Ministry of Education

Blueprint for National Exit Examination to be held in 2016 E.C

Band: One

Program: - Bachelor of Science Degree in Chemical Engineering

(Revised Version-2016 E.C)

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1. Introduction

Graduates' performance and overall understanding of chemical engineering profession needs to be assessed to assure that students meet graduate profiles and the program learning outcomes. Currently, all universities in Ethiopia have a set of fixed exams that students must pass as graduation requirements. However, there is a growing trend of implementing exit exams at the end of the bachelor's program, initiated by some programs on their own accord. The Ministry of Education now intends to establish and implement exit examinations for all undergraduate programs at a national level. The purpose of exit exams goes beyond fulfilling graduation requirements. They are designed to help students prepare for more advanced postgraduate studies and to assess their skills, attitudes, and knowledge in the field of chemical engineering upon completion of their education program. By introducing exit exams, not only do students fulfill the requirements for graduation, but it also helps to foster a mindset of academic achievement, enhances their prospects for securing industrial jobs, reduces disparities among programs at different universities, and establishes evaluation standards. Ultimately, the implementation of exit exams ensures quality education and creates equal opportunities for professional licensing and employment in the job market for graduates from different universities.

As part of the national harmonization of chemical engineering curricula, universities offering Chemical Engineering Programs in Ethiopia have currently implemented a standardized curriculum. Hence, a total of 17 common major courses have been identified. Additionally, competency areas have been determined to align with the program's learning outcomes. The objective of this document is to provide a blueprint for the exit exam, which will assist in the preparation of exam items based on the identified courses and their corresponding competencies and learning outcomes.

2. Objective of Test Blueprint

The objective of the test blueprint for the chemical engineering program's exit exam is to assist in the preparation of a comprehensive and representative examination that covers the complete learning domain expected from graduating chemical engineering students. The test blueprint serves for the following purposes:

- Facilitate the construction of a balanced and representative set of exam items for the selected courses, ensuring that the exam adequately covers the identified competencies.
- Guide the experts involved in developing and preparing the exam by providing a framework for setting appropriate exam items. This includes determining the proper distribution of questions among the identified courses, course themes, learning outcomes, and competencies.

  - By following the test blueprint, the exam developers can ensure that the exit exam effectively evaluates the students' understanding and proficiency in the chemical engineering program, and that it aligns with the desired learning outcomes and competencies.

3. Expected Profile of the Graduates

A graduate profile is a description of attributes (knowledge, skill, and attitude) that the program aspires for its students to attain. In line with this conceptual framework chemical engineering program has more or less the same graduate profiles as it is drawn from three different curricula. The chemical engineering program has the following key occupational tasks and responsibilities that should be attained by graduates.

- Involving in the plant layout, design, construction, and operation of industrial plants.
- Conducting economic and technical feasibility studies of chemical and process industries,
- Modeling process, design, and evaluation by using appropriate computer programs,
- Designing, testing, and commissioning processes, equipment, and plants.
- Managing troubleshoots and solving problems to optimize the production processes;

- Overseeing the construction, modification, operation, and maintenance of pilot plants, processing units, or processing plants;
- Acting as a liaison between plant engineering personnel and equipment suppliers.
- preparing tender documents, bid evaluation, and coordinating industrial construction projects;
- Ensuring efficient, optimum, safe, and environmentally responsible plant operation; establishing and conducting quality control programs; operating and assessment procedures and control strategies to ensure consistency and adhere to standards;
- Frontally work with control and instrumentation specialists, supervision, and cooperation with other engineering personnel;
- Participating and advising industry and governmental bodies regarding environmental policies and standards;
- Teaching undergraduate Chemical Engineering Courses and assisting advanced courses.
- Working in multidisciplinary environments as well - especially under the conditions of globalization international cooperation or business;
- Coordinating research and development activities;
- Working in sustainable energy technologies and energy optimization systems;

Generally, Chemical Engineering graduates should have basic scientific, technical, ethical, communication, and leadership skills wherever they work and pursue their further studies.

