Ministry of Education

Test Blueprint for National Exit Examination to be held in 2015 E.C

Band:

Program: Bachelor of Science (BSc) in Mathematics

January, 2023

Addis Ababa

Ethiopia

TABLE OF CONTENTS

1. Introduction 1
2. Objectives/Significance of Test Blueprint preparation 2
3. Steps we followed to develop test blueprint 2
4. Expected Profile of Graduates 3
5. General Objectives of the Program 3
6. Specific Objectives of the Program 3
7. Themes and list of courses with their credit hour 4
8. Share of the Themes/Courses/Items in Percentage (%) 9
9. Conclusion 10

1. Introduction

The Ministry of Education of Ethiopia has announced the implementation of exit exam for all undergraduate program students (public and private), beginning with the 2022/2023 academic year, in order to improve the quality of graduates produced by higher learning institutions. The exit exam aimed at checking whether students have acquired the required knowledge, skills and attitudes or not. To implement this, it requires determining competency areas for a specific program, which is already completed. Based on the competency areas prepared, it needs to plan the construction of tests.

Planning of a test is a first and vital step in the construction of an achievement test. An achievement test demands very systematic and careful planning, as a fact that good planning is a symbol of success. Tests are the tools that provide scores that measure level of student learning and study program learning outcomes. In order to achieve the valid and reliable measurement of student learning and program learning outcomes, the development of valid and reliable test is the mandatory. Test should be able to measure student performance in all dimensions of knowledge, skill and attitude. The carefully planned test construction contributes to improve the overall quality of the test in terms of test content validity, difficulty level, discrimination power and test reliability. Test preparation is not an easy task; it requires a careful planning and guideline to make the task simple. Test construction needs the preparation of test blue print. Test blueprint is defined as a complete plan that explains how to develop a test. The term refers to a map or specification of assessment to ensure that all aspects of the curriculum and educational domains are covered by the assessment programs over a specified period of time. It helps curriculum developers/test constructors to match various competencies with the course content and the appropriate modality of assessment.

Generally, test blueprint will help to ensure tests:

1) Appropriately assess the achievement of instructional objectives of the course;

2) Appropriately reflect key course goals, objectives and the material learned or covered during the instruction period; and

3) Include the appropriate item formats along with the knowledge and skills being assessed.

Keeping this in mind, the team has prepared this test blueprint document in order to help the test developers or content specialists in their process of valid and reliable test construction. The

major points considered in the process of preparing this test blue print guideline were the core competencies that have been already identified for the themes of courses, the course contents, course credit hours, and the learning outcomes with their corresponding levels of achievement by learning domains. In line with these, the number of test items that should adequately assess the performance of students in all the content topics will be determined through discussion with the content specialists who construct the blueprint and test for their corresponding study program.

Therefore, the main purpose of this manual is to give direction on how to develop blueprint for content specialists so that they can develop a test blueprint for their respective program.

2. Objectives/Significance of Test Blueprint preparation

Test blueprint preparation is generally opted to assist the preparation of a test that is representative, broadly sampled, and consisting of complete knowledge domain expected of the Ethiopian higher education students on completion of their study program. The specific objectives of test blueprint are to:

- Facilitate the construction of a representative and balanced test items for the selected courses in accordance with the competencies identified.
- Guide test developers or writers to write or set appropriate test items.

3. Steps we followed to develop test blueprint

To prepare this document we followed the following steps:

1. Listing the identified core competencies corresponding to the respective course.
2. Listing the specific and minimum competencies to be assessed by the exam.
3. Listing out the major learned course contents corresponding to these listed minimum competencies.
4. Listing the specific, measurable learning outcomes under these minimum competencies using action verbs (Note: the number and the importance of these learning outcomes proportionally contribute to the total test items. The weight of the categories of the list of learning outcomes under each competencies and contents should lead to the number of total test items to be constructed)
5. Determination of the test format.
6. Content weighting - Experts judge the weight to be given to the listed learning outcomes and their corresponding contents.
7. Identifying the categories of learning domains to which each of these learning outcomes belongs using their action verbs.

