United Nations Educ

INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING BENCHMARKS DOCUMENT

First Edition

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Executive Summary

Benchmarks are considered as self-improvement and quality management/quality assurance tools, allowing higher education institutions/programs to compare themselves with others regarding some aspects of implementation, with a view of finding ways to improve current performance. Engineering and at present computing disciplines attract quality students from a broad cross section of the population; a crucial concern is to be sure that they are offered the best education possible; best in the sense of seeking to prepare them to become capable and responsible professionals, scientists, and engineers. Thus, all over the world, responsible professional bodies as well as scientific computing and engineering societies are getting more and more involved in providing advice and support for higher education in various ways, including the formulation of benchmarks. Several reports that define and update guidelines for computing and engineering curricula have appeared over the past four decades. Recent efforts have targeted international participation, reflecting the need for the leading professional organizations to become truly global in scope and responsibility.

Aware of these efforts and global changes, we had to launch a similar process in Palestine. This process is intended to fill a gap and raise awareness among Palestinian Higher Education Institutions to the issues related to curriculum and graduates' specifications; two major pillars of high quality higher education. This is why this document focuses solely on curriculum and graduates' specifications, that is, the volume of studies, knowledge areas, and professional practical and transferable skills. However, as program specifications are also of importance, a template has also been developed and included in this document. This template is proposed to help Palestinian Higher Education Institutions judge their current curricula based on their goals and indented learning outcomes. All this draws upon recent efforts and published reports in computing and engineering curricula developed by the IEEE Computer Society, the Association for Computing Machinery (ACM), the Association for Information Systems (AIS), Computing Curricula 2005[1], Japan Accreditation Board for Engineering Education (JABEE)[2], Accreditation Board for Engineering & Technology[3] , [4](ABET), Quality Assurance Agency[5], [6] (QAA) in UK, Education and Training Foundation (ETF)[7], UNESCO[8], Council for Higher Education Accreditation[9] (CHEA).

[1] Computing Curricula2005, 2006

[2] Criteria for Accrediting Japanese Engineering Education Programs, applicable in the year 2004-2007.

[3]ABET: Criteria for Accrediting Computing Programs, Oct. 2006

[4] ABET 07-08

[5] Computing 2007

This document presents benchmarks and guidelines for undergraduate first-degree (bachelor, B.Sc.) programs in the fields of Information Technology & Electrical Engineering (ITEE). The embraced programs are Computer Science (CS), Information Technology (IT), Information Systems (IS), Computer Engineering (CE), and Electrical & Electronics Engineering (EE). All of these programs are currently offered by most of the national Higher Education Institutions (HEIs) that award undergraduate programs. These HEIs are universities as well as university colleges and institutes.

This manuscript describes the expectations of graduates of the fields covered by this study, and shows how graduates of each field or discipline differ from those of other disciplines. It illustrates the expected background, knowledge areas, and professional practical and transferable skills employers expect to find in graduates of ITEE programs. The volume of study (credits) for each field of study is presented. Furthermore, various groups of topics are presented along with their respective weights for both minimum (Threshold) and superior (Excellent) level programs. These weights as published by ACM were reviewed by an expert group from our national faculty members who work at all national HEIs that provide the first university degree of computing and engineering programs, and are accordingly tabulated. Besides this volume of study (credits) it is recommended to include the students' work load hours for each course in the program specification's document in order to provide the students with appropriate indications of the needed efforts.

This guide seizes its importance and usefulness from the fact that, presumably unlike most of areas of specializations, the programs covered in it are interrelated and overlapped. Hence, it has been decided to highlight the distinctions, sometimes clear and other times vague, between them. ACM methodology qualitatively distinguishes between them. We complement it by a quantitative approach; Fig. (1) shows how the expert group did comparatively perceive the ITEE programs vis-à-vis the different knowledge areas and skills.

This benchmarking document is proposed as a useful tool for all those who are responsible for designing programs in the computing and engineering fields. The wide range of information is not intended to be exclusive but rather representative of the diversity of knowledge and skills that have to be considered when improving a program of study or designing a new one. In fact the user will see himself/herself forced to take difficult decisions

[6] Engineering 2006

[7] Tuning Educational Structures in Europe

[8] Understanding and assessing quality, 2007

[9] Glossary of Key Terms in Quality Assurance and Accreditation

when it comes to replying to all the requirements as specified by the benchmark and abiding by the constraints and regulations of the Higher Education Institution. But also, while the benchmark is one per specialty, each institution can be creative enough to come up with a distinctive program.

Furthermore, this script offers guidance to higher education national stakeholders, including prospective students, their parents and guidance counselors, Accreditation and Quality Assurance Commission (AQAC), Ministry of Education and Higher Education (MoEHE), private sectors such as the Engineering Association, the Palestinian Information Technology Association (PITA), and the Palestinian Federation of Industries (PFI). Finally, it offers guidance to a broader audience, including regional and international higher education stakeholders.

To ensure sustainability it is highly recommended to periodically (every two years) review this first version of the benchmarking guide (document).