4. Objectives of the Program

4.1. General Objectives

Chemical Engineering graduates are well equipped for a wide variety of positions as practicing chemical engineers or for graduate studies in engineering and scientific disciplines.

The program encourages continued learning and professional development by providing the proper knowledge and stimulation in a setting that promotes personal growth. The main objectives of the program include:

1. Provide students with a high-quality education that will enable them to adapt to a rapidly changing technical environment.
2. Produce graduates who will be productive throughout their careers in a wide range of industrial, professional, and academic environments.
3. Develop graduates with strong sense of ethics, professionalism, and the ability to succeed as both individual and team contributors.
4. To produce qualified Chemical Engineers who are instrumental in the development of the industrial sector of the country.
5. To carry out research in line with the development needs of the country.
6. To provide consultancy and technical services to the industrial sector and other socioeconomic sectors of the country.
7. To produce technically sound and practically competent engineers of global standard.
8. To train professionals equipped with relevant knowledge and skills, who would contribute to the development of the country.

4.2. Specific Objectives

The specific objectives are very specific statements that describe exactly what a student will be able to do in some measurable way. There may be more than one measurable specific objectives defined for a given competency. The specific objectives identified for Chemical Engineering Program are presented below:

1. Apply knowledge of basic science, engineering fundamentals and chemical engineering principles to solve complex engineering problems.

2. Identify, formulate, and analyze complex chemical engineering problems to design their solutions, develop systems and processes that meet specified needs with appropriate consideration for public health, safety, and environmental considerations using principles of science and chemical engineering.

3. Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply them to manage projects in multi-disciplinary environments.

4. Recognize the need for, and have the preparation and ability to engage in, independent and life-long learning in the broadest context of technological changes in chemical engineering profession.

5. Learning Outcomes and Competencies

5.1. Learning Outcomes

After completing the Chemical Engineering program, graduate students will be able to:

- ♣ Create a comprehensive understanding of fundamental principles and concepts in chemical engineering; including thermodynamics, transport phenomena, reaction kinetics, and process design.
- ♣ Know the fundamental concepts and principles of mass transfer processes.
- ♣ Formulate and solve problems related to material and energy balances in various processes, considering single and multiple components, as well as systems with and without chemical reactions.
- ♣ Apply the fundamental concepts, principles, and applications of heat and mass transfer processes in chemical industries.
- ♣ Know the application of various unit operations in chemical and process industries.
- ♣ Know the most common unit operations involved in chemical process industries.
- ♣ Build the capability to utilize thermodynamic equations and principles when designing distillation columns, heat exchangers, liquid-liquid separation processes, leaching processes, and chemical reactors.
- ♣ Understand heat and mass transfer processes that enable to design equipment that is useful for chemical separation.
- ♣ Develop and apply kinetic equations for sizing different reactor models.
- ♣ Develop and apply design equations for homogenous and heterogeneous reactions with single and multiple reactor systems.
- ♣ Understand enzyme reactions by utilizing knowledge from the study of enzyme kinetics and applying principles of catalysis.
- ♣ Set up an efficient bioreactor system for cultivating cells under optimal conditions.
- ♣ Understand how real reactors are more complex than the ideal ones and how the heterogeneous reaction kinetics involve more complex procedures than the homogeneous ones.
- ♣ Understand the fundamental principles of process equipment design and key parameters involved in the design of equipment.
- ♣ Distinguish the economic evaluation of the project and different profitability analyses.
- ♣ Develop a strong sense of confidence to undertake designing and modelling tasks.

