



MINISTRY OF EDUCATION

Identification of Competencies and Courses for Exit Examination

Chemical Engineering Program

Courses and Competencies Identified for Exit Exam 2015 (First Draft)

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1. Introduction

Chemical Engineering is a profession that principally deals with the conversion of raw materials into variety of products. It is also concerned with conceiving an idea, designing, operating, controlling, optimizing and improving (modifying and modernizing) process industries to produce useful products and energy sources. Examples of products that are the results of the works of chemical engineers include various chemicals, petrochemicals, plastics, pharmaceuticals, agrochemicals, processed foods, energy (fuels, nuclear energy and others), pulp and paper, beverages, cement, ceramics, polymers, dyes and many others. Chemical Engineering, therefore, focuses on various processes that cause chemical, physical, biological, energy content changes in addition to designing and inventing the way to do so. In this context, Chemical Engineers use the principle of chemistry, physics, biology, mathematics, economics and engineering arts to efficiently use, produce, design, and convert energy sources, materials and process plants.

In one or another ways graduates performance and overall understanding of the profession should be assessed in order to assure whether students meet graduate profiles and the program learning outcomes. All the universities in Ethiopia have a series of fixed exams as graduation requirements for their students. Exit exams at the end of a bachelor academic track are recently being implemented by some programs by their own initiation. Currently, ministry of education intends to set and implement exit examinations for selected programs.

Currently, about 20 public universities in Ethiopia are running chemical engineering program. Among them, 18 universities put into effect nationally harmonized chemical engineering curriculum. The remaining two science and technology universities implemented their own curricula which are slightly deviated from the aforementioned one. These discrepancies pose challenges in the process of national exit examination preparation as far as courses and their themes considered. Due to this fact, 17 common compulsory courses were identified from both curricula and competency areas were determined as indicated in Tables 2 and 3.

1.1. Objectives of Exit Examination

Exit examination is not intended only for the sake of graduation fulfilment, rather it changes students mind setup for better academic achievement. In addition to this, the objective is

extended to securing industrial jobs, reducing the differences among the same programs at different universities, and setting standards in the evaluation systems. More specifically, exit examination will have the following explicit objectives;

- To ensure quality education and common gateway for the professional license in chemical Engineering
- To produce skilled and competent manpower to national and international market in Chemical Engineering profession.
- Assessing students' educational achievement in major areas of Chemical Engineering discipline.
- Ensuring whether the graduation profile of Chemical Engineering curriculum have achieved at least common standards of knowledge, practical skills and attitudes.
- Improving trust and confidence in industrial sectors, research and academic institutions.
- Facilitating the efforts of students to revise the core learning outcomes of the courses which will be covered by the exit examination.
- Ensuring all graduates from Higher Education Institutions (HEIs) satisfy the requirements of the market and employability.
- Creating competitive spirit among Chemical Engineering departments in Ethiopia with the vies to encouraging them to give due attention to the national standards.

1.2. Significance of Exit Examination

Implementing of exit examination has immense significance to measure graduating students' skills, knowledge and attitudes of different competencies the are set for Chemical Engineering program. In addition to competency identification, exit examination implementation process enables to systematically identify the core courses which will be included for exit examination.

1.3. Expected Graduates Profile

Graduate profile is a description of attributes (knowledge, skill and attitude) which the program aspires for its students to be attained. 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. 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 liaison between plant engineering personnel and equipment suppliers.
- ❖ preparing tender document, bid evaluation, coordinating the 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 of 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 environment as well as - especially under the conditions of globalization-in 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 study.

2. Competencies and Learning Outcomes

3.1. Competencies

Competencies can be defined as the applied knowledge, skills, and attitude that enable people to successfully perform in professional, educational, and other life contexts. The term competency is more commonly used in relation to professional fields (i.e., Engineering).

In this context, competencies are categorized as what chemical engineering graduates should know, the skills they should demonstrate and the attitudes they should possess upon graduation. Table 1 below presents the competencies identified for the exit examination of Chemical Engineering Program.

3.2. Learning Outcomes

Learning outcome is a very specific statement that describes exactly what a student will be able to do in some measurable way. There may be more than one measurable outcomes defined for a given competency. Generally, the term learning outcome is used more commonly in the context of a program or course of instruction. In this regard, Table 1 below presents the learning outcomes identified for Chemical Engineering Program.

Table 1: Competencies and learning outcomes

All the stated competencies comprise **knowledge**, **attitude** and **skill** inseparably.

Competencies	Learning outcomes
Engineering Knowledge	Apply knowledge of basic science, engineering fundamentals and chemical engineering principles to solve complex engineering problems.
Problem analysis and design of solutions	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.
Project management and decision making	Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply them to manage projects in multi-disciplinary environments.