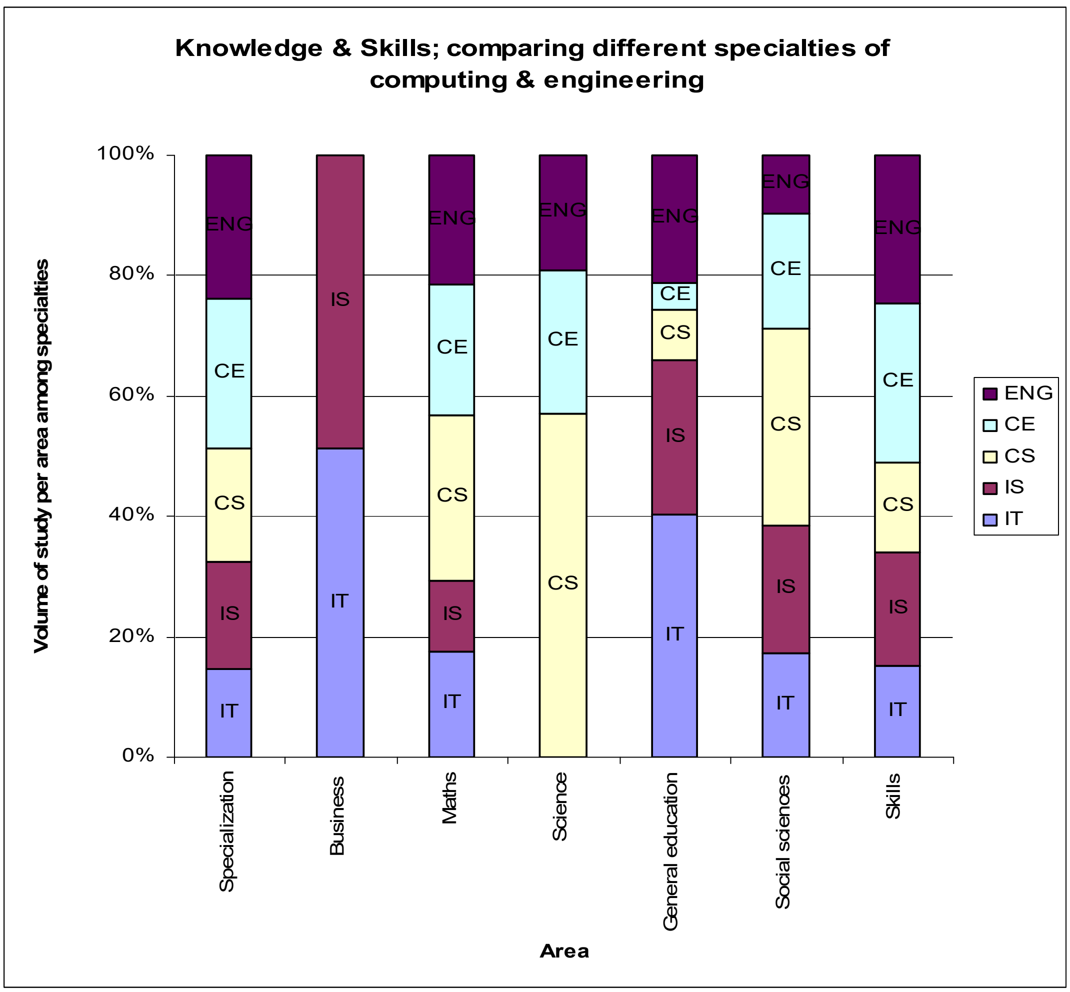

Fig. (1): Quantitative discernment of the ITEE programs with reference to the different knowledge areas and skills.

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1- Introduction

For the last few years, several formal and informal discussions at different levels within the main players (stakeholders) of Higher Education (HE) were accomplished to develop Field Benchmarks (FB) in the major disciplines. These disciplines include Information Technology (IT), Engineering, Sciences, Arts & Education, Law, and Medical Professions. FB statements set out expectations about standards of degrees in a range of subject areas. They describe what gives a discipline its coherence and identity, and define what can be expected of a graduate in terms of the techniques and skills needed to develop understanding in the field/subject. Namely, FBs describe the general characteristics, attributes, capabilities and standards associated with specific levels of award in a particular field area. These include, topics and subjects to be taught and covered, number of credit hours, naming, typical resources that must be available (human resources, library, equipment, etc.). In addition, a program specification is a concise description of the intended outcomes of learning from a HE program, and the means by which these outcomes are achieved and demonstrated. That is to say, while Program Specifications are one of a number of ways in which Higher Education Institutions (HEIs) are able to describe the intended learning outcomes; FB statements represent general expectations about the standards of achievement and general attributes to be expected of a graduate in a given subject area. These FBs and program specifications are badly needed by all national HEIs as well as the national Accreditation and Quality and Assurance Commission (AQAC). These benchmarks come in line with other crucial national activities including, the national program comprehensive evaluation's project, accreditation and recognition locally, regionally, and globally, as well as programs reviewing at the institutional level. This, with no doubt, will in turn lead to further enhance the capacity of HEIs and AQAC, and create professional interactive links with the various other HE stakeholders such as the Ministry of Education and Higher Education (MoEHE), Council of Higher Education, Professional bodies including Palestine IT Association (PITA), the engineering association, Palestinian Federation of Industries (PFI) as well as private sectors.

