



Ministry of Education

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

Band: One [Technology and Engineering]

Program: - Bachelor of Science Degree in Industrial Engineering

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Industrial Engineering Blueprint

1. Introduction

Industrial Engineers deal with systems that need to be planned, designed, implemented, improved and evaluated. Industrial Engineers integrate knowledge and skills from several field of science. Industrial Engineers acquire knowledge from technical sciences, economic sciences, management science as well as human science. Industrial engineers comprehend knowledge from several fields of study /engineering and sciences/ in order to increase productivity, and produce quality goods and services at optimal.

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. 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. 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 construction needs the preparation of test blue print. Test blueprint is defined as a complete plan that explains how to develop a test.

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.

2. Objective of test blueprint

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.

2.1. Steps to develop test blueprint

- i. Listing the identified core competencies corresponding to the respective course
- ii. Listing the specific and minimum competencies to be assessed by the exam
- iii. Listing out the major learned course contents corresponding to these listed minimum competencies.
- iv. 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)
- v. Determination of the test format
- vi. Content weighting - Experts judge the weight to be given to the listed learning outcomes and their corresponding contents.
- vii. Identifying the categories of learning domains to which each of these learning outcomes belongs using their action verbs.
- viii. Construction of test blueprint table
- ix. Allocating the number of test items for each learning outcomes by their corresponding types and levels of learning domains.
- x. Determination of the sub-total and total test items by their categories of learning domains and learning outcomes.

3. Expected Profile of the Graduates

Graduate profile is a description of attributes (knowledge, skill and attitude) which the program aspires for its students to be attained. Graduates from the Industrial Engineering Undergraduate Program expected to have the theoretical and practical knowledge required to design, implement, lead and improve production processes of goods and services, thus contributing to business competitiveness and profitability. Industrial Engineering program has the following key occupational tasks and responsibilities that should be attained by graduates.

❖ **Analyze and develop work measurements, Ergonomics and Safety**

- Study time, motion, methods, and speed involved in maintenance, production, & other operations to establish standard production rate and improve efficiency
- Perform ergonomic studies and evaluations of workstations and product designs
- Monitor safety and health programs

❖ **Analyze and improve operations to ensure productivity**

- Prepare charts, graphs, and diagrams to illustrate workflow, routing, floor layouts, material handling, and machine utilization
- Planning for work assignments in accordance with worker performance, machine capacity, production schedules, and anticipated delays
- Supervise, monitor and control manufacturing and service operations
- Develop new layouts of work areas and improve layouts of existing ones

❖ **Ensure establishment and achievement of quality standards**

- Record test data, applying statistical quality control procedures
- Analyze worker using equipment to verify that equipment is being operated and maintained according to quality assurance standards
- Recommend modifications to existing quality or production standards to achieve optimum quality within limits of equipment capability
- Evaluate data and write reports to validate or indicate deviations from existing standards

❖ **Establish systems for Industrial communication and knowledge transfer**

- Knowledge transfer and adoption of new technology effectively
- Bridge the perspective difference among technical and managerial personnel

❖ **Perform Simulation, Optimization and Queuing systems analysis**

- Optimize production processes in a semi-conductor manufacturing plant

- Develop queuing analysis methods to investigate waiting times in connection with a product line
- Develop and analyze complex decision models, to provide economic solutions.
- Analyze the technical feasibility of establishment of new organizations
- ❖ **Establish reliability, maintenance and replacement policies of industries**
 - Develop maintenance planning, scheduling and control
 - Investigate and analyze the costs of purchasing new vs. repairing existing equipment
 - Perform downtime studies of various operations using time study and work sampling
- ❖ **Develop and improve supply chain and logistic systems of industries**
 - Investigate delivery of materials, including scheduling, route modification and material handling
 - Analyze, design and implement distribution procedures of industries
- ❖ **Perform continuous improvement program**
 - Improve system efficiency at all levels
 - Design new approaches to business procedures and communications
 - Study business processes so that work teams operate safely and more effectively

4. Competencies and Learning Outcomes

4.1. Competencies

A competency is commonly described as a combination of skills, knowledge and attitudes that enable an individual to perform a task or an activity successfully within a given context. In this case the program competency description in terms of knowledge, skill, and attitude as follow.