8. Construction of test blueprint table.
9. Allocating the number of test items for each learning outcomes by their corresponding types and levels of learning domains.
10. Determination of the sub-total and total test items by their categories of learning domains and learning outcomes.

4. Expected Profile of Graduates

A graduate of the program will be able to:

- Acquire fundamental knowledge of mathematics to teach in primary and secondary schools.
- Develop mathematical skills needed in modeling and solving practical problems.
- Apply mathematics to solve real world problems in various application areas such as in industries, economics and health science.
- Develop the knowledge, skills and attitudes necessary to pursue further studies in mathematics and related fields of study.
- Create job opportunities by applying the acquired knowledge and skills.

5. General Objectives of the Program

The general objective of mathematics BSc program is to train qualified, adaptable, motivated, and responsible Mathematicians who will contribute to the scientific and technological development of Ethiopia.

6. Specific Objectives of the Program

Specific objectives of the program are;

- ✓ Provide an in-depth understanding of the fundamental principles and techniques of Mathematics.
- ✓ Develop mathematical concepts and definitions, and to extend and generalize them to new situations.
- ✓ Progress Mathematical thinking, reasoning and an appreciation of Mathematics as a primary language of science.
- ✓ Understand the connections between mathematics and other disciplines, and being able to recognize mathematical ideas embedded in other contexts.

- ✓ Develop the fundamental concepts of mathematical modeling and how to apply mathematics to real-world situations.

7. Themes and list of courses with their credit hour

Based on the identified courses and core competences for the exit exam in mathematics BSc program, we have the following themes and list of courses with their respective credit hours.

Themes	Course Name	Credit hour	General objectives	Specific objectives
Theme I (Analysis)	Calculus I	4	To introduce the basic concepts of limit, continuity, differentiation, integration, and some of their applications.	➢ understanding the formal definition of limit and continuity, ➢ evaluating limits of functions, ➢ determining points of discontinuity of functions, ➢ applying Intermediate Value Theorem, ➢ evaluating derivatives of different types of functions, ➢ applying derivatives to solve problems, ➢ evaluating integrals of different types of functions, ➢ applying integrals to find areas and volumes.
	Calculus II	4	The main objective of this course is to lay strong foundation to theoretical concepts and techniques in calculus that are needed for the advanced studies in pure and applied mathematics.	➢ finding derivatives of inverse functions, ➢ evaluating integrals of different types of functions, ➢ evaluating limits by L' Hopital's Rule, ➢ determining convergence or divergence of a series, ➢ finding the interval of convergence of a power series, ➢ approximating a function by using its power series, ➢ applying integrals (arc length, surface area), ➢ approximating integrals by Trapezoidal, and Simpson's rules, ➢ finding the Taylor's series expansion of a function

	Calculus of Functions of Several Variables	4	The course extends the notion of differential and integral of functions of one variable to functions of several variables to develop more advanced ideas that are essential in pure and applied mathematics.	➢ understanding vector algebra, ➢ writing equations of lines and planes in space, ➢ evaluating partial derivatives, ➢ finding gradients and directional derivatives of a function of several variables, ➢ using differentials for approximation, ➢ using tangent plane approximation, ➢ applying partial derivatives to physical problems, ➢ evaluating multiple integrals of different functions of several variables, ➢ applying integrals to physical problems, ➢ understanding the core theorems of the course.
	Calculus of Function of Complex Variables	4	To promote students to appreciate striking results and applications of complex analysis which are not revealed in the theory of functions of one variable and equips them with profound and elegant mathematical proofs.	➢ understanding the significance of differentiability of complex functions, ➢ distinguishing between differentiable functions and analytic functions, ➢ applying Cauchy-Riemann equations, ➢ evaluating integrals along a path in the complex plane, ➢ applying Cauchy integral formula to evaluate line integrals, ➢ representing analytic functions by a power series, ➢ proving Fundamental Theorem of Algebra, ➢ distinguishing the singularities of a function, ➢ writing the Laurent series of a function, ➢ calculating the residue, ➢ applying the Residue theorem, ➢ understanding the properties of Mobius transformation and its action on circles.