The UNESCO, Ramallah Office, has funded this pilot eleven-month project entitled "Development of IT and Electrical Engineering Benchmarks", to establish FBs in the field of IT and Electrical Engineering. The project's team is composed of four national experts lead by Dr. Labib Arafeh from Al-Quds University, Dr. Mahmoud Al-Saheb from the Palestine Polytechnic University, Dr. Hatem Elaydi from the Islamic University of Gaza, and Dr. Hanna Abdel Nour from Al-Quds University. Several team meetings have been conducted over the duration of the project. To share the proposed FBs with all related stakeholders, two national workshops were conducted. Furthermore, five sub-national workshops were conducted that involved eighty five specialties' experts who work at all national HEIs that offer the first degree in IT and Electrical Engineering. Thus, promoting the culture of programs' reviewing and development, and building the capacity of these experts in using benchmarks, which will enhance the quality of IT and Electrical Engineering programs. The QAA has defined subject/field benchmark statements set out expectations about standards of degrees in a range of subject/field areas. They describe what gives a subject its coherence and identity, and define what can be expected of a graduate in terms of the abilities and skills needed to develop understanding in the subject. In other words, they set out the academic characteristics and standards of programs in a clear and detailed manner. Thus, benchmark statements do not represent a national curriculum in a subject/fieled area rather they allow for flexibility and innovation in program design, within an overall conceptual framework established by an academic field community, with an intention to assist those involved in program design, delivery, and review. They may also be of interest to prospective students and employers, seeking information about the nature and standards of awards in a field area. Benchmark standards are measures of achievement on conclusion of a program of study, for which this document defines threshold and excellent in the context of a B.Sc. degree program.

General standards and benchmarks have several dimensions to include/be aware of; Objectives and Assessments, Student Support, Faculty, Curriculum, Laboratories and Computing Facilities, Institutional Support and Financial Resources, Institutional Facilities, etc. These standards may be used for accreditation purposes. However, our focusing was on the crucial dimensions of curriculum and graduates' specifications rather than teaching and learning, environments and resources, institutional educational environment and facilities that might be fulfilled.

There is an unlimited number of Computer related programs (Computing) that are offered at HEIs global wise. These include, Computer Engineering, Computer Science, Software Engineering, Information Technology, and Information Systems. Furthermore, Information Systems as a field of academic study exists under a variety of different names. The different labels reflect historical development of the field, different ideas about how to characterize it, and different emphasis when programs were started. Among the names associated with the academic discipline of IS there is Information Systems, Management Information Systems, Computer Information Systems, Information Management, Business Information Systems, Informatics, Information Resources Management, Information Technology, Information Technology Systems, Information Technology Resources Management, Accounting Information Systems, Information Science, and Information and Quantitative Science.

We feel that this guide will be useful for faculty members at HEIs, administrators, students, parents, private sectors and other professional bodies and employers. This is due to the computing field specialty as it changes rapidly with new emerging applications. In addition, computing is a broad discipline that crosses the boundaries between mathematics, science, engineering, and business and because computing embraces important competencies that lie at the foundation of professional practice.

We have adopted the ACM methodology in identifying the commonality and differences among computing disciplines, by drawing the problem space of computing[10]. It represents the main knowledge areas that range from organizational issues and Information systems through Application technologies, Software methods and Technologies, System Infrastructure to Computer Hardware and architecture; against the development range that runs from Theory, Principles, Innovation, to Application, Deployment, Configuration, and Application Development.

The produced document is based on the opinion of experts from most of the Palestinian institutions and should be used as guidelines for future curricula updating and new programs. Throughout this document the authors have put the necessary efforts to describe the state of the art in the field of benchmarking academic programs, and on the other hand to reflect the opinion of the Palestinian experts daily involved in the educational system and in direct contact with the students and aware of the realities of the Palestinian labor market and economic situation. We cannot claim that this work, the first of its kind in the region, is comprehensive and considers every aspect of benchmarks. It needs to be enhanced and updated every so often. This is because ITEE and its related topics keep frequently changing and advancing. Thus, it is highly recommended that this document should be periodically updated, at least every two years.

The structure of this document is organized as follows: Section two presents some useful terminologies and definitions that will be used throughout the document; Section three reviews the program specifications and introduces a template; Section four set ups program's levels and the rating of topics; Section five presents the computing benchmarks for Computer Science, Information Systems, Information Technology, and Computer Engineering programs; Section six deals with Electrical Engineering programs' benchmarks including Power, Electronics/Communications, & Computer Engineering. The Computer Engineering program is included to emphasize on its engineering aspects similar to the other engineering programs.

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[10] ACM, CC2005, March 2006

2- Brief Descriptions

Several terminologies have been used through out this document. These include:

a. **Benchmarks:** Measures of achievement on conclusion of a program of study, for which this document defines threshold and excellent in the context of bachelor degrees. QAA[11], CHEA, and UNESCO have defined benchmarking as a point of reference to make comparison. That is, benchmark statements as Subject benchmark statements that provide a means for the academic community to describe the nature and characteristics of programs in a specific subject. They also represent general expectations about the standards for the award of qualifications at a given level and articulate the attributes and capabilities that those possessing such qualifications should be able to demonstrate. UNESCO has furtherlly defined benchmarking as a standardized method for collecting and reporting critical operational data in a way that enables relevant comparisons among the performances of different institutions or programs, usually with a view to establishing good practice, diagnosing problems in performance, and identifying areas of strength. Benchmarking gives the institutions / programs the external references and the best practices on which to base its evaluation and to design its working processes.

b. **Scope.** Benchmark statements do not represent a national curriculum in a subject area rather they allow for flexibility and innovation in program design, within an overall conceptual framework established by an academic subject community.

c. **Who needs benchmarks**: Benchmark statements are intended to assist those involved in program design, delivery, and review. In addition, benchmarks may also be of interest to prospective students and employers, seeking information about the nature and standards of awards in a subject area. Palestinian universities and colleges offer over fifty undergraduate programs in Computing and Electrical Engineering, with five different titles for a single-subject degree program alone. This collection of programs encompasses widely differing titles and differing content.

d. **Higher Education Program of study** (**Program**): a collection of one or more different compulsory and optional / elective courses leading to the first degree.