- ♣ Know the primary application areas of heat exchangers, and provide an overview of their practical applications.
- ♣ Identify, formulate, and analyse complex chemical engineering problems to design their solutions, and develop systems and processes that meet specified needs with appropriate consideration for public health, safety, and environmental considerations using principles of science and chemical engineering.
- ♣ Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply them to manage projects in multi-disciplinary environments.
- ♣ Appreciate the designing techniques for different equipment.
- ♣ Understand the special behaviour of various chemicals and materials.
- ♣ Understand what chemical process controls, the needs and incentives for controlling a chemical process, analyse the characteristics of a control system, and formulate the problems that must be solved during its design.
- ♣ Understand the types of feedback controller and examine their effects on the response of a chemical process.
- ♣ Recognize the need to develop a mathematical model of a chemical process, a methodology for modelling a chemical process, and the scope and difficulties of mathematical modelling for process control purposes.
- ♣ Know the main raw materials, steps, and process descriptions for the manufacturing of different chemical process technologies.
- ♣ Study and interpret block diagrams, flow sheets, and mathematical models of various chemical processes.
- ♣ Analyse the stability characteristics of a feedback control system and how to design the appropriate feedback system to control a given process.

5.2. Competencies

Competencies encompass the practical application of knowledge, skills, and attitudes that empower individuals to effectively perform in various professional, educational, and personal contexts. In the context of the chemical engineering field, competencies represent the desired knowledge, skills, and attitudes that graduates should possess upon completing their studies. Table 3.1 provides a comprehensive representation of the competencies associated with the chemical engineering program in terms of knowledge, skills, and attitudes.

Table 5.1. Core Competencies of the Program

S/N	Areas of Competency	Expected Competencies to be Achieved
1	Knowledge	Generally, Graduates will be to contribute in the world of Job: - • Demonstrate proficiency in conducting laboratory experiments, collecting and analyzing data, and interpreting experimental results to evaluate the performance of chemical processes and systems. • Recognize the practical application of science, engineering, and technology, which includes integrating principles, techniques, procedures, and equipment to the design, and production of various goods and services. • Optimize the process flow, plant design, and material utilization in industries. • Describe optimized production processes for maximizing safe and effective chemical production. • Analyze and evaluate the special behavior of chemical, and biochemical systems. • Strive to excel in education, research, and service, thereby making significant contributions to the field of chemical engineering to the state, the nation, and the world. • Investigate various approaches to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems. • Design and optimize chemical processes and systems by integrating knowledge of chemistry, engineering principles, and economic considerations, while considering safety, sustainability, and ethical implications. • Collaborate effectively in interdisciplinary teams, demonstrating leadership skills, adaptability, and an understanding of diverse perspectives to solve engineering problems and achieve project goals. • Understand the societal and environmental impacts of chemical engineering practices, and apply principles of sustainable development to develop innovative and responsible solutions. • Know how to manage projects effectively, coordinate teams, and ensure project objectives are met within specified timelines and budgets.

2	Skill	• Operate, maintain, and identify problems in various chemical and process industries. • Apply chemical engineering software to optimize the process flow, plant design, and material utilization. • Develop and interpret block diagrams, flow sheets, and mathematical models of various chemical processes. • Carry out different chemical engineering laboratory activities. • Apply mathematical and scientific principles to analyze and solve complex problems in chemical engineering, employing quantitative and qualitative analysis methods.
3	Attitude	• Being adaptable and flexible in their approach, willing to learn new technologies, adapt to changing circumstances, and tackle unfamiliar problems. • Communicate effectively and function within a team to collaborate and create an inclusive environment with the scientific community and stakeholders. • Being loyal, ethical, and responsible to the profession and the community. • Stay updated with advancements in the field of chemical engineering, engage in lifelong learning, and demonstrate a commitment to professional growth and ethical conduct. • Develop a strong sense of confidence to undertake designing and modeling tasks in chemical, biochemical, and explosive industries.

6. Themes, List of Courses and Credit Hours

The selection of themes for the courses is based on careful consideration of the program's learning outcomes and the contribution of each course towards achieving those outcomes. Consequently, the courses included in the exit examination are categorized into the following themes: chemical engineering basics, reaction engineering and biochemical engineering, transport phenomena and separation processes, process industries and control, and chemical engineering design. These themes are illustrated in Table 6.1.