4.1.1. Knowledge: the graduates expected to know basic business principles like strategic planning, resource allocation, leadership technique, production methods, and coordination of people, Material and Machine. Subsequent points indicated below are core points that describe the important knowledge areas industrial engineers should acquire.

- To identify and applying principles, techniques, procedures, and equipment to the design and production of various goods and services
- Define raw materials characteristics, procurement processes, supply and distribution system of raw materials to manufacturing

- Identify Optimization techniques for maximizing effective manufacturing and distribution of goods.
- Develop and conduct appropriate experimentation analyzes and interprets data, and use engineering judgment to draw conclusions.
- Recall design techniques , principle of layout and Layout facilities
- State business and management principles involved in strategic planning, resource allocation, human resources/behavior modeling, leadership technique, production methods, Coordination of people and resources

4.1.2. Skills: - Effective and efficient performances of business activities depend on the skills and abilities of the Industrial Engineer. The subsequent points clarify the Skills and Abilities that are required by Industrial Engineers.

- ⇒ Industrial Engineers use both basic and advanced calculations to determine the current and potential productivity of a process.
- ⇒ Good leadership skills assist the Industrial Engineer in implementing productivity changes. The ability to develop relationships with coworkers is useful when making recommendations.
- ⇒ Industrial Engineers often need to create viable solutions for a variety of challenges. Whether it is to improve the production of a certain product or to reduce waste, the ability to develop a plan to overcome the problem is important.
- ⇒ Analysis and evaluation of work method and measurement system
- ⇒ Industrial Engineers need to use analytical skills to evaluate and interpret data. They also use these skills to create reports and describe the results to company decision-makers
- ⇒ Analysis and evaluation of production and inventory system

4.1.3. Attitude

- The ability to generate business ideas, identify business opportunities, conduct feasibility studies and plans, and organize for their implementation.
- Collaborate in teams to accomplish a common goal by integrating personal initiatives
- Communicate effectively and efficiently with clients, users and peers both verbally and in writing, using appropriate terminology.
- Recognize and be guided by the social, professional, and ethical issues involved in the use of technology

- Manage one's own learning and development, including time management and organizational skills
- Keep abreast of current developments in the discipline to continue one's own professional development.

5. Learning Outcomes

This guideline incorporates the ideas of Competence Based Education (CBE) on the Bachelor of Science in Industrial Engineering national harmonized curriculum. The competencies are identified according to the graduate professional profiles, measurable and achievable.

- Identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics.
- Apply appropriate Industrial Engineering tools and techniques to design, analyze and improve operations/process and productivity of a business.
- Ability to model, simulates, and optimizes production/service systems to utilize the maximum capacity of the plant.
- Design the entire industrial plants, make a proper site location, execute machine installation & commissioning, establish standard operating procedures, and develop a maintenance and replacement policies for manufacturing industries.
- An ability to plan, schedule and control production and optimize production costs.
- An Ability to design quality standards and policies, and establish continuous improvement programs.

6. Themes and list of courses

As it explained earlier at introduction, exit exam plays key role for quality education. The main idea behind an exit exam is the need to check whether students have attained the intended learning outcomes of the program they have attended. Providing quality education is a major goal of universities in the Ethiopia. Being able to track and evaluate student knowledge before students graduate is a key in determining the direction of the university and whether it is meeting its mission objectives. The examination tests students' knowledge of their program learning outcomes as well as measuring the university's educational quality. As a result, in order to measure students' knowledge of their program learning outcomes the following courses are selected for Industrial Engineering program.

Table 1: Courses Selected for exit exam

S/N	Course Thematic	Course Name	ECTS	Cr.Hr	Total selected Courses
1	Operation Management	Production Planning and Control-I	5	3	5
		Production Planning and Control- II	5	3	
		Supply Chain Management and Logistics	5	3	
		Methods and Value Engineering	5	3	
		Maintenance Engineering and Management	5	3	
Total			25	15	
2	Quality Control & Management	Statistical Quality Control	5	3	2
		Quality Management System	5	3	
Total			10	6	
3	Mechanical Design & Manufacturing	Manufacturing Process-I	5	3	2
		Manufacturing Process-II	5	3	
Total			10	6	
4	Industrial Systems Design & Ergonomics	Facility Lay out Design and Material Handling	5	3	2
		Ergonomics and Industrial Safety	5	3	
Total			10	6	
5	Engineering Optimization	Operations Research- I	5	3	2
		Operations Research-II	5	3	
	Total		10	6	
6	Industrial Management	Engineering Economics and Costing	5	3	2
		Project Management	5	3	
Total			10	6	15
	Over all Total ECTS and CR.Hr.		75	45	

