operators: Theory and Applications. McGraw-Hill, New-York.1966					
Electronic Materials						
Other Learning Materials						

<table>
<tr><td>Course Name</td><td colspan="5">Banach Algebras</td></tr>
<tr><td rowspan="2">Course Information</td><td>Course Code</td><td>Course No.</td><td>Course Level</td><td>Credit Hour</td><td>Prerequisite(s)</td></tr>
<tr><td>Math0817</td><td>1649</td><td>5th/6th</td><td>4</td><td>None</td></tr>
<tr><td>Course Track</td><td colspan="5">☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives</td></tr>
<tr><td colspan="6">Course Description:
This course deals with Banach Algebras, their essential properties, Gelfand transform, algebras of operators on Hilbert spaces, spectral theorem, W* and C* algebras.</td></tr>
<tr><td colspan="6">Course Objectives:
This course provides a clear understanding of the main concepts related to Banach Algebras</td></tr>
<tr><td colspan="6">Courses Learning Outcomes:
1. State the basic definitions and fundamental results related to the main concepts in Banach algebras.
2. Compute the Gelfand transform.
3. Analyse operator algebras on Hilbert spaces.
4. Find the spectrum of some operators.
5. Apply the properties of W* and C* algebras.
6. Make a presentation on a topic in Mathematics</td></tr>
<tr><td rowspan="2">Assessment Policy</td><td>Assignments, Quizzes, Presentations Project/ Report</td><td colspan="2">20%</td><td>Lab</td><td>NA</td></tr>
<tr><td>Midterm</td><td>30%</td><td>Final</td><td>50%</td><td>Others</td><td>NA</td></tr>
<tr><td>Textbook</td><td colspan="5">• W. Rudin .Functional Analysis. McGraw-Hill Science, Second edition 1991.</td></tr>
<tr><td>References</td><td colspan="5">• Browder: “Introduction to Function Algebras”
• W. Arveson: “An Invitation to C* Algebras”</td></tr>
<tr><td>Electronic Materials</td><td colspan="5"></td></tr>
<tr><td>Other Learning Materials</td><td colspan="5"></td></tr>
</table>

<table>
<tr><td>Course Name</td><td colspan="6">Numerical Methods for Linear Algebra</td></tr>
<tr><td rowspan="2">Course Information</td><td>Course Code</td><td>Course No.</td><td>Course Level</td><td>Credit Hour</td><td colspan="2">Prerequisite(s)</td></tr>
<tr><td>Math0817</td><td>1651</td><td>5th/6th</td><td>4</td><td colspan="2">None</td></tr>
<tr><td>Course Track</td><td colspan="6">☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives</td></tr>
<tr><td colspan="7">Course Description:
This course is mainly concerned with direct methods, iterative methods, error analysis for solving linear systems. Generalized inverses orthogonalization and least square. The eigenvalue problem, iterative methods for eigenvalue problems, reductions, the QR method, tridiagonal forms, The Rayleigh-Ritz procedure.</td></tr>
<tr><td colspan="7">Course Objectives:
Definition and properties of matrices- Matrix norms, sequences and series- Linear systems, direct methods - Linear systems , Iterative methods - Methods for computing eigenvalues and eigenvectors - Generalized Inverse of matrices and least square problems.</td></tr>
<tr><td colspan="7">Courses Learning Outcomes:
1. To state the basic definitions, concepts, and some fundamental results in numerical linear algebra.
2. Recognize matrices of important special classes, such as normal, unitary, Hermitian, positive definite
3. Approximate eigenvalues and eigenvectors of matrices
4. Solve least square problems using Generalized Inverse of matrices and singular value decomposition.
5. Code a numerical method in a modern computer language</td></tr>
<tr><td rowspan="2">Assessment Policy</td><td>Assignments, Quizzes, Presentations Project/ Report</td><td colspan="3">20%</td><td>Lab</td><td>NA</td></tr>
<tr><td>Midterm</td><td>30%</td><td>Final</td><td>50%</td><td>Others</td><td>NA</td></tr>
<tr><td>Textbook</td><td colspan="6">G. H. G. and C. F. Van Loan . Matrix Computations Hopkins Fulfillment Service; 3rd Ed. , 1996 (Textbook)</td></tr>
<tr><td>References</td><td colspan="6">• G. Allaire S. M. Kaber. Numerical Linear Algebra , Springer Science+Business Media, LLC, 2008 3
• Harue Yanai, Kei Takeuchi, Yoshio Takane, Projection Matrices, Generalized Inverse Matrices, and Singular Value Decomposition , Springer New York Dordrecht Heidelberg London, Springer Science+Business Media, LLC , 2011</td></tr>
<tr><td>Electronic Materials</td><td colspan="6">http://www.mathworks.com/help/symbolic/linear-algebra-1.html</td></tr>
<tr><td>Other Learning Materials</td><td colspan="6"></td></tr>
</table>