Table 6.1. Courses list for exit examination

S/N	Themes	Course Name	Course Credit	Course ECTS
1	Chemical Engineering Basics	Introduction to Chemical Engineering	3	5
		Chemical Engineering Thermodynamics I	3	5
		Chemical Engineering Thermodynamics II	3	5
		Mechanical Unit Operations	3	6
		Fluid Mechanics for Chemical Engineers	3	5
		Fluid Machines in Chemical Engineering	3	5
		Total credit hours/ECTS	**18**	**31**
2	Reaction Engineering and Biochemical Engineering	Reaction Engineering I (Kinetics)	3	5
		Reaction Engineering II (Reactor Design)	3	6
		Introduction to Biochemical Engineering	3	5
		Total credit hours/ECTS	**9**	**16**
3	Transport phenomena and separation processes	Thermal Unit Operations	3	6
		Heat and Mass Transfer	3	5
		Mass Transfer Unit Operation	3	5
		Total credit hours/ECTS	**9**	**16**
4	Process Industries & Control	Process Industry I	3	5
		Process Industry II	3	5
		Process Dynamics and Control	3	6
		Total credit hours/ECTS	**9**	**16**
5	Chemical Engineering Design	Chemical Engineering Apparatus Design	3	6
		Plant Design and Engineering Economics	3	6
		Total credit hours/ECTS	**6**	**12**
Grand total Cr.Hrs/ECTS			**51**	**91**

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

Table 7.1: Share of Themes, Courses/Items in %

S/N	Themes	Share of Themes in %	Course Name	Share of Items Per Course In %
1	Chemical Engineering Basics	35	Introduction to Chemical Engineering	6
			Chemical Engineering Thermodynamics I	6
			Chemical Engineering Thermodynamics II	6
			Mechanical Unit Operations	6
			Fluid Mechanics for Chemical Engineers	6
			Fluid Machines in Chemical Engineering	5
2	Reaction Engineering and Biochemical Engineering	18	Reaction Engineering I (Kinetics)	7
			Reaction Engineering II (Reactor Design)	5
			Introduction to Biochemical Engineering	6
3	Transport phenomena and separation processes	18	Thermal Unit Operations	6
			Heat and Mass Transfer	6
			Mass Transfer Unit Operation	6
4	Process Industries & Control	17	Process Industry I	5
			Process Industry II	6
			Process Dynamics and Control	6
5	Chemical Engineering Design	12	Chemical Engineering Apparatus Design	5
			Plant Design and Engineering Economics	7

Note: - The share of items of themes and courses are calculated based on the following formula:

- Share of themes = $\frac{a}{b}\ x\ 100$; 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 = $\frac{Credit\ hour\ of\ the\ course}{Credit\ hour\ of\ the\ theme}\ x\ Share\ of\ themes\ in\ \%$
- Share of items per course = $Share\ of\ the\ course\ X\ Total\ number\ of\ items$

Table 7.2: Share of themes, courses and item of course from a total of 100 test items

Themes	Course Name	Cr. Hrs.	Weight of Course or Proportion	Number of test Items from each course	Cognitive						Affective	Psychomotor	Total
					Remember	Understand	Apply	Analyze	Evaluate	Create			
Theme One Share = **35** Items from the total	Introduction to Chemical Engineering	3	3/18 = 0.167	0.167*35 = 6	1	2	0	1	1	0	1	0	6
	Chemical Engineering Thermodynamics I	3	3/18 = 0.167	0.167*35 = 6	1	2	1	1	1	0	0	0	6
	Chemical Engineering Thermodynamics II	3	3/18 = 0.167	0.167*35 = 6	1	2	1	1	1	0	0	0	6
	Mechanical Unit Operations	3	3/18 = 0.167	0.167*35 = 6	1	1	1	1	0	0	1	1	6
	Fluid Mechanics for Chemical Engineers	**3**	3/18 = 0.167	0.167*35 = 6	0	1	1	1	1	0	1	1	6
	Fluid Machines in Chemical Engineering	**3**	3/18 = 0.167	0.167*35 = 5	1	0	1	0	1	0	1	1	5
	Total credit hours of Theme one	**18**											
Theme Two Share = **18** Items from the total	Chemical Reaction Eng. I (kinetics)	3	3/9 = 0.33	0.33*18 = 7	1	1	1	1	1	0	1	1	7
	Chemical Reaction Eng. II (Reactor Design)	3	3/9 = 0.33	0.33*18 = 5	0	1	1	1	0	0	1	1	5
	Introduction to Biochemical Eng'g.	3	3/9 = 0.33	0.33*18 = 6	2	1	1	1	1	0	0	0	6
	Theme two total credit	**9**											
Theme Three Share = **18** Items from	Thermal Unit Operations	3	3/9 = 0.33	0.33*18 = 6	1	1	1	1	0	0	1	1	6
	Heat and Mass Transfer	3	3/9 = 0.33	0.33*18 = 6	1	1	1	1	1	0	0	1	6
	Mass Transfer Unit Operation	3	3/9 = 0.33	0.33*18 = 6	1	1	1	1	1	0	0	1	6