Theme II (Numerical Analysis/ Optimization)	Numerical Analysis I	3	The course aims at introducing students in finding numerical solutions to problems for which analytical solutions either do not exist or are not easily obtainable. It help student develop programming skills.	➢ understanding sources of errors, and identify absolute and relative errors, ➢ understanding a range of iterative methods for solving linear and non-linear systems of equations, ➢ comprehending the convergence properties of the numerical methods, ➢ grasping practical knowledge of polynomial interpolation in numerical differentiation and integration, ➢ appreciating the application of basic linear algebra and calculus concepts in deriving the numerical algorithms, ➢ examining how a small change in the data and ill-conditioned algorithms affect the solution of the mathematical problems, ➢ translating mathematical algorithms into computer programming,
	Linear Optimization	3	The course intends to introduce students to both theoretical and algorithmic aspects of linear optimization, like linear programming, geometric and simplex methods, duality theory and further variations of the simplex method, sensitivity analysis, interior point methods and transportation problems.	➢ understanding the interplay between geometry and linear algebra, matrix algebra, ➢ solve systems of linear equations, ➢ understanding the fundamental principles of linear programming, ➢ formulate optimization problems, ➢ understanding decision process with respect to an optimization problem, ➢ test convexity of sets, ➢ understanding theorems and algorithms of the simplex method, ➢ solving linear programming problems by the simplex method, ➢ applying theorems and algorithms in duality theory, ➢ doing sensitivity analysis, ➢ comprehending and solving the transportation problem,

	Mathematical Modeling	3	The course aims at providing a concise mathematical formulation of characteristic problems of real life with emphasis on quantitative aspects of the problems. It develops the basic concepts and methods in modeling focusing on forecasting relevant solutions to specified area problems.	➢ understanding the importance of model, ➢ understanding properties of models, ➢ giving examples of models, ➢ understanding dimensional analysis, ➢ using graph in modeling, ➢ developing mathematical models representing a physical problem, ➢ testing stability of the model, ➢ using models for forecasting.
Theme III (Differential Equations)	Ordinary Differential Equations	4	The course targets to introduce the basic theory of linear ODEs and systems of linear ODEs together with various techniques of solution methods.	➢ distinguishing various classes of differential equations, ➢ understanding the underlying theory of linear ODEs, ➢ understanding various techniques of solving ODEs, ➢ applying the techniques to solve ODEs problems, ➢ applying the theory of power series to solve certain classes of differential equations, ➢ deriving the properties of Laplace transform, ➢ applying Laplace transform to solve certain classes of ODE, ➢ understanding the interrelation between ODEs and linear algebra, ➢ expressing physical problems in terms of differential equation.
	Partial Differential Equations	3	To introduce students to the concepts and analytical methods for solving partial differential equations.	➢ defining Fourier series of periodic functions, ➢ expanding periodic functions in terms of sine and cosine, ➢ computing Fourier series, ➢ determining the order and classification of PDEs ➢ solving PDEs, ➢ modeling some physical problems using PDEs, ➢ applying Fourier and Laplace transforms for solving PDEs, ➢ solving one dimensional heat flow and wave equations, ➢ solving Laplace equations, ➢ understanding and applying generalized functions.

	Financial Mathematics I	3	To discuss the basic concepts of Financial Mathematics which are useful for Financial Markets. Hence, to reach in to its goal the course contains the basic units of financial markets such as basic finance, probability spaces, random variables, options and arbitrage, Discrete-Time Portfolio Processes and expectations.	➢ describing an elementary account of the basic principles of finance ➢ describing the most common types of financial derivatives ➢ grasping the idea of the role of arbitrage in finance theory ➢ getting the notion of rigorous mathematical framework for the notion of a self-financing portfolio ➢ describing what is meant by expectations and able to apply it in financial market
Theme IV (Algebra)	Modern Algebra I	3	The course intends to provide students with a solid introduction to modern group theory, ring theory and fields and its extension.	➢ understanding the concept of groups and its properties, ➢ understanding the action of a group on a set, ➢ determining the conjugacy classes, ➢ understanding the concepts of a ring, subrings , ideals and quotient rings, ➢ grasping the concepts of Euclidean domain, unique factorization domain and principal ideal domains, ➢ understanding the concept of field extension, ➢ distinguishing between the different types of field extensions, ➢ applying the main theorems of group rings and fields.
	Linear Algebra I	3	The objective of this course is to lay down a strong foundation for advanced studies in linear algebra and related courses.	➢ understanding the basic ideas of vector algebra, the concept of vector space over a field, the basic theory of matrix, ➢ solving system of linear equations, ➢ determining row reduced echelon forms of a matrix, eigenvalues and eigenvectors of a square matrix, ➢ grasping Gram-Schmidt process, ➢ finding an orthogonal basis for a vector space, ➢ inverting orthogonal matrix, ➢ finding the linear transformation with respect to bases,