[11] Computing 2007.

e. **Field of study**: normally synonymous with a collection of programs of study leading to an award within a single discipline, in this case computing and Electrical Engineering.

f. **Computing capabilities and skills:** Students are expected to develop a wide range of abilities and skills. These may be divided into three broad categories[12]:

   i. Computing-related cognitive abilities and skills, i.e. abilities and skills relating to intellectual tasks;
   ii. Computing-related practical skills;
   iii. Additional transferable skills that may be developed in the context of computing but which are of a general nature and applicable in many other contexts.

   Cognitive, practical and generic skills need to be placed in the context of the program of study as designed by the HEI and/or the possible program / electives selected by the individual student. The implicit interplay between these identified skills both within and across these three categories is recognized. These abilities & skills are detailed in Appendix 1.

g. **Computing:** We can define computing to mean any goal-oriented activity requiring, benefiting from, or creating computers. Thus, computing includes designing and building hardware and software systems for a wide range of purposes; processing, structuring, and managing various kinds of information; doing scientific studies using computers; making computer systems behave intelligently; creating and using communications and entertainment media; finding and gathering information relevant to any particular purpose, and so on. The list is virtually endless, and the possibilities are vast[13]. Students study computing for different reasons such as vocational reasons, and richness and diversity. Most of the national HEIs offer many computing programs with different names and contents. The reason behind that may be to attract students, others looking for permission form AQAC to start their programs without duplicating other current programs that are offered at other universities.

   A typical first degree (Bachelor of Science, B.Sc.) in one of the computing disciplines prepares a student for entry into the computing profession. Because computing provides such a wide range of topics or choices, it is impossible for anyone to become

[12] QAA, Computing 2007

[13] ACM, CC2005-March06Final

proficient at all of them. Hence, an individual who wishes to become a computing professional requires some focus for his or her professional life.

Computing is not a single discipline but it is rather a family of disciplines. The computing fields matured in the mid 1990s as shown in Fig. (2)[13]. According to ACM, five major disciplines in computing are currently well defined and recognized after 1990[13]. These five-degree programs are: **Computer Engineering, Computer Science, Software Engineering, Information Technology, and Information Systems**.

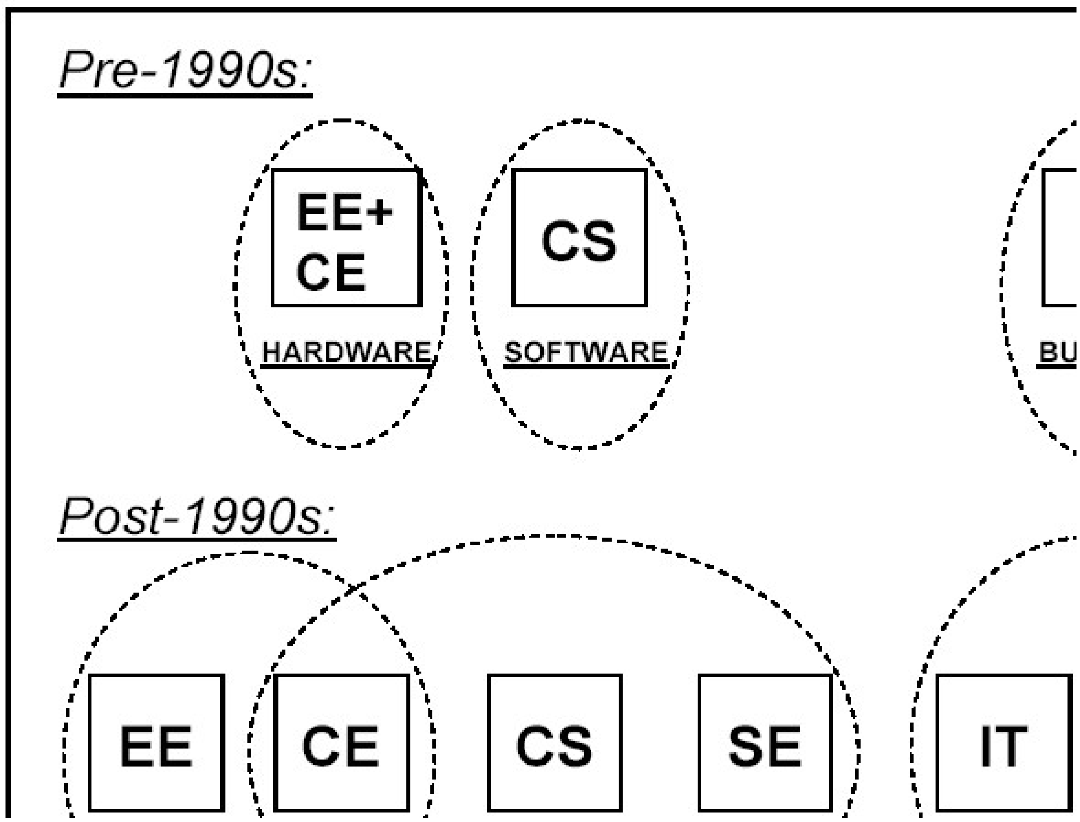

Fig. (2), The development of different computing disciplines[13]

h. Engineering: Engineering is concerned with developing, providing and maintaining infrastructure, products, processes and services for society. Engineering addresses the complete life cycle of a product, process or service, from conception, through design and manufacture, to decommissioning and disposal, within the constraints imposed by the commercial, legal, social, cultural and environmental considerations[14]. The three main pillars that Engineering highly depends on are scientific fundamentals,