the total	**Theme three total credit**	**9**											
Them Four Share = **17** Items from the total	Process Industry I	3	3/9 = 0.33	0.33*17 = 5	1	1	1	1	0	0	1	0	5
	Process Industry II	3	3/9 = 0.33	0.33*17 = 6	1	1	1	1	0	0	1	1	6
	Process Dynamics and Control	3	3/9 = 0.33	0.33*17 = 6	1	1	1	1	0	0	1	1	6
	Theme four total credit	**9**											
Theme five Share = 12 Items from the total	Chemical Engineering Apparatus Design	3	3/6 = 0.5	0.5*12 = 5	1	1	0	1	1	0	1	0	5
	Plant Design and Engineering Economics	3	3/6 = 0.5	0.5*12 = 7	1	1	1	1	1	0	1	1	7
	Theme six total credit	**6**											
Total for the Program		**51**			**16**	**19**	**15**	**16**	**11**	**0**	**12**	**11**	**100**

Note: - The number of items assigned in the levels of domains is based on the nature of learning outcomes/objectives.

8. Test Blueprint (Table Specification) for Chemical Engineering Program

Table 8.1: Test Blueprint (Table Specification) for Chemical Engineering program

Themes	Share of themes	Competency/General Objective	Courses under the themes	Cr. Hrs.	Share of courses	Learning Outcome/ Specific Objectives	Total	Learning outcomes and test weight/ items							
								Cognitive						Affective	Psychomotor
								Remembering	Understanding	Applying	Analysing	Evaluating	Creating		
1. Chemical Engineering Basics	35 items	Develop a solid foundation in the basic principles of chemical engineering and acquire fundamental skills in chemical engineering calculations, with a focus on material (mass) and energy balances in chemical processes. Additionally, it is essential to understand the fundamental principles of thermodynamics and their application to heat and mass transfer, ensuring efficient operation of process units in the process industry. Furthermore, the objective is to gain a comprehensive understanding of particulate solids, solid handling in chemical and related industries, efficiency assessment of solid-solid or solid-liquid separation equipment, and the determination of power requirements for agitation and	Fundamentals of Chemical Engineering	3	6 items	Identify and discus the material and energy balances for different process systems.	6%		1						
						Analyse the effect of material and energy balance for processes involving single and multiple components with and without reactions.					1				
						Appreciate the role of material and energy balances in different process systems.								1	
						Define classification of processes such as steady-state, transient, continuous, and batch processes and process variable		1				1			
						Understand the basics principles and concepts of chemical engineering.			1						
			Chemical Engineering Thermodynamics I	3	6 items	Define and explain basic concepts in thermodynamics.	6%		1						
						Recognize the volumetric properties of fluids.		1							
						Explain phase and reaction equilibrium mathematically and graphically by applying equilibrium criterion.			1						
						Apply the thermodynamics equations and principles in designing power plants, refrigeration thermodynamics of flow processes, production of power from heat, refrigeration and liquefaction, chemical equilibrium and thermodynamic analysis of processes, and chemical reactors and chemical processes.						1			
						Calculate sensible, latent and standard heats of reactions.					1				
						Apply the second of law of thermodynamics to solve engineering problems.				1					