Table 2 Test Blueprint (Share of the Themes/Courses/Items in Percentage (%)) for BSC in Industrial Engineering Program

Themes	Name of Courses	Credit hour	Share of the themes in %.	General objective	Learning outcomes	Learning outcomes								No. of items
						Cognitive						Affective	Psychomotor	
						Remembering	Understanding	Application	Analysis	Evaluation	Creation/Synthesis			
Production and Operations Management	Production Planning and Control-I	3	34	➤ To develop an ability to apply operations management concepts in manufacturing and service organizations.	➤ plan different production activities	-	1	-	-	-	-	-	-	7
					➤ apply different forecasting techniques	1	-	-	1	1	-	-	-	
					➤ develop strategies for different operations	-	1	-	-	-	-	-	-	
					➤ perform and develop product/service design	-	1	-	-	-	1	-	-	
	Production Planning and Control- II	3		➤ To Define appropriate processes for work flow activities and production measures	➤ manage inventory	-	2	-	-	-	-	-	-	7
					➤ plan requirement of material for any production or service operation	-	-	-	1	1	-	-	-	
					➤ schedule activities effectively	-	1	-	1	1	-	-	-	
	Supply Chain Management and Logistics	3		➤ Determine methods and procedures of production distribution activities and Manage supplier relationship	➤ develop an appreciation for the challenges in managing a supply chain	-	2	-	-	-	-	-	-	7
					➤ use analytical tools and conceptual frameworks to design and optimize a supply chain	-	2	-	1	1	-	-	-	
					➤ develop analytical and modeling skills	-	1	-	-	-	-	-	-	
	3	➤ To Define proper work methods for the tasks,	➤ Relate the effect of Work Study on economy and	-	1	-	-	-	-	-	-			

	Methods and Value Engineering			Work design, measurement, to improve worker performance, health, safety, and maintain productivity	organization profit in particular										7
					➤ Model and improve processes using the techniques of Method Study	-	2	-	-	1	-	-	-		
					➤ Set time standards using the techniques of Work Measurement	-	1	-	1	1	-	-	-		
	Maintenance Engineering and Management	3		➤ To know Machine installation, machine operation, maintenance system, maintenance planning, maintenance performance evaluation techniques and replacement analysis of machines.	➤ make failure model analysis	-	1	-	1	-	-	-	-		6
					➤ know and apply effective maintenance management elements	-	1	-	-	-	-	-	-		
					➤ develop preventive and corrective maintenance models and schedule	-	-	-	1	1	-	-	-		
					➤ analyze maintenance cost	-	-	-	-	1	-	-	-		
	Theme One total credit	15				1	17	-	7	8	1	-	-		
	Statistical Quality Control	3	13	➤ To help students to know the role of statistical quality control tools and techniques of calculating the process capability indices.	➤ Apply statistical thinking to quality improvement	-	1	-	-	-	-	-	-		7
					➤ Use statistical tools to analyse work problems	-	1	-	1	-	-	-	-		
					➤ Develop and analyse run charts and control charts for variables and attributes data	-	-	-	1	1	-	-	-		
					➤ Quantify process capability	-	-	-	-	1	-	-	-		
					➤ Compute and interpret process capability indexes	-	-	-	-	1	-	-	-		
Quality Control & Management	Quality Management System	3		➤ To Understand different quality improvement programs and apply	➤ Apply different techniques of TQM	-	1	1	-	-	-	-	-		6
					➤ Design different products/service that best	-	1	-	-	-	1	-	-		