[14] QAA, Engineering 2006

mathematics and a range of creative abilities that distinguish the engineer from the scientist; to conceive, make and actually bring to fruition something which has never existed before. This creativity and innovation to develop economically viable and ethically sound sustainable solutions is an essential and distinguishing characteristic of engineering, shared by the many diverse, established, and emerging disciplines within engineering. Thus, an emphasis for a typical engineer to have an Engineering analysis (the ability to apply acquired knowledge to analyze systems using analytical and CAD techniques with the aim of solving an engineering matter), and Design (the ability to invent and produce a system according to previously defined specifications and needs).

3- Program Specifications

Program specifications consist of a brief description of the Intended Learning Outcomes (ILOs) of a higher education program in terms of: knowledge and understanding, key skills, cognitive skills, subject specific practical skills, and transferable skills. That is, it shows the means by which the ILOs are going to be achieved and demonstrated in terms of: teaching and learning and assessment methods. Program specifications have several benefits including: public information and accountability, their preparation can provide a stimulus to teaching teams to reflect on, clarify and better integrate the aims and ILOs of their programs with their design and delivery. They can be used by several higher education stakeholders that include:

1. Students as a source of information to understand of a program;
2. HEIs and faculty members, to
    a. Promote discussion and reflection on new and existing programs;
    b. Ensure that there is a common understanding about the aims and ILOs for the program;
    c. Satisfy themselves that the designers of programs are clear about their ILOs;
    d. Serve as a reference point for internal review and monitoring of the performance of a program.
3. Internal and external reviewers and examiners, as a source of information, to understand the aims and ILOs of programs;
4. Employers, as a source of information, to know the skills and other transferable intellectual abilities developed by the program;
5. Professional, statutory and regulatory bodies, to accredit programs that can lead to entry to a profession or other regulated occupation.

The contents of a program specification template, a modified version of QAA guidelines[15], include:

1. Awarding body/HEIs: Faculty, and Department;
2. Details of accreditation by a professional/statutory body;
3. Program title;
4. Criteria for admission to the program;
5. HEI's mission and aims of the program;
6. Relevant subject benchmark statements and other external and internal reference points used to inform program outcomes;
7. Program structures and requirements, levels, modules, credits, awards, and Program's ILOs: knowledge and understanding; skills and other attributes; [*You may include the Courses Distribution (Table 1); sowing the courses major field and its level*]
8. Teaching, learning and assessment strategies to enable outcomes to be achieved and demonstrated. [*You may include the Intended Learning Outcomes table (Table 2); sowing the ILOs, courses covering these ILOs, used teaching and learning methods, and the assessment methods*];
9. Mode of study;
10. Language of study;
11. Potential employments;
12. Departmental / Faculty / University Facility & Community Involvement;
13. Date at which the program specification was written or revised;
14. Furthermore, HEIs may wish to include information on:
    1. What makes the program distinctive;
    2. Assessment regulations;
    3. Student support;
    4. Methods for evaluating and improving the quality and standards of learning, including consideration of stakeholder feedback from, for example, current students, graduates, & employers.

[15] Guidelines for Preparing Program Specifications, QAA 2006.

The developed program specifications templates are:

Table 1: Program specifications - Courses' Distribution Table

Knowledge Area / Level (year/semester)	Math.	General Sciences	…	
Year 1	**[list of courses]**	**…**		
Year 2	**…**			
Year 3				
Year 4				
Year 5				

Table 2: Program specifications - Intended Learning Outcomes

The program provides the students with the following knowledge and skills:			
Area of knowledge	Course	Teaching and Learning method	Assessment method
A. KNOWLEDGE AND UNDERSTANDING			
A1. [1st subject; i.e.,			
A1.1 …	…	…	…
A1.2 …			
…			
A2. …			
A2.1 …			
…			
B. COGNITIVE AND INTELLECTUAL SKILLS			
B1.1 …			
…			
C. SUBJECT SPECIFIC SKILLS [i.e., Algorithms, Programming,…]			
C1.1 …			
…			
D. TRANSFERABLE SKILLS [i.e., writing, communication,…]			
D1.1 …			
…			

4- Program's level and topic's rating

a. **Level**: A hierarchical categorization of material within a discipline such as Computing; in full-time courses this is likely to be closely related to the semester or year of study.

b. **Threshold level vs. Excellent level Graduate:** Each topic has to undergo an evaluation that results in a rating from zero (**0**) to ten (**10**) (see Topic Rating). There are also two levels to be specified; a threshold level and an excellent level of studies. We can describe the graduate of a threshold level as an IT graduate who is able to apply and manage current available technology, while an excellent level graduate is more concerned with the development and application of new technologies, concepts, techniques, and services.

c. **Topic Rating Rules:** The rating (grading) of topics was done according to the following criteria:

- 0: the topic is irrelevant to the branch of study.
- 1: the topic is hardly relevant. Can be a little covered in one of the courses.
- 2-3: the topic is relevant and it is a plus to the graduate. It is to be dealt with in one of the courses.
- 4-5: the topic is relevant and can be assigned a minimum number of credit hours as an elective course.
- 6-7: the topic is relevant and can be assigned a minimum number of credit hours as a compulsory course.
- 8-9: the topic is compulsory and has to be developed as much as possible.
- 10: the topic is a must for the considered branch of study. It has to be given the highest weight possible.