Course Name	Special functions in Applied Mathematics				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1653**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
This course deals with Gamma function, Beta function, the Hypergeometric function, Bessel functions, Legendre polynomials, Orthogonal polynomials, Elliptic functions.

Course Objectives:
At the end of the course, students are expected to have a clear understanding of certain ideas concerning advanced partial differential equations and their solutions in real life. This enables us to define more clearly some special functions like the Gamma, Beta, Hypergeometric, Bessel, and Generalized hypergeometric functions. The remainder of the course is then essentially a catalogue of "prototype" solutions of these equations. We also give special theorem in orthogonal, Legendre, Hermite and Leguerre polynomials.

Courses Learning Outcomes:

1. To revisit the basic definitions, concepts and fundamentals of Partial Differential Equations.
2. To compute some special integrations by using the definitions of Gamma and Beta functions
3. To analyze the PDE problems and develop the solutions using some special functions like Bessel, hypergeometric, Generalized hypergeometric and Legendre polynomials
4. To explain the use of these special functions and their properties and develop some applications.
5. To solve problems related to the concepts of the course.
6. To apply the special functions and their use in the solution of pure and applied mathematics problems.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• E. D. Rainville: "Special Functions"					
References	• H. Hochstadt: "The Functions of Mathematical Physics" • N. N. Lebedev: "Special Functions and Their Applications"					
Electronic Materials						
Other Learning Materials						

Course Name	Integral Transforms and Operational Methods				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1654**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
This course deals with the different integral transforms such as Fourier transform, Laplace transform, Mellin transform and Hankel transform as well as their applications in operational calculus.

Course Objectives:
This course provides a clear understanding of the main concepts related to the common integral transforms and their applications.

Courses Learning Outcomes:

7. State the basic definitions and fundamental results related to the main concepts of integral transforms
8. Compute the integral transforms of several functions using different analytical methods.
9. Apply the Fourier and Laplace transforms in computing improper integrals, solving functional equations and ordinary or partial differential equations
10. Apply the Mellin transform in studying the zeta function and computing some series sums
11. Use the Hankel transform in studying and computing some definite and improper integrals related to the Bessel function

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• B. Davies: “Integral Transforms and Their Applications”					
References	• R. V. Churchill: “operational Mathematics”					
Electronic Materials						
Other Learning Materials						

Course Name	Applied Functional Analysis I				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1655**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
This course is intended to familiarize the students with the basic concepts, principles and methods of functional Analysis and its applications.

Course Objectives:
This course is mainly concerned with: the spectral theory of compacts linear operators on normed spaces, the spectral theory of unbounded linear operators on Hilbert space, and the Sturm-Liouville theory and its applications to differential equations.

Courses Learning Outcomes:

1. State the basic definitions and fundamental results related to the main concepts of the course
2. Use the main properties of Hilbert spaces
3. Study compact self-adjoint operators and their spectral properties
4. Apply the theory of spectral decomposition of unbounded self-adjoint operators
5. Apply the theory of Sturm-Liouville theory to the study of the properties of some differential equations
6. Make a presentation on a topic in Mathematics.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• H. Brezis: "Functional Analysis, Sobolev Spaces and Partial Differential Equations". Springer New York Dordrecht Heidelberg London					
References	• M.A. Al-Gwaiz: "Sturm-Liouville Theory and its Applications". Springer (SUMS).					
Electronic Materials						
Other Learning Materials						

Course Name	Applied Functional Analysis II				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1656**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
At the end of the course, students are expected to have a clear understanding of the distribution theory, the Fourier analysis and their properties.