Lifelong learning	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.
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3. Courses to Be Included In the Examination

The courses to be considered for the exit examination have been selected in view of the two different curricula, i.e., the national harmonized curriculum (being implemented by about 18 universities) and the curriculum developed and being implemented by Adama Science and Technology University and Addis Ababa Science and Technology University. The differences in the two curricula have been compromised by considering the compulsory courses in both the curricula. Based on this, **seventeen** courses have been selected to be considered for the exit examination. The major categories of the courses are basic sciences and engineering, reaction engineering, industrial processes and their control, environmental engineering, and engineering design. The list of courses to be considered for the exam is presented in Table 2.

Table 2: Courses list for exit examination

S/N	Course Name	Course Credit	Course ECTS
1	Fundamentals of Chemical Engineering	3	5
2	Chemical Engineering Thermodynamics I	3	5
3	Chemical Engineering Thermodynamics II	3	5
4	Mechanical Unit Operations	3	5
5	Fluid Mechanics for Chemical Engineers	3	5
6	Fluid Machines in Chemical Engineering	3	5
7	Chemical Reaction Kinetics	3	5
8	Chemical Reactor Design	3	5
9	Fundamentals of Biochemical Engineering	3	5
10	Thermal Unit Operations	3	5
11	Heat and Mass Transfer	3	5
12	Mass Transfer Unit Operation	3	5
13	Basic Environmental Engineering	3	5
14	Process Industries	3	5
15	Process Dynamics and Control	3	5
16	Chemical Engineering Apparatus Design	3	5

17	Plant Design and Engineering Economics	3	5
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4. Course Themes

The themes for the courses have been set by considering the learning outcomes of the program and the contribution of each course for the learning outcomes. Hence, the courses considered for the exit exam are categorized as themes of chemical engineering basics, chemical and biochemical reaction engineering, transport phenomena and separation processes, process industries, environmental engineering, process control, and chemical engineering design. Table 3 below demonstrates the mapping of each course to the themes. Table 4 below shows the mapping of competencies, learning outcomes, course themes, and courses.

Table 3 Course with their themes

S/N	Course Name	Course Theme
1	Fundamentals of Chemical Engineering	Chemical Engineering Basics
2	Chemical Engineering Thermodynamics I	
3	Chemical Engineering Thermodynamics II	
4	Mechanical Unit Operations	
5	Fluid Mechanics for Chemical Engineers	
6	Chemical Reaction Kinetics and Reactor Design	Chemical and Bio-chemical Reaction Engineering
7	Chemical Reactors Design	
8	Fundamentals of Biochemical Engineering	
9	Thermal Unit Operations	Transport phenomena and separation processes
10	Heat and Mass Transfer	
11	Mass Transfer Unit Operation	
12	Basic Environmental Engineering	Environmental Engineering
13	Process Industries	Process industries and Control
14	Process Dynamics and Control	
15	Fluid Machines in Chemical Engineering	Chemical Engineering Design
16	Chemical Engineering Apparatus Design	
17	Plant Design and Engineering Economics	

Table 4: Mapping of competencies, learning outcomes, course themes and courses

Competencies	Learning outcomes	Course themes	Courses
Engineering Knowledge	Apply knowledge of basic science, engineering fundamentals and chemical engineering principles to solve complex engineering problems.	Chemical Engineering Basics	- Fundamentals of Chemical Engineering - Chemical Engineering Thermodynamics - Fluid Mechanics for Chemical Engineers - Mechanical Unit Operations
Problem analysis and design of solutions	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.	Environmental Engineering	Basic Environmental Engineering
		Process Industries and Control	Process Dynamics and Control
		Transport phenomena and separation processes	- Thermal Unit Operations - Heat and Mass Transfer - Mass Transfer Unit Operation
		Chemical and Bio-chemical Reaction Engineering	- Chemical Reaction Kinetics and Reactor Design - Fundamentals of Biochemical Engineering
Project management and decision making	Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply them to manage projects in multi-disciplinary environments.	Chemical Engineering Design	- Fluid Machines in Chemical Engineering - Chemical Engineering Apparatus Design - Plant Design and Engineering Economics
Lifelong learning	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.	Process industries and Control	Process Industries

5. Conclusions

If implemented effectively, exit examinations can have a vital role 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 program quality. In view of this, this document is produced to assist the setting of the exit examinations for chemical Engineering program, which is being delivered by twenty government universities. The graduate profiles, competencies, and major learning outcomes of the program have been set. Seventeen courses have been selected to be considered for the exit examination. Themes for the courses have been set by considering the learning outcomes of the program and each course is mapped to a theme. The mapping of competencies, learning outcomes, course themes, and courses has been performed.

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