5- Computing Benchmarks

Any computing program should enable students to achieve several general attributes by the time of graduation[4], these include:

(a) An ability to apply knowledge of computing and mathematics appropriate to the discipline;
(b) An ability to analyze a problem, identify and define the computing requirements appropriate to its solution;
(c) An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs;
(d) An ability to function effectively on teams to accomplish a common goal;
(e) An understanding of professional, ethical, legal, security, and social issues and responsibilities;
(f) An ability to communicate effectively with a range of audiences;
(g) An ability to analyze the local and global impact of computing on individuals, organizations and society;

(h) Recognition of the need for, and an ability to engage in, continuing professional development;

(i) An ability to use current techniques, skills, and tools necessary for computing practice.

Furthermore, each discipline or program has its own additional attributes that are associated with its graduates.

5.1. Information Systems Program

Information Systems as a field of academic study exists with a combination of computing and Business under a variety of different names. The different labels reflect historical development of the field, different ideas about how to characterize it, and different emphases when programs were started. A sample of names associated with the academic discipline of Information Systems include nationally, regionally, and globally Information Systems, Management Information Systems, Computer Information Systems, Information Management, Business Information Systems, Informatics, Information Resources Management, Information Technology, Information Technology Systems, Information Technology Resources Management, Accounting Information Systems, Information Science, and Information and Quantitative Science.

5.1.1. Information Systems Objectives: An IS program enables students to achieve additional attributes, beside the general computing attributes, by the time of graduation, including an understanding of processes that support the delivery and management of information systems within a specific application environment.

5.1.2. Information Systems Curricula: Computing is a highly diverse subject that overlaps with many other subject such as; electrical engineering, math, physics, philosophy and physiology. Several characteristics of the Information Systems (IS) profession have been relatively constant over time and have been integrated into the curriculum. These include:

- IS professionals must have a broad business and real world perspective.
- IS professionals must have strong analytical and critical thinking skills.
- IS professionals must have interpersonal communication and team skills and have strong ethical principles.
- IS professionals must design and implement information technology solutions that enhance organizational performance.

The curriculum combines professional requirements with general education requirements and electives to prepare students for a professional career in the information systems field, for further study in information systems, and for functioning in modern society. The professional requirements include coverage of basic and advanced topics in information systems as well as an emphasis on an IS environment. Curricula are consistent with widely recognized models and standards. The following table summarizes the minimal percentage of main areas that should be included in the program. Note that the sum of the suggested, by consultants, percentages is less than 100; this leaves range of freedom for diversity. However, Participants suggested a 100% distribution of the topics.

Table 3: IS – Volume of Study

TOPIC	SUGESSTED	NATIONAL
Information Systems topics	35%	42%
Information Systems Environment	12.5%	19%
Math (statistics & discrete)	8%	6%
General education	12.5%	12%
Economical, Social and Ethical topics	12.5%	11%
Collaborative Skills	5%	10%

5.2. Information Technology Program

Information Technology (IT) in its broadest sense encompasses all aspects of computing technology. IT, as an academic discipline, focuses on meeting the needs of users within an organizational and societal context through the selection, creation, application, integration, and administration of computing technologies. IT is a dynamic discipline that addresses the use of computing and information technology in business, education, government, and other organizations or applications. The scope of the discipline includes the development of systems based on computer and information technology and the application of those systems to enhance enterprise operations. The work of IT professionals is essential for effective operations in today's knowledge-based society. IT professionals should be able to work effectively at planning, implementation, configuration, and maintenance of an organization's computing infrastructure.

5.2.1. IT Program outcomes: IT graduates must possess several skills upon graduation, namely the ability to:

(a) Use and apply current technical concepts and practices in the core information technologies;

(b) Analyze, identify, and define the requirements that must be satisfied to address problems or opportunities faced by organizations or individuals;

(c) Design effective and usable IT-based solutions and integrate them into the user environment

(d) Assist in the creation of an effective project plan;

(e) Identify and evaluate current and emerging technologies and assess their applicability to address the users' needs;

(f) Analyze the impact of technology on individuals, organizations and society, including ethical, legal, and policy issues;

(g) Demonstrate an understanding of best practices and standards and their application;

(h) Demonstrate independent critical thinking and problem solving skills;

(i) Collaborate in teams to accomplish a common goal by integrating personal initiative and group cooperation;

(j) Communicate effectively and efficiently with clients, users and peers both verbally and in writing, using appropriate terminology;

(k) Recognize the need for continued learning throughout their career.

