



Test Blueprint for Material Science and Engineering for the National Exit Examination:

Program: Bachelor of Science in Materials Science and Engineering

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1. INTRODUCTION

Materials Science and Engineering (MSE) combines Engineering, Physics, Chemistry and Biology, Geology, etc. principles to solve real-world problems associated with the field of metals, semiconductors, alloys, glasses, ceramics, polymers, biomaterials, thin films, nanomaterials, energy materials, composite materials, and other manufacturing industries. Generally, the materials science and engineering field focused on the basic understanding of materials through their design, development, and characterization regarding structure, properties, processing, and performance along with the underlying theoretical framework. As the MSE program is multidisciplinary that integrates Basic Science and Engineering, could play a key role in improving the living standard of the society in the world. To advance the progress and development of the MSE program for the realization of Ethiopia growth transformation plan (GTP) well-trained graduates are required. The graduates in the MSE program will be trained in the focus of addressing the transformation of Agricultural Development Led Industrialization (ADLI) to Science Technology and Innovation (STI) Led Industrialization.

To achieve this, the MSE program has designed and implemented a well-organized B.Sc. curriculum. However, the MSE curriculum is not harmonized at the national level. Additionally, the implementation of the curriculum designed by different universities mainly focused on evaluating the performance, skills, and attitude of the students at the course level. Such an evaluation method needs mapping with program learning outcomes to assess the overall competence of the graduates. Therefore, additional program outcome measurement techniques have to be set. Currently, the ministry of education intends to set and implement exit examinations for selected programs. The main aim of the exit exams is to assess the graduates' performance and overall understanding of the profession with respect to the graduate profiles and the learning outcomes of the program. Consequently, quality education will be

ensured and a common getaway for the professional license and equal market opportunity will be created for all graduates from different universities. For this purpose, this document was developed to address the aforementioned problems.

General Objectives of Exit Examination

The national public administration exit exam shall have the following objectives

- To produce skilled and competent manpower for national and international markets.
- Inspire graduates in acquiring fundamental skills and knowledge in Materials Science and Engineering core courses.
- Enhance graduates' chance to win scholarships for further studies and projects.
- Assessing students' educational achievement in major areas of Materials Science and Engineering (MSE).
- Ensuring whether the graduation profile of the Materials Science and Engineering curriculum has achieved at least common standards of knowledge and practical skills.
- Improving public trust and confidence in graduates working as industry specialists, entrepreneurs, education sectors, and public administration activities of professionals.
- Facilitating the efforts of students to revise the core learning outcomes of the courses covered by the exit examination
- Ensuring all graduates from HEIs satisfy the requirements of the labor market and employability through the national wide implementation of competency-based exit exam.
- Creating a competitive spirit among Materials Science and Engineering departments in Ethiopia with the view to encouraging them to give due attention to the national standards.

Specific of the Objective

It is important to prepare test blueprint using the competency areas of Materials Science and Engineering and the learning outcomes to measure how much graduates acquired skills, knowledge, and attitudes. The as-prepared test blue print will aid the examiners to develop questions that will help assess graduate of materials science and engineering of different concept of the discipline that they have been explored to over the priode of their stay in the university.

The following shows the specific objective of the test blueprint

- To determine the share of each theme of course selected as the competency areas for assement of the basic skills, knowledge, and attitude of graduating students;
- To systematically identify the contribution/weight of each courses to the total number of question to be included in the exit exam;
- To map each courses to a particular learning outcome domains and in turn determine the number of question for each domains based on the pre-determined learning outcome of the course

2. GRADUATES PROFILE

After the successful completion of the Bachelor of Science in Materials science and Engineering, the graduates would have the following profiles:

- Knowledge of contemporary issues that requires engineering materials solutions.
- Get basic knowledge of the properties and strengths of different classes of materials;
- Be specialists in the investigation and design of materials and can work in industry, research institutes, government institutions, and universities.
- Conversant with sustainable materials development and their optimization processes;
- Develop production processes of materials