				different ISO standards for quality management	suits customers expectation										
					➤ Apply different ISO standards for quality management	1	-	1	-	-	-	-	-	-	
	Theme Two total credit	6				1	4	2	2	3	1	.-	-		
Manufacturing Process 1	Manufacturing Process-I	3	13	➤ To understand the basic types of casting processes, powder metallurgy principles and metal forming process	➤ Understand the technology, principles, terminology, and steps of powder metallurgy	-	1	-	-	-	-	-	-		6
					➤ Understand the basic types of casting processes and analyze casting defects	-	1	-	-	-	-	-	-		
					➤ Understand different types of die set and die cutting operation,	-	1	-	-	-	-	-	-		
					➤ Understand press work and metal forging,	-	1	-	-	-	-	-	-		
					➤ Design die for press work and metal forging	-	1	-	-	-	-	-	-		
					➤ Demonstrate skill in practical works of foundry and metal forming processes	-	1	-	-	-	-	-	-		
	Manufacturing Process-II	3		➤ To Understand welding process and the fundamental mechanics of metal cutting, effects of work piece and physical properties on machinability and	➤ Understand different types of welding processes and decide where to apply them.	-	1	-	-	-	-	-	-		7
					➤ Know different types of hazards in welding shop and their protection methods		1	-	-	-	-	-	-		
					➤ Understand the fundamental mechanics of metal cutting	-	1	-	-	-	-	-	-		

				surface integrity issues	➤ Optimize of machining parameters as a function of tool and work piece material	-	1	-	-	-	-	-	-	
					➤ Identify the effects of tool wear on product quality	-	1	-	-	-	-	-	-	
					➤ Know the types and operation principles of non-conventional machining process	-	1	-	-	-	-	-	-	
					➤ Demonstrate skill in practical works of arc, resistance, and gas welding process	-	1	-	-	-	-	-	-	
	Theme Three total credit	6				-	13	-	-	-	-	-	-	
Human Factors and Plant Design	Facility Lay out Design and Material Handling	3	14	-understanding of the issues involved in the design of an industrial production system by identifying the challenges in plant location, materials handling, and plant layout	➤ Formulate models and analytical procedures for the study of facilities layout planning	-	2	-	-	-	-	-	-	7
					➤ know and apply different material handling systems	-	2	-	-	-	-	-	-	
					➤ Design a factory layout incorporating product, process, and personnel requirements	-	1	1	1	-	-	-	-	
	Ergonomics and Industrial Safety	3		➤ To know the interface between human beings, machines, and work environment, equipment and their selection for usability, simplicity; hazard, analysis; environmental conditions and Human fatigues	➤ Design workplace and work	-	1	-	-	1	-	-	-	7
					➤ Familiar with the application of computers and integrating the industrial information to assist the decision making.	-	1	-	-	-	-	-	-	
					➤ Understand human physiological responses to stressful situations.	-	2	-	-	-	-	-	-	

					➤ Understand hazards in industry, and their impacts on safety of personnel, property and environments;	-	2	-	-	-	-	-	-	
	Theme Four total credit	6				-	11	1	1	1	-	-	-	
Engineering Optimization	Operations Research- I	3	13	➤ To Understand deterministic analytical problem solving and resource optimization methods	➤ Develop mathematical model for deterministic problems;	-	1	-	-	-	1	-	-	7
					➤ Solve deterministic models and interpret the result;	-	1	-	1	-	-	-	-	
					➤ select the best optimization technic to solve deterministic model	-	1	-	1	1	-	-	-	
	Operations Research-II	3		➤ To understand stochastic analytic methods and network analysis for solving problems	➤ Model and solve a variety of problems using stochastic operations research techniques.	-	1	-	1	-	-	-	-	6
					➤ Interpret the results of optimization	-	1	-	-	1	-	-	-	
					➤ design and analyse algorithms, and to distinguish good algorithms from not-so good ones;	-	1	-	-	-	-	-	-	
					➤ Understand and appreciate proofs; and an appreciation for the capabilities and limitations of stochastic models in operations research.	-	1	-	-	-	-	-	-	
	Theme Five total credit	6				-	7	-	3	2	1	-	-	