5.2.2. Information Technology Curricula: Although, computing is a highly diverse subject, and overlaps with many other subjects including electrical engineering, math, physics, philosophy, and physiology, the characteristics of the IT profession have been relatively constant over time and have been integrated into the curriculum. The characteristics of IT professional must have:

- A broad business and real world perspective;
- Strong analytical and critical thinking skills;
- Interpersonal communication and team skills and have strong ethical principles;
- Design and implement IT solutions that enhance organizational performance.

Therefore, curriculum combines professional requirements with general education requirements and electives to prepare students for:

- A professional career in the information technology field,
- Further study in information technology, and
- Functioning in modern society.

The professional requirements include coverage of basic and advanced topics in IT as well as an emphasis on an IT environment. Curricula are consistent with widely recognized models and standards. The following table summarizes the minimal percentage, suggested by the team and modified by the IT specialists, of main areas that should be included in the program. The leftover percentage is left for HEI diversity and excellence.

Table 4: IT – Volume of Study

TOPIC	SUGGESTED	NATIONAL
Information Technology topics	35%	35%
Information Systems Environment (Business)	12.5%	20%
Math (statistics & discrete)	8%	8%
General education	12.5%	11%
Economical, Social and Ethical topics	12.5%	9%
Collaborative Skills	5%	8%

5.3. Computer Science Programs:

Computer Science (CS) spans a wide range, from its theoretical and algorithmic foundations to advanced developments in exciting areas such as robotics, computer vision, intelligent systems, and bioinformatics.

5.3.1. Computer Science Objectives: CS program enables students to achieve additional attributes, beside the general computing attributes, by the time of graduation. Namely, an ability to apply:

(a) Apply mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices;

(b) Design and development principles in the construction of software systems of varying complexity.

The work of computer scientists may fall into three categories:

- Design and implement challenging software. Supervise other programmers, and keeping them aware of new approaches.
- Devise new ways to use computers in all CS areas including networking, database, and human-computer-interface enabled the development of the World Wide Web.

- Develop effective ways to solve computing problems. Although, CS spans the range from theory through programming, Curricula that reflect this breadth are sometimes criticized for failing to prepare graduates for specific jobs. Thus, while other disciplines may produce graduates with more immediately relevant job-related skills, CS provides a comprehensive foundation that permits graduates to adapt to new technologies and new ideas.

Although, CS spans the range from theory through programming, Curricula that reflect this breadth are sometimes criticized for failing to prepare graduates for specific jobs. Thus, while other disciplines may produce graduates with more immediately relevant job-related skills, CS provides a comprehensive foundation that permits graduates to adapt to new technologies and new ideas.

5.3.2. Computer Science Curriculum: The curriculum is consistent with the program's documented objectives. It combines technical requirements with general education requirements and electives to prepare students for a professional career in the computer field, for further study in computer science, and for functioning in modern society. The technical requirements include up-to-date coverage of basic and advanced topics in computer science as well as an emphasis on science and mathematics. The following table summarizes the minimal percentage of main areas that should be included in the program.

Table5: CS– Volume of Study

TOPIC	SUGGESTED	NATIONAL
Computer Science topics	35%	45%
Math	12.5%	14%
Science	12.5%	12%
Social Sciences	25%	17%
Skills	5%	8%

5.4. Computer Engineering Programs

Computer Engineering (CE) is defined as the discipline that embodies the science and technology of design, construction, implementation, and maintenance of software and hardware components of modern computing systems and computer-controlled equipment. It has evolved over the past three decades as a separate discipline. Computer engineering is solidly grounded in the theories and principles of computing, mathematics, science, and engineering and it applies these theories and principles to solve technical problems through the design of computing hardware, software, networks, and processes. Therefore, CE field of study involves the study of hardware, software, communications, and the interaction among them. CE's curriculum focuses on the theories, principles, and practices of traditional electrical engineering and mathematics and applies them to the problems of designing computers and computer-based devices.

An important distinction should be made between computer engineers, electrical engineers, other computer professionals, and engineering technologists. While such distinctions are sometimes ambiguous, computer engineers generally should satisfy the following three characteristics.

- Possess the ability to design computers and computer-based systems that include both hardware and software to solve novel engineering problems, subject to trade-offs involving a set of competing goals and constraints. In this context, "design" refers to a level of ability beyond "assembling" or "configuring" systems.
- Have a breadth of knowledge in mathematics and engineering sciences, associated with the broader scope of engineering and beyond that narrowly required for the field.
- Acquire and maintain a preparation for professional practice in engineering.

Therefore, developing any curriculum for undergraduate study in CE should reflect the current needs of CE students. Furthermore, CE curriculum should reflect current educational practice and suggest improvements where necessary. The discussion that follows attempts to accomplish this in preparing a body of knowledge commensurate with producing competent computer engineering graduates.

5.4.1 Computer Engineering Outcomes: Since learning outcomes imply assessment and since assessment guides learning, teachers should exercise considerable care in selecting and formulating these. Typically, CE graduates must possess the various knowledge and skills upon graduation including:

(a) The ability and intellectual foundation for considering issues from a global and multilateral viewpoint.

(b) Understanding of the effects and impact of technology on society and nature, and of engineers' social responsibilities.

(c) Knowledge of mathematics, natural sciences and information technology, and the ability to apply such knowledge.

(d) Specialized engineering knowledge in each applicable field, and the ability to apply such knowledge to solve actual problems.

(e) Design abilities to organize comprehensive solutions to societal needs.