- Improve and engineer new or existing materials to benefit the industries, environment and society.
- Pursue further study in a postgraduate school to increase human capital development in the country
- Participate in the design, characterization, processing, and fabrication of advanced materials.
- Propose cost-effective manufacturing processes to improve the competitiveness of the existing local industries in the global market.
- Have awareness of materials selection, processing, characterization, and application.
- Identifying the basic source of materials from locally available resources.
- Acquire the capability to work collaboratively, conduct independent and multidisciplinary research
- Develop innovative solutions to the technological needs of the country and contribute to the establishment of a knowledge-based economy.
- Ensure efficient, optimum, safe, and environmentally responsible plant operation
- Advise industries and governmental bodies regarding environmental policies and standards;
- Familiarity in operating different experimental instruments and machines
- Apply the materials science concepts and thinking to their everyday life.
- Bring constructive change to the community through an entrepreneurial spirit.
- Engage different stakeholders through experience sharing at different forums.

3. COMPETENCIES AND LEARNING OUTCOMES

3.1. Broad Competencies for Material Science and Engineering

Sl.No	Areas of Competency	Expected Competencies to be achieved
1.	Knowledge	Generally, Graduates will be able to ➤ Formulate different materials applications with the knowledge of basic thermodynamic laws ➤ Solve complex materials problems using the knowledge of materials selection, properties, processing, characterization, and applications ➤ Develop new materials using basic knowledge of mathematics, physics, chemistry, and engineering concepts and models.
2.	Skill	➤ Design, process, create and characterize new materials for a specific purpose using the concepts of materials science and engineering. ➤ Interpreting experimental data to make correct decisions ➤ Develop practical and real-life problems solving skills for Society and implement materials development research; ➤ Operate different experimental instruments and machines relevant to materials science

		and engineering ➤ Competent in applying materials science and engineering judgments in industries, research institutes, and other governmental and non-governmental institutions; ➤ Analyze and design a system, component, or process to meet desired needs of industries and society within realistic constraints; ➤ Apply materials science and engineering principles and thinking to solve societal problems.
3.	Attitude	➤ Recognize ethical and professional responsibilities of materials scientists and engineers in global, economic, environmental, and societal contexts for sustainable materials utilization. ➤ Aspire for further studies to acquire new knowledge and emerging technologies to be a competitive material scientist and engineer globally. ➤ Communicate effectively and function within a team to collaborate and create an inclusive environment with the scientific community and stakeholders

3.2. General Learning Outcomes

After completing the Materials Science and Engineering program, graduate students will be able to:

- Identify the relationship between Processes - Structures - Properties - Performance with various applications.
- Understand the fundamental concepts of different classes of materials.
- Understand the basic principles of thermodynamics
- Understand the basic concepts of crystallography and crystal imperfections
- Understand atomic vibrations, thermal properties, optical, magnetic, and electronic behaviors in solid materials
- Understand the structure-property-processing relationship in metals and their alloys
- Understand the structure-property-processing relationship in ceramics and their applications
- Understand how the polymer can be polymerized, processed, characterized, and how those polymers are applied in our lives and science as well.
- Understand basic solid materials properties and elements of quantum mechanics.
- Describe the basic principles of semiconductors and devices.
- Understand thermomechanical processing of metals
- Understand the extraction and beneficiations of metals from ores
- Ability to design the structure of a material to produce a predetermined set of properties.
- Interpret the chemical, physical and mechanical properties of materials
- Conduct an appropriate experiment and analyze the results using suitable techniques.
- Evaluate materials in terms of the basic properties like Electrical, Mechanical, Thermal, Magnetic and Optical
- Demonstrate a proper understanding of materials selection, handling, and utilization.
- Stimulate innovative ideas and thoughts to design experiments independently.

- Realize the Economic, Environmental, and Societal Impact of Materials Science and Engineering

4. CATEGORIZING COURSES OF THE PROGRAM INTO THEMES

The graduates' competencies and learning outcomes of the MSE program are assessed with the following four major thematic areas;

Sl.No.	Module	List of Thematics in the MSE Program	Cr.hrs
1	Fundamentals	Basics Materials Science and Engineering	15
2	Materials Classifications	Metals	8
		Ceramics	9
		Polymers	6

5. COURSES TO BE INCLUDED IN THE TEST BLUEPRINT

The courses to be considered for the blueprint preparation have been selected in view of assessing the competencies and learning outcomes that graduates are expected to attain. Therefore, a total of 13 major mandatory courses are selected for exit exams under a specified thematic area.