	Number Theory	3	The course intends to provide basic concepts in number theory, which mainly deals with properties of integers.	➢ explaining basic properties of integers; ➢ using prime factorization of integers to find the LCM and GCF of two or more integers, ➢ computing the LCM and GCF of two or more integers with the help of Euclidean Algorithm, ➢ applying different techniques to solve Diophantine Equations, ➢ understanding the basic notions of congruences, ➢ constructing the rings of integers modulo n, ➢ applying Euler- Fermat Theorem, ➢ expressing a rational number as a decimal expansion, ➢ differentiating the different types of continued fractions.
Total Credit Hour		44		

Table 1: Themes and list of courses with credit hour.

8. Share of the Themes/Courses/Items in Percentage (%)

The following table describe share of themes and categorized courses in them. The share for each course is allocated in terms of three learning domains cognitive, attitude and psychomotor, based on its credit hour and specific objectives given in Table 1 above.

Themes	Course Name	Credit hour	Weight of Course or proportion	Number of test items from each courses in %	Cognitive	Attitude	Psychomotor	Total
Theme I (Analysis) Share=37 Items from the total	Calculus I	4	4/16=0.25	0.25*37=9	6	1	2	9
	Calculus II	4	4/16=0.25	0.25*37=9	5	2	2	9
	Calculus of Function of Complex Variables	4	4/16=0.25	0.25*37=9	7	-	2	9
	Calculus of Function of Several Variables	4	4/16=0.25	0.25*37=10	7	1	2	10
	Theme I total Credit	16						
Theme II	Numerical Analysis I	3	3/9=0.33	0.33*20=7	5	1	1	7

(Numerical Analysis/ Optimization) Share=20 Items from the total	Linear Optimization	3	3/9=0.33	0.33*20=7	5	-	2	7
	Mathematical Modeling	3	3/9=0.33	0.33*20=6	3	1	2	6
	Theme II total Credit	9						
Theme III (Differential Equations) Share=22 Items from the total	Ordinary Differential Equations	4	4/10=0.4	0.4*22=9	7	-	2	9
	Partial Differential Equations	3	3/10=0.3	0.3*22=7	6	-	1	7
	Financial Mathematics I	3	3/10=0.3	0.3*22=6	3	1	2	6
	Theme III total Credit	10						
Theme IV (Algebra) Share=21 Items from the total	Modern Algebra I	3	3/9=0.33	0.33*21=7	6	-	1	7
	Linear Algebra I	3	3/9=0.33	0.33*21=7	5	1	1	7
	Number Theory	3	3/9=0.33	0.33*21=7	5	1	1	7
	Theme IV total Credit	9						
Total Credit Hour		44			70	9	21	100

Table 2: Share of the themes/courses.

9. Conclusion

Exit examination can have a vital role in producing knowledgeable, skillful and attitudinally matured graduates. It contributes to prepare competent graduates as it can serve as a quality check for effectiveness. It also helps in improving academic programs' quality and effectiveness. Furthermore, it can create the platform for cooperation among academic programs at different universities to work jointly to improve the programs' quality.

In view of this, this document is produced to assist the setting of the exit examinations for all programs, which is being delivered by Ministry of Education. To meet the graduation profile, competency and learning outcome, exit exam competency selection and identifying core course was done for 2015 EC graduating students. As a result, preparing test blueprint is necessary to prepare fairly distributed items based on the above criteria.