		mixing processes. By achieving these objectives, individuals will be equipped with the necessary knowledge and skills to apply chemical engineering principles and calculations in solving problems related to process design, optimization, and operation across various industries.	**Chemical Engineering Thermodynamic II**	**3**	**6 items**	Estimate thermodynamic properties of ideal non-ideal solutions.						1			
						Analyze and predict the behaviour of compressible fluids under various flow conditions and within different types of equipment.					1				
						Explain the solution thermodynamics and understand the application of solution thermodynamics for chemical engineering point of view	**6%**	1	1						
						Develop a comprehensive understanding of the application of thermodynamics in analysing the behaviour of compressible fluids in duct flow.			1						
						Apply the thermodynamics equations and principles in designing distillation column, heat exchanger, liquid-liquid separation, leaching process and chemical reactors.				1					
			Mechanical Unit Operations	**3**	**6 items**	Identify the different powder handling and processing equipment in chemical engineering with their working principles.		1						1	
						Compare and contrast the different fluid-particles mixture separation equipment and show their practical application areas.					1				
						Apply fluidization and beneficiation techniques.				1					
						Asses the energy requirement by comminution machines and recommends possible ways of improving energy efficiency.									
						Familiar with various separation techniques, such as filtration, sedimentation, centrifugation, and cyclones, is important for separating solids from liquids or gases.	6%								1
						Recognize, classify, explain, and apply filtration equipment for different chemical industries; design of filtration process and select suitable type of filter for filtration of slurry or suspension.			1						
						Operate the various cyclones, filters and other mechanical separation equipment.									1
			Fluid Mechanics for Chemical Eng.	**3**	**6 items**	Understand different flow regimes of fluid flow in channels and pressure losses			1						
						Identify the relationship between flow regimes and flow parameters to apply in process fluid machines	**6%**			1					
						Have the knowledge of solving/identifying fluid mechanics problems									1
						Evaluate the use of dimensionless groups in design							1		

						and scale up of fluid flow equipment's									
						Analyse the nature of forces exerted by static fluid on their containers					1				
						Gain insight and cultivate an appreciation for fluid mechanics by means of hands-on experiments and demonstrations.							1		
			Fluid Machines for Chemical Eng.		**5 items**	Know the different type of fluid machines used in the process industry and their applications	**5%**	1							
						Improve the performance of fluid machine									1
						Recognize the significance of fluid machines in chemical engineering applications							1		
						Evaluate the effect of different operation parameter						1			
						Illustrate the effects of flow parameters on fluid machine characteristics				1			1		
Total	**35 items**			**18**	**35 items**			**5**	**8**	**5**	**5**	**4**	**1**	**5**	**4**
2. Reaction and Biochemical Engineering	**17 items**	Gain a thorough understanding of the many types of reactors used in chemical processes, as well as reaction kinetics and classifications. This involves the capacity to create performance formulas for different kinds of reactors and efficiently regulate the distribution of products in several reactions. Understanding the fundamentals of chemical reactor design also makes it possible to assess operational performance in both homogeneous and heterogeneous reactions. Moreover, developing critical techniques for the design, operation, and management of bioreactors and fermenters in bioprocesses requires a grasp of the underlying principles of biological reactions.	**Reaction Engineering I (Reaction Kinetics)**	**3**	**6 items**	Develop and apply kinetic equations for sizing different reactor models.	**6%**			1					
						Evaluate and analyze product distribution for multiple reactions.					1				
						Understand design concepts for design of homogenous and heterogeneous reactors.			1						
						Discus the three basic ideal reactors with respect to conversation.		1							
						Select appropriate reactor types (e.g., batch, continuous, plug flow, stirred tank), sizing reactors, and optimizing reactor configurations.							1		
						Design homogenous and heterogeneous reactors.									1
			Reaction Engineering II (Reactor Design)	**3**	**5 items**	Select the appropriate kinetic equation for heterogeneous reaction with mass resistance.	**5%**								1
						List different types of reactors for non-catalyzed heterogeneous reactions.							1		
						Understand basics of non-ideal flow and develop models for non-ideal reactors.			1						
						Justify the effect of temperature and pressure on reaction kinetics and reactor design of a real reactor.				1					
						Understand the different ways of contacting catalysts and reactants in solid catalytic reactions.									