Sl. No.	Themes	Course Name	Cr.hrs
1.	Materials science and engineering basics	Fundamentals of Materials science and Engineering	3
		Thermodynamics of Materials	3
		Crystal Structures of Materials	3
		Solid State Physics for Materials	3
		Fundamentals of Semiconductors	3

		Total Cr.hrs	15
7.	Metals	Fundamentals of Metallurgy	3
		Principle of Extractive Metallurgy	3
		Metal Processing with Lab	2
		Total Cr.hrs	8
11.	Ceramics	Fundamentals of Ceramics	3
		Glasses and Glass-Ceramics	3
		Ceramic Processing with Lab	3
		Total Cr.hrs	9
15.	Polymers	Fundamentals of Polymers	3
		Polymer Processing with Lab	3
		Total Cr.hrs	6
Total Cr.hrs of program			38

6. TEST BLUEPRINT CONTENTS PREPARATION

The blue print content was prepared according to the following formula
Share of the Themes/Courses/Items in Percentage (%) as per the table below

- Share of themes (T) = $\frac{a}{b} \times 100$, Where “a” is the credit hour of a theme and “b” is the total credit hour of the program.
Credit hour of a theme is the sum of credit hours of courses in the theme.
- Share of courses per theme (C) = $\frac{\text{Credit hour of the course}}{\text{Credit hour of the theme}} \times 100$
- Share of items per course = $\frac{\text{Share of the course} \times \text{Total number of items}}{\text{Total number of items}}$

Table: Material science and Engineering Exist Exams Blueprint showing the learning outcomes and number of

Themes	Name of Courses	Cr. hrs	General Objective	Learning outcome	Learning outcomes								
					Cognitive								
					Remembering	Understanding							
Material Science Basic Share of the themes in % = 39.5 %	Fundamentals of Materials science and Engineering	3	The primary objective of the course is to equip the student with a number of fundamental materials theories as well as some area of application. The student will learn the basics en general knowledge about Materials Science en Engineering.	1. Describe the Materials Sci and Eng. Paragon	1	X	X	X	X	X	X	X	8
				2. Understand the fundamental concepts and properties of different classes of materials	X	1	X	X	X	X	X	X	
				3. Be aware of the roles of different materials at specific eras of human	X	X	X	X	X	X	1	X	

				developemtn									
				4. Value the important role materials and materials science and engineering professionals plays in the advancement of new technology	X	X	X	X	X	X	1	X	
				5. Explain basic concept (Atoms, Bonding, Crystal, Unit cell etc) core to the material science and engineering decipline	X	1	X	X	X	X	X	X	
				6. Classify everyday materials based on their application and	X	1	X	X	X	X	X	X	

				structure									
				7. Solve basic equations related to the mechanical properties of engineering materials	X	X	1	X	X	X	X	X	
				8. Demonstrate appropriate knowledge of the range of different materials properties	X	X	1	X	X	X	X	X	
	Thermodynamics of Materials	3	The primary objective of the course is to equip the student with the essential competence to understand thermodynamics of materials and chemical reactions in MS&E, taking in account the size of the system in order to apply the classical thermodynamics or the statistical thermodynamics	1. Name various and different thermodynamics principles	1	X	X	X	X	X	X	X	8
				2. Solve simple problems related to different thermodynamic principle	X	X	1	X	X	X	X	X	
				3. Differentiate different thermodynamic terms as it applies to different systems	X	X	X	1	X	X	X	X	

				4. Compare the fundamental differences between different laws of thermodynamic	X	X	X	X	1	X	X	X	
				5. Make simple inference from the solutions to simple thermodynamic problems	X	X	X	1	X	X	X	X	
				6. Define simple thermodynamic laws and their mathematical expression	1	X	X	X	X	X	X	X	
				7. Classify and identify common materials properties base on their thermodynamic properties	X	1	X	X	X	X	X	X	
				8. Explain the relationship between thermodynamic terms such as Heat, work, Internal Energy and Enthalpy	X	1	X	X	X	X	X	X	