Industrial Management	Engineering Economics and Costing	3	13	➤ To understand the basic concept of time value of money and methods for alternative and investment evaluation	➤ Apply different technics for estimating the cost of product/service	-	1	-	-	1	-	-	-	6
					➤ Analyse industrial operations economy	-	1	-	1	-	-	-	-	
					➤ Know components of cost of a product	-	1	-	-	-	-	-	-	
					➤ Know time value of money	-	1	-	-	-	-	-	-	
	Project Management	3		➤ To achieve project goals and targets while keeping in mind the project scope, time, quality, cost and facilitates the project workflow with team collaboration on a single project.	➤ Apply PERT and CPM for managing the project	-	1	-	1	-	-	-	-	7
					➤ Crash projects by considering cost aspects, and resource levelling	-	1	-	-	1	-	-	-	
					➤ Use charts and networks for scheduling and managing projects	-	1	-	1	-	-	-	-	
					➤ Plan and organize projects	-	1	-	-	-	-	-	-	
	Theme Six total credit	6		...		-	8	-	3	2	-	-	-	
Total for the program		45				2	60	3	16	16	3	-	-	100

Key: In the cells/boxes there are numbers that indicate the number of items that correspond to the levels of domains.

Assumption:-for share of the themes in program and share of the courses in the themes should be taken as follows.

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.

$$\text{Share of courses per theme (C)} = \frac{\text{Credit hour of the course}}{\text{Credit hour of the theme}} \times 100$$

$$\text{Share of items per course} = \text{Share of the course} \times \text{Total number of items}$$

Table 3 Calculation of share of themes, courses and items from a total of 100 test items for Industrial Engineering program

Themes	Course Name	Learning outcomes	Credit hour	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 = 34 items from the total	1		3	3/15 = 0.2	0.2*34 = 6.8	1	3	-	1	1	1	-	-	7
	2		3	3/15 = 0.2	0.2*34 = 6.8	-	3	-	2	2	-	-	-	7
	3		3	3/15 = 0.2	0.2*34 = 6.8	-	5	-	1	1	-	-	-	7
	4		3	3/15 = 0.2	0.2*34 = 6.8	-	4	-	1	2	-	-	-	7
	5		3	3/15 = 0.2	0.2*34 = 6.8	-	-	2	-	2	2	-	-	6
	Theme one total credit		15			1	19	2	5	8	3	-	-	
Theme Two Share = 13 items from the total	1		3	3/6 = 0.5	0.5*13= 6.5	-	2	-	2	3	-	-	-	7
	2		3	3/6 = 0.5	0.5*13= 6.5	1	2	2	-	-	1	-	-	6
	Theme two total credit		6											
Theme Three Share = 13 items from the total	1		3	3/6 = 0.5	0.5*13= 6.5	-	6	-	-	-	-	-	-	6
	2		3	3/6 = 0.5	0.5*13= 6.5	-	7	-	-	-	-	-	-	7
	Theme three total credit		6											
Theme Four Share = 14 items from the total	1		3	3/6 = 0.5	0.5*14= 7	-	5	1	1	-	-	-	-	7
	2		3	3/6 = 0.5	0.5*14= 7	-	6	-	-	1	-	-	-	7
	Theme Four total credit		6											
Theme Five Share = 13 items from the total	1		3	3/6 = 0.5	0.5*13= 6.5	-	3	-	2	1	1	-	-	7
	2		3	3/6 = 0.5	0.5*13= 6.5	-	4	-	1	1	-	-	-	6
	Theme Five total credit		6											
Theme Six Share = 13 items from the total	1		3	3/6 = 0.5	0.5*13= 6.5	-	4	-	1	1	-	-	-	6
	2		3	3/6 = 0.5	0.5*13= 6.5	-	4	-	2	1	-	-	-	7
	Theme Six total credit		6											
Total for the program			45			2	60	3	16	16	3	-	-	100

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

7. Conclusion

This guideline is designed to implement the National Exit Examination for B.Sc. in Industrial Engineering undergraduate programs throughout Ethiopian Higher Education Institutes. To prepare this guideline the following criteria were considered into account.

- ✓ Professional graduate profiles,
- ✓ Competency and learning outcomes of the programs
- ✓ Correlation of graduate profiles and competency of the program
- ✓ Selection of core competency courses

The key competencies of the program are selected and the courses which matches the competency areas are selected for exit exam. The exam contents will focus on key knowledge of the program from each course and the courses which match the exit exam types. Accordingly, fifteen [15] courses are selected for exit exam which are grouped into different six [6] thematic areas. The selected courses are thematized to groups according to their similarities and lastly, test blueprint is prepared fairly distribute items based on the assumption criteria.