						Understand the various non-ideal flow models and analyze the flow in real reactors using Residence Time Distribution (RTD).					1				
			Introduction to Biochemical Engineering	**3**	**6 items**	Understand and solve enzyme reactions based on its kinetics study and applied catalysis.	6%	1			1				
						Apply the design equations to design an effective bioreactor to cultivate the cells in the optimum conditions.				1					
						List the design criterion of sterilization.		1							
						Integrate principles, theories and laws to design a bioreactor.			1						
						Evaluate microbial growth kinetics in batch and continuous cultures and exercise on biomass production, its application and downstream processing.					1				
Total	**18 items**			**9**	**18 items**			**3**	**5**	**2**	**2**	**2**	**1**	**1**	**2**
3. Transport and Separation Process	**18 items**	Develop an understanding of the fundamental principles governing heat and mass transfer, analyse heat and mass transfer processes in various systems, design thermal and mass transfer equipment, evaluate and optimize system performance, solve practical problems, and consider safety and environmental aspects. By achieving these objectives, individuals will be equipped with the knowledge and skills to analyse, design, and optimize systems involving heat and mass transfer, ensuring efficient and safe operations	**Thermal Unit Operations**	**3**	**6 items**	Understand the science behind heat transfer operations in the industry	6%		1						
						Analyze the equations used in designing heat transfer equipment's					1				
						Identifies the parameters to optimize performance of heat transfer equipment.		1							
						solve the size of different heat transfer equipment's				1					
						Align safety measures to prevent overheating and thermal loss									1
						Express the classification of heat exchanging equipment's								1	
			Heat and Mass Transfer	**3**	**6 items**	Apply the basic principles of heat transfer.	6%			1					
						Identify all mechanisms of heat transfer with applications.		1							
						Solve problems of steady and unsteady state heat conduction governed by Fourier's law.					1				
						Understand the radiation mechanism of heat exchange between bodies.			1						
						Evaluate problems of steady state heat convection governed by Newton's second law for cooling.						1			
						Operate heat exchanger equipment safely									1

			Mass Transfer Unit Operations	**3**	**6 items**	Identify fundamental of mass transfer principles	6%		1						
						Differentiate the various separation processes					1				
						Define the different types of separation mechanism		1							
						Interpret basic principles of separation mechanism				1					
						Evaluate the design parameters of separation equipment						1			
						Optimize the performance of the separation equipment									1
Total	**18 items**			**9**	**18 items**			**3**	**3**	**3**	**3**	**2**	**0**	**1**	**3**
5. **Process Industries and Control**	**17 items**	Develop knowledge and skills in analysing process behaviour, designing effective control strategies, optimizing process operations, understanding industrial processes, and solving real-world challenges in chemical process industries.	**Process Industry I**	**3**	**5 items**	Defines process flow diagram of selected chemical products	5%	1							
						Illustrate the production processes of ammonium nitrate, nitric acid and ammonium sulphate				1					
						Improve the production processes of Sulfuric acid and Recovery of used sulfuric acid									1
						Understand the manufacturing process of soda ash, sodium bicarbonate, and Caustic soda			1						
						Distinguish manufacture process of nitrogen Fertilizers, Phosphate Fertilizers, Potash Fertilizers					1				
			Process Industry II	**3**	**6 items**	Explain unit operation and processes in sugar and cement processing factories	6%	1							
						Apply chemical engineering skill in design sugar and leather processing factories				1					
						Align measure to optimize the sugar and leather processing factories									1
						Understand Leather Manufacturing, process			1						
						Differentiate unit operation and processes in alcohol and beverage processing factories					1				
						Justify utilizing alternative fuels and raw materials in cement production								1	
			Process Dynamics and Control	**3**	**6 items**	Reproduce fundamental and empirical models for dynamic processes	6%								1
						Justify stability and check the stability of systems								1	
						Interpret control diagrams				1					
						Identify control valves and its application		1							
						Understand of tuning			1						
						Analyze response of systems					1				