	Crystal Structures of Materials	3	To understand fundamental theory of the structure of crystalline solids, crystalline changes, their influences on the properties of crystals and the basics for microscopic examination of crystal structures.	1. Define basic concepts of crystallography and crystal imperfections	1	X	X	X	X	X	X	X	8
				2. List common crystal system in engineering materials	1	X	X	X	X	X	X	X	
				3. Distinguish between different crystal systems with respect to their unique properties	X	1	X	X	X	X	X	X	
				4. Classify different materials into appropriate crystal	X	1	X	X	X	X	X	X	

				systems									
				5. Using mathematical equation ascertain/index/justify different X-ray diffraction pattern into appropriate crystal system	X	X	X	1	X	X	X	X	
				6. Deduce and infer different crystallographic direction using basic miller indices	X	X	X	1	X	X	X	X	
				7. Explain the physical	X	1	X	X	X	X	X	X	

				properties of crystal using tensor									
				8. Compare different methods of crystal growth and their respective limitation	X	X	X	X	1	X	X	X	
	Solid State Physics for Materials	3	To understand crystal structures, interatomic forces, X-ray/ Neutron/ Electron diffraction in crystals, lattice vibrations, the free-electron model, energy band in solids, semiconductors, and dielectric & optical properties of solids	1. Identify basic principles such as atomic vibrations, thermal properties, optical, magnetic, and electronic behaviours in solid materials	1	X	X	X	X	X	X	X	8
				2. Using the concept of band theory, classify materials into different	X	1	X	X	X	X	X	X	

				groups									
				3. Describe the basic mathematical equations that characterizes the basic principles in Solid state physic for materials	1	X	X	X	X	X	X	X	
				4. Compare and contracts different magnetic/Dielectric properties that can exist in materials	X	X	X	X	1	X	X	X	
				5. Distinguished between the different types of	X	1	X	X	X	X	X	X	

				semiconductors									
				6. Demonstrate appropriate application of semiconductors based on doping level and bias	X	X	1	X	X	X	X	X	
				7. Using simple mathematical relations solve simple problems in semiconductor physics	X	X	1	X	X	X	X	X	
				8. Appropriate materials Selections for different applications based on materials properties	X	X	X	1	X	X	X	X	

	Fundamentals of Semiconductors	3	To understand the basic properties of semiconductors, elements of quantum mechanics, energy band theory, equilibrium carrier statistics, recombination-generation processes, and carrier transport.	1. List common semiconductor materials and their crystal structure	1	X	X	X	X	X	X	X	8
				2. Understand basic principles in quantum mechanics such as Black-body radiation and wave-particle duality	X	1	X	X	X	X	X	X	
				3. Explain simple electronic transport properties such as equilibrium carrier statistic, recombination and generation process in Semiconductor	X	1	X	X	X	X	X	X	
				4. Demonstrate an in-depth knowledge of the following semiconductor devices (pn-junction, transistors, diodes, solar cells, and Light Emitting	X	X	1	X	X	X	X	X	

				Diode)									
				5. Using simple mathematical equations solve simple problems with respect to carrier concentration, current density, doping level etc. in semiconductor	X	X	1	X	X	X	X	X	
				6. Differentiate between a diode, a rectifier and a transistors	X	X	X	1	X	X	X	X	
				7. Differentiate between a Light Emitting Diode and a solar Cell	X	X	X	1	X	X	X	X	
				8. Justifies the selection of certain semiconductor	X	X	X	X	1	X	X	X	

				materials and not others for specific application based on several engineering factors									
	Total Credit of Theme	15											
Metals Share of the themes in % = 21%	Fundamentals of Metallurgy	3	The primary objective of the course is to equip the student with the essential knowledge to understand the metallurgy and fundamental concept in with respect to materials properties in MS&E	1. Describe simple metallurgical phenomenon such as phase diagram, solidification, diffusion, Kinetics, heat transport in metals	1	X	X	X	X	X	X	X	8
				2. List different types of equilibrium phase diagrams and with examples of engineering systems they are prominent	1	X	X	X	X	X	X	X	
				3. Distinguish between different types of diffusion using simple	X	1	X	X	X	X	X	X	