Course Objectives:
This course is mainly concerned with: Distribution theory, convolutions, Fourier transforms, Sobolev spaces, variational methods for boundary value problems, various variational methods of approximation.

Courses Learning Outcomes:

1. State the basic definitions and fundamental results related to the main concepts of the course
2. Calculate the convolution of two functions.
3. Interpret the Fourier transform of a function (or a distribution).
4. Evaluate the variational methods for boundary value problems and variational methods of approximation
5. Make a presentation on a topic in Mathematics

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• S. L. Sobolev: “Applications of Functional Analysis in Mathematical Physics”.					
References	• I. Stakgold: “Boundary Value Problems of Mathematical Physics”.					
Electronic Materials						
Other Learning Materials						

Course Name	Theory of Distributions				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1657**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
In this course we will introduce the notions of distributions and study their main properties and applications

Course Objectives:
The main objective of this course is to study the main properties of the distribution theory and its applications in the field of partial differential equations

Courses Learning Outcomes:

1. To state the basic definitions, concepts and some fundamental results in Distributions
2. Justify that a given functional on test functions space is a distribution
3. Apply the different operations on distributions to solve some ODE
4. Examine the convergence of a sequence or a series of distributions
5. Apply distribution theory to solve some PDE
6. To examine some operations (convergence, multiplication,, derivation, ..) on Sobolev spaces

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• Gerrit Van Dijk: Distribution Theory 2013 Gruyter Gmbtt/ Berlin/Boston					
References	• M.A. Al-Gwaiz: Theory of Distributions (Chapman & Hall/CRC Pure and Applied Mathematics					
Electronic Materials						
Other Learning Materials						

Course Name	Algebraic Topology (I)				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1661**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:

This course is mainly concerned with Homology groups of a simplicial complex, relative homology, homeomorphisms induced by simplicial maps, simplicial approximation, the topological invariance of the homology groups, homomorphism induced by homotopic maps. The Eilenberg-Steenrod axioms. Singular homology theory, excision in singular homology, the isomorphism between singular and simplicial homology, the homology of CW complexes

Course Objectives:

At the end of the course, students are expected to have a clear understanding of the simplicial complex, the homotopic maps and the homology groups.

Courses Learning Outcomes:

1. To recognize and state some of the basic definitions of concepts concerning Algebraic topological such as Homology groups and Homotopy
2. To compute the Homology groups of a simplicial complex, the homology of CW complexes and the relative homology
3. To examine the topological invariance of the homology groups and the homomorphism induced by homotopic maps
4. To recognize homeomorphisms induced by simplicial maps and the simplicial approximation
5. To recognize the Eilenberg-Steenrod axioms., excision in singular homology.
6. To examine the isomorphism between singular and simplicial homology

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• M. J. Greenberg and J. R. Harper: "Algebraic Topology: A First Course"2018,Taylor, Francis group • *J. R. Munkres, Elements of Algebraic Topology, Addison-Wesley, 1984.* • J. W. Vick:" Homology Theory: An Introduction To Algebraic Topology" Academic Press, New York 1973					
References	• M. J. Greenberg and J. R. Harper: "Algebraic Topology: A First Course"2018,Taylor, Francis group					
Electronic Materials	http://pi.math.cornell.edu/~hatcher/					
Other Learning Materials						

Course Name	Algebraic Topology (II)				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1662**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:

This course is mainly concerned with Cohomology, relative cohomology, the cohomology of a CW complex, cup products. Homology with arbitrary coefficients. Homological algebra , the universal coefficient theorems, the Kunneth formula, the Eilenberg-Zilber theorem. Duality in manifolds, homology of manifolds, Pioncare duality, the cap product, Lefschitz duality, Alexander duality, Alexander-Pontryagin duality

Course Objectives:

At the end of the course, students are expected to have a clear understanding of the Cohomology, Homology with arbitrary coefficients and Pioncare duality

Courses Learning Outcomes:

1. To recognize and state some of the basic definitions of concepts concerning Algebraic topological such as Cohomology groups , Pioncare duality, the cap product and homology of manifolds
2. To compute the Cohomology, relative cohomology, the cohomology of a CW complex
3. To examine cup products and cap product
4. To recognize the Homology with arbitrary coefficients, Homological algebras and homology of manifolds
5. To recognize the universal coefficient theorems, the Kunneth formula, the Eilenberg-Zilber theorem. Duality in manifold.
6. To examine Pioncare duality, Lefschitz duality, Alexander duality, Alexander-Pontryagin duality
7. Make a presentation on a topic in Mathematics

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• M. J. Greenberg and J. R. Harper: "Algebraic Topology: A First Course"2018,Taylor, Francis group • *J. R. Munkres, Elements of Algebraic Topology, Addison-Wesley, 1984.* • J. W. Vick:" Homology Theory: An Introduction To Algebraic Topology" Academic Press, New York 1973					
References	• M. J. Greenberg and J. R. Harper: "Algebraic Topology: A First Course"2018,Taylor, Francis group					
Electronic Materials	http://pi.math.cornell.edu/~hatcher/					
Other Learning Materials						

Course Name	Differential Geometry (I)				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1671**	**5th/6th**	**4**	None
Course Track	☐University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
It is mainly concerned with two parts: Study of curves in Euclidean spaces: arc length, tangent, normal and binomial vectors, curvature and torsion. Frenet formulas. Isoperimetric inequality.
Study of surfaces in Euclidean spaces: Local differential geometry of surfaces, the first and second fundamental forms. Local isometries. Geodesics. Gaussian and mean curvature of surfaces. The Gauss-Bonnet theorem.

Course Objectives:
This course provides a clear understanding of the main concepts related.

Courses Learning Outcomes:

1. Define the regular curves - Arc Length, tangent, normal and binomial vectors
2. State the theory of curves in R^3, the Local theory of surfaces
3. Define the curvature and torsion of curves. Serret-Frenet equations.
4. Outline the First and second fundamental forms- Gaussian and mean curvatures- Geodesics.
5. Reorganize whether a given curve (resp. surface) is regular or not.
6. Estimate the curvature and torsion of a regular curve.
7. Calculate the first and second fundamental forms of surfaces.
8. Find the Gaussian and mean curvature of surfaces.
9. Work as part of a team and independently.
10. The ability of managing different knowledge resources and the ability managing time.
11. Use computer for graphing some curves and surfaces in the three-dimensional space.
12. Make a presentation and discuss results of work.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm	30%	**Final**	50%	**Others**	NA
Textbook	• M.P. do Carmo, " Differential Geometry of Curves and Surfaces: Revised and Updated Second Edition". Dover Publications, 2016 ISBN-13: 978-0486806990, ISBN-10: 0486806995 • *D. J. Struik: "Lectures on Classical Differential Geometry".* Dover Publications *1988.* ISBN-13: 978-0486656090 ISBN-10: 0486656098					
References	• D. J. Struik: "Lectures on Classical Differential Geometry". Dover Publications 1988. ISBN-13: 978-0486656090 ISBN-10: 0486656098					
Electronic Materials	http://pi.math.cornell.edu/~hatcher/					

Other Learning Materials	

Course Name	Differential Geometry (II)				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1672**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
It is mainly concerned with definitions and properties of differentiable manifolds and maps. Also, Vector bundles, tangent and cotangent bundles, differential forms, and exterior derivatives. Riemannian manifolds. Curvature equations, geodesics, and completeness. Special manifolds and constructions.

Course Objectives:
This course provides a clear understanding of the main concepts related.