Total	**17 items**			**9**	**17 items**			**3**	**3**	**3**	**3**	**0**	**0**	**2**	**3**
5. Chemical Engineering Design	**12 items**	Develop a comprehensive understanding of process equipment design, encompassing criteria, procedures for equipment selection and sizing, equipment design techniques for common unit operations (including pressure vessels, heat exchangers, piping systems, and separation columns), principles of chemical plant design, and the ability to conduct overall economic analysis for a plant.	**Chemical Engineering Apparatus Design**	**3**	**5 items**	Understand factors to be considered while selecting construction materials for any chemical and process equipment.	**5%**		1						
						Understand & evaluate the mechanical design procedure of selected process equipment (heat exchangers, separation columns) .						1			
						Recognize the design codes and standards while designing equipment.								1	
						Understand the separation column operating principles is vital for selecting the appropriate column design for a given application.		1							
						Know the role of strength of materials in designing process equipment					1				
			Chemical Plant Design & Economics	**3**	**7 items**	Gain an understanding of the design criteria and determine the optimal location for a chemical plant, taking into account relevant design considerations	7%		1						
						Recognize economic, construction, safety, operability, and other constraints on design.									1
						List the steps in process design development and know what are the items should be compared to select a best suited process.		1							
						Analyse, synthesize and design processes for the production of products on a commercial scale				1		1			
						Recognize the limitations of available design data and methods								1	
						Know the economic evaluation of project and different profitability analysis					1				
Total	**12 items**			**6**	**12 items**			**2**	**2**	**2**	**1**	**2**	**0**	**2**	**1**

9. Share of Competencies (KSA) per Courses

Table 9.1: Share of Competencies (KSA) per Courses

S/No.	Themes	Course Name	Cr. Hours	Share of Courses (%)	Share of Competencies (%)			Total
					Cognitive	Affective	Psychomotor	
1	Chemical Engineering Basics	Introduction to Chemical Engineering	3	6	5	1	0	6
		Chemical Engineering Thermodynamics I	3	6	6	0	0	6
		Chemical Engineering Thermodynamics II	3	6	6	0	0	6
		Mechanical Unit Operations	3	6	4	1	1	6
		Fluid Mechanics for Chemical Engineers	3	6	4	1	1	6
		Fluid Machines in Chemical Engineering	3	5	3	1	1	5
2	Reaction Engineering and Biochemical Engineering	Reaction Engineering I (Kinetics)	3	7	5	1	1	7
		Reaction Engineering II (Reactor Design)	3	5	3	1	1	5
		Introduction to Biochemical Engineering	3	6	6	0	0	6
3	Transport phenomena and separation processes	Thermal Unit Operations	3	6	4	1	1	6
		Heat and Mass Transfer	3	6	5	0	1	6
		Mass Transfer Unit Operation	3	6	5	0	1	6
4	Process Industries & Control	Process Industry I	3	5	4	1	0	5
		Process Industry II	3	6	4	1	1	6
		Process Dynamics and Control	3	6	4	1	1	6
5	Chemical Engineering Design	Chemical Engineering Apparatus Design	3	5	4	1	0	5
		Chemical Plant Design & Economics	3	7	5	1	1	7
Total (Aggregate)			**51**	**100**	**77**	**12**	**11**	**100**

10. Conclusions

If implemented effectively, exit examinations can play a crucial role in enhancing the quality and effectiveness of academic programs. Additionally, they can serve as a platform for collaboration among academic programs across different universities, fostering joint efforts to improve program quality. With this in mind, this document has been created to provide guidance for the preparation of exit exam items for the Chemical Engineering program. These items are designed to be illustrative and representative of the broad knowledge domain covered by the program. They aim to ensure a balanced assessment of the graduate profiles, identified competencies, and major learning outcomes by selecting appropriate courses and assigning them appropriate weightings. The document also specifies the distribution of course themes, the weighting of each course within each theme, and the number of exam items to be included from each course.