				mathematical equations									
				4. Explain the important concept such as nucleation and growth phenomenon in alloys	X	1	X	X	X	X	X	X	
				5. Using simple phase rule relationship predict different microstructure obtainable at different composition on a common Temperature Vs. Composition phase diagram	X	1	X	X	X	X	X	X	
				6. Using simple mathematical relation differentiate between different mass and heat transfer problems	X	X	X	1	X	X	X	X	
				7. With the understanding of solidification in metals justifies and compare the selection of processing routes such as equilibrium and non-	X	X	X	X	1	X	X	X	

				equilibrium processing									
				8. Understand the role metals and alloys plays in the development of the modern society	X	X	X	X	X	X	1	X	
	Principle of Extractive Metallurgy	3	To understand processing methods and technologies of extractive metallurgy to remove valuable metals from an ore and to refine the extracted raw metals into a purer form.	1. Appreciate the early development of metal extraction and discovery of metals	X	X	X	X	X	X	1	X	8
				2. List the use of ferrous and non-ferrous metal in Ethiopia history	1	X	X	X	X	X	X	X	
				3. Describe the approach of metal extraction and refining from sources such as oxides, sulphide	1	X	X	X	X	X	X	X	
				4. Identify the sources of ferrous and non-ferrous metal	X	1	X	X	X	X	X	X	

				5. Explain different metal exploration methods based on their sources	X	1	X	X	X	X	X	X	
				6. Demonstrate the understanding of the underlying principle of mineral separation and beneficiations from ores	X	X	1	X	X	X	X	X	
				7. Solve simple balance chemical equation necessary for metal and mineral extraction	X	X	1	X	X	X	X	X	
				8. Compares different methods to produce precious metals such as gold, silver platinum etc.	X	X	X	X	1	X	X	X	
	Metal Processing with Lab	2	To deepen the student understanding of metals processing chain, from the ore	1. Create different metal alloys and composites using simple techniques such as milling, casting and forming	X	X	X	X	X	1	X	X	5

			beneficiation process until the metallurgical-mechanical process engineering.	2. Design new metal alloys and composites using casting, forming and welding.	X	X	X	X	X	1	X	X	
				3. Combine different comminution techniques for raw materials processing before further processing	X	X	X	X	X	X	X	1	
				4. Differentiate, screen and separate raw materials into different component before processing	X	X	X	1	X	X	X	X	
				5. Using different techniques characterize final product and make appropriate inference on their quality/properties	X	X	X	X	X	X	X	1	
	Total Credit of Theme	8											

Ceramics Share of the themes in % = 23.7%	Fundamentals of Ceramics	3	To introduce the student to the basic knowledge of ceramic materials and the subject ceramics engineering and equipped the student with the required understanding needed for probable higher studies and specialization in ceramic engineering.	1. Describe the history and use of ceramic in everyday life	1	X	X	X	X	X	X	X	8
				3. List the chemical composition of common ceramic materials	1	X	X	X	X	X	X	X	
				5. Distinguish between soft and hard ceramic materials based on their physical properties	X	1	X	X	X	X	X	X	
				7. Explain the different properties of ceramic materials	X	1	X	X	X	X	X	X	
				9. Classify different ceramic materials based on their chemical composition, structure and imperfections	X	1	X	X	X	X	X	X	
				11. Use simple mathematical equation to express the different properties of	X	X	X	1	X	X	X	X	

				ceramics									
				13. Compare different processing techniques for ceramic materials and make an appropriate judgement	X	X	X	X	1	X	X	X	
				15. Understand the role of ceramic materials plays in the development of the modern society	X	X	X	X	X	1	X	X	
	Glasses and Glass-Ceramics	3	Understand the basic principles of the glass formation, structure of glasses, and various properties including thermal, optical and chemical properties of glasses. In addition student will understand the relaxation	1. Outline the basic principle of glass formation	1	X	X	X	X	X	X	X	8
				2. Identify different properties of glass such as optical, thermal and chemical and mechanical	1	X	X	X	X	X	X	X	
				3. Explain the different glass-transition phenomenon such viscosity, relaxation and glass-transition	X	1	X	X	X	X	X	X	

			phenomenon in glasses and spectroscopic properties of rare-earth doped glasses and their applications.	temperature									
				4. Predict the structure of glass base on their nature and classify different types of glass	X	1	X	X	X	X	X	X	
				5. Appropriate selection of glass for different application based on their properties	X	X	1	X	X	X	X	X	
				6. Separate glass based on their physical properties and applications	X	X	X	1	X	X	X	X	
				7. Justify the relationship and differences between different types of glass	X	X	X	X	1	X	X	X	
				8. Value the role of glass and glass-ceramic based on their importance and properties	X	X	X	X	X	X	1	X	