Courses Learning Outcomes:

1. Define the Differentiable Manifolds, the Tangent Space, the tangent bundle and submanifolds.
2. State the theories on Riemannian manifolds.
3. Recognize the tensors and tensor fields, cotangent bundle, tensor bundles.
4. Recognize the Riemann curvature tensor.
5. Recognize the geodesics.
6. Calculate the Differential forms, and exterior derivatives
7. Estimate the Tensors and tensor fields, cotangent bundle, tensor bundles.
8. Compute the Riemannian metrics. Curvature equations.
9. Recognize the Levi-Civita Connection
10. Work as part of a team and independently.
11. The ability of managing different knowledge resources and the ability managing time.
12. Use computer for computing tensors and graphing 1-dimensional and 2- dimensional manifolds (curves and surfaces).
13. Make a presentation and discuss results of work.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm(s)	30%	**Final**	50%	**Others**	NA
Textbook	• *M. P. Do Carmo:" Riemannian Geometry", Birkhäuser (1992)* • *J. Lee, Riemannian Manifolds, An Introduction to curvature, Springer (1997), ISBN-13: 978-0387983226, ISBN-10: 0387983228* • *N. J. Hicks," Notes on Differential Geometry", Van Nostrand Reinhold Co. (1965). ISBN-10: 0442034059, ISBN-13: 978-0442034054* • *M. Spivak: "A Comprehensive Introduction to Differential Geometry", Publish or Perish, 1979, ISBN-13: 978-0914098836, ISBN-10: 0914098837*					
References	• F. Warner, " Foundations of Differentiable Manifolds and Lie groups, Springer (1983). ISBN-13: 978-0387908946, ISBN-10: 0387908943 • B. A. Dubrovin, A. T. Fomenko , and S. P. Novikov:" Modern Geometry - Methods and Applications: Part I: The Geometry of Surfaces, Transformation Groups, and Fields", Springer (1991). ISBN-13: 978-0387976631, ISBN-10: 0387976639					

Electronic Materials	Several web sites are already exists concerning Differentiable Manifolds and Riemannian manifolds, which have provided students with some lecture notes, examples, and exercises. https://personalpages.manchester.ac.uk/staff/theodore.voronov/manifolds.html
Other Learning Materials	

Course Name	Algebraic Geometry				
Course Information	**Course Code**	**Course No.**	**Course Level**	**Credit Hour**	**Prerequisite(s)**
	Math0817	**1673**	**5th/6th**	**4**	None
Course Track	☐ University Requirement ☐ College Requirement ☐ Specialized Core ☒ Electives				

Course Description:
Algebraic Geometry is a course designed to study affine and projective algebraic varieties and introduce the language of schemes. One of the principles of this course is to start from easily formulated problems whose solutions requires the use of sophisticated algebra-geometric techniques such as sheaves and Cohomology.

Course Objectives:
This course aims to give good understanding of the affine and projective algebraic varieties and introduce the language of schemes.

Courses Learning Outcomes:

1. To know affine and projective varieties, sheaves and rational maps.
2. To know the Tangent space and singular points
3. To know the Tangent space and singular points
4. Find the coordinate ring associated to an algebraic variety and study the converse.
5. Construct rational maps
6. Find the intersection of algebraic varieties
7. Work as part of a team and independently.
8. The ability of managing different knowledge resources and the ability managing time.
9. Discuss results of work with others.

Assessment Policy	**Assignments, Quizzes, Presentations Project/ Report**	20%			**Lab**	NA
	Midterm(s)	30%	**Final**	50%	**Others**	NA

Textbook	• Daniel Perrin, Algebraic Geometry: An Introduction, Universitext. Berlin: Springer; Les Ulis: EDP Sciences (ISBN 978-1-84800-055-1), 258 p. (2008).
References	• Robin Hartshorne, Algebraic Geometry, Graduate Texts in Mathematics. 52. New York-Heidelberg-Berlin: Springer-Verlag. XVI, 496 p. (1977).
Electronic Materials	
Other Learning Materials	Computer-based programs/CD, professional standards or regulations and software.

Useful Links

1. Deanship of Postgraduates Studies, King Faisal University
2. Deanship of Scientific Research, King Faisal University
3. Deanship of Library Affairs, King Faisal University
4. College of Science, King Faisal University
5. Department of Mathematics and Statistics

Prepared by

Department Of Mathematics and Statistics