	Ceramic Processing with Lab	3	To introduce the basic knowledge of the Processing techniques of ceramics, testing of ceramics, inspection of ceramics, and near net shape manufacturing processes of ceramics with process flow sheet starting with powder and finishing with the near net shape of product for the student to gain hands-on experience in this area.	1. Create different ceramics and ceramic composites using simple technique such as milling and foundry	X	X	X	X	X	1	X	X	8
				2. Design new ceramic materials and composites using foundry techniques	X	X	X	X	X	1	X	X	
				3. Articulate different ceramic processing techniques	X	1	X	X	X	X	X	X	
				4. Arrange different processing sequence for ceramic processing	X	X	X	1	X	X	X	X	
				5. Justify materials selection for the creation and fabrication of specific ceramic materials.	X	X	X	X	1	X	X	X	

				6. Value the relationship between processing technique and the final ceramic product	X	X	X	X	X	X	1	X	
				7. Precise evaluation of ceramics materials base on their properties	X	X	X	X	X	X	X	1	
				8. Appropriate manipulation of ceramic processing parameters	X	X	X	X	X	X	X	1	
	Total Credit of Theme	9											
Polymers Share of the themes in % = 15.8 %	Fundamentals of Polymers	3	This course is designed to help student understand how the polymer can be synthesized, characterized, and how those polymers are applied in our lives and science as well	1. Discuss the basic concept of polymer	1	X	X	X	X	X	X	X	8
				2. List the type of polymerization techniques	1	X	X	X	X	X	X	X	
				3. Classify the polymers based on their chemical	X	1	X	X	X	X	X	X	

				compositions and properties									
				4. Explain the strengthening mechanism in polymer	X	1	X	X	X	X	X	X	
				5. Solve simple chemical and mathematical equation in polymerization techniques	X	X	1	X	X	X	X	X	
				6. Separate polymers into different categories based on their polymerization techniques	X	X	X	1	X	X	X	X	
				7. Compare amorphous and crystalline polymers based on their properties	X	X	X	X	1	X	X	X	

				8. Judge the impact of polymer products in the modern life	X	X	X	X	X	X	1	X	
	Polymer Processing with Lab	3	To introduce the student to the basic knowledge of the Processing techniques of polymers and the synthesis of polymers with specific properties. The student will develop an understanding of the relationship between the process/synthesis parameters and the properties of the polymer obtained. The student will gain a hands-on experience in this area.	1. Create different polymer and po imple technique	X	X	X	X	X	1	X	X	7
				2. Develop polymer with distinct properties	X	X	X	X	X	1	X	X	
				3. Articulate and differentiate different polymers processing techniques	X	1	X	X	X	X	X	X	
				4. Arrange different processing sequence for polymer processing and synthesis	X	X	X	1	X	X	X	X	
				5. Justify materials selection for the creation and fabrication of specific polymer materials.	X	X	X	X	1	X	X	X	

[illegible]

7. CONCLUSION

This blueprint for the national exit examination in Materials Science and Engineering will have a vital role in aiding examiners to prepare questions to assess the knowledge, skill and attitude of Materials Science and Engineering graduate in the country. The outcome of this whole exercise will help in improving academic programs' quality and effectiveness. It is clear that evaluating the graduates against the core competencies and learning outcomes set out by the curriculum and in line with the industrial needs would be important to enhance the trust of the employers in the graduate's skills. To realize this, it is important to have a guideline i.e. the test blueprint that could be used as a reference to prepare for the comprehensive exit exam that could address the relevant focus areas of the program. Based on the identified graduate profiles, competencies, and learning outcomes the percentage of each number of test items with respect to each learning domains have been determined and summarized in the table above. It is expected that this blueprint will be followed for the preparation of the exit exam in **Materials Science and Engineering (B.Sc.)**.

The number of test items based on the selected courses are believed will test the knowledge, skills, and attitudes that are expected as the attainment of the competencies and learning outcome of **Materials Science and Engineering Degree**.