(f) Arabic and English-language communications skills including methodical writing, verbal presentation, and debate abilities.

(g) The ability to carry on learning on an independent and sustainable basis.

(h) The ability to implement and organize works systematically under given constraints.

5.4.2. Computer Engineering Curriculum: A computer engineering program requires a great variety of knowledge, practical skills, transferable skills, and attitudes that need consideration within the one single framework. Students who enjoy and respond to particular approaches can be confident that they will continue to enjoy and be successful at the more advanced levels.

The curriculum is consistent with the program's documented objectives. It combines technical requirements with general education requirements and electives to prepare students for a professional career in the CE field, for further study in computer engineering, and for functioning in modern society. The technical requirements include up-to-date coverage of basic and advanced topics in computer engineering as well as an emphasis on science and mathematics. The following table summarizes the minimal percentage, proposed by the team and modified by CE experts, of main areas that should be included in the program. For the engineering programs, the typical level credit hours requirement as agreed upon is 166. The excellent level credit hours requirements should not exceed 180; 15 additional credit hours for the core courses and 15 additional credit hours for the CE specialization track. Skills have not been explicitly mentioned in this table!

Table 6: CE – Volume of Study

TOPIC	SUGGESTED	NATIONAL	NATIONAL (CREDIT HOURS)
Social Sciences: General education Complementary	25% 12% 15%	23% 10% 13%	38 16 22
Mathematics	10%	11%	18
Physics	5%	4%	7
Electricity/Electronics	30%	31%	53
Specialization track: CE	20%	26%	42

5.5 Computing Knowledge Areas

For each discipline, a core of topics has been identified, this is important since we are not defining a general degree title in computing such as in UK. The core includes computing topics, non-computing topics, and transferable and professional skills. The main topics have been adopted form ACM[16]. The weights TH: Threshold (0-10) and EX: Excellent (0-10) for each topic have been suggested by participants that reflect the local market needs has been considered. These topics and corresponding weights are as shown in Table 7:

Table 7.1: Knowledge Areas, ACM and National Weights

Topics	CS				IT				IS				CE			
	ACM		National		ACM		National		ACM		National		ACM		National	
	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX
COMPUTING TOPICS																
Programming Fundamentals	8	10	10	10	4	8	7	9	4	8	6	8	8	8	8	10
Integrative Programming	2	6	5	8	6	10	6	7	4	8	6	8	0	4	2	4
Algorithms & Complexity	8	10	9	10	2	4	3	5	2	4	2	5	4	8	6	8
Computer Architecture & Organization	4	8	7	8	2	4	1	1	2	4	2	4	10	10	10	10
Operating Systems Principles & Design	6	10	7	9	2	4	1	1	2	2	2	4	4	10	4	10
Operating Systems Configuration & Use	4	8	5	7	6	10	1	1	4	6	2	6	4	6	4	6
Net Centric Principles and Design	4	8	6	8	6	8	6	8	2	6	2	4	2	6	2	6
Net Centric Use and Configuration	4	6	4	7	8	10	4	5	4	8	2	6	2	4	2	4
Platform technologies	0	4	4	6	4	8	2	3	2	6	2	4	0	2	0	2
Theory of Programming Languages	6	10	7	9	0	2	1	2	0	2	0	2	2	4	2	4
Human-Computer Interaction	4	8	5	7	8	10	3	5	4	10	5	10	4	10	4	10
Graphics and Visualization	2	10	5	7	0	2	4	5	2	2	7	10	2	6	2	6
Intelligent Systems (AI)	4	10	6	9	0	0	0	0	2	2	1	3	2	6	2	6
Information Management (DB)	4	10	7	9	2	2	4	5	2	6	4	6	2	6	2	6

[16] ACM: CC 2005, March2006

Table 7.1: Knowledge Areas, ACM and National Weights

Topics	CS				IT				IS				CE			
	ACM		National		ACM		National		ACM		National		ACM		National	
	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX
Information Management (DB)	2	8	5	7	6	8	5	6	8	10	5	8	2	4	2	4
Scientific computing (Numerical methods)	0	10	6	9	0	0	0	0	0	0	0	2	0	4	0	4
Legal / Professional / Ethics / Society	4	8	5	7	4	8	7	8	4	10	7	10	4	10	7	10
Information Systems	0	4	4	6	2	6	4	6	10	10	10	10	0	4	0	4
Analysis of Business Requirements	0	2	3	5	2	4	2	3	10	10	10	10	0	2	0	2
E-business	0	0	3	5	2	4	1	2	8	10	10	10	0	0	0	2
Analysis of Technical Requirements	4	8	4	6	6	10	3	5	4	8	2	4	4	10	5	10
Engineering Foundations for SW	2	4	3	5	0	0	0	0	2	2	1	1	2	4	2	4
Engineering Economics for SW	0	2	2	5	0	2	0	0	2	4	3	6	2	6	2	6
Software Modeling and Analysis	4	6	5	7	2	6	0	0	6	6	4	7	2	6	2	6
Software Design	6	10	6	9	2	4	0	0	2	6	2	5	4	8	4	8
Software Verification and Validation	2	4	4	6	2	4	0	0	2	4	2	4	2	6	3	6
Software Evolution (maintenance)	2	2	4	6	2	4	0	0	2	4	1	3	2	6	3	6
Software Process	2	4	3	5	2	2	0	0	2	4	1	4	2	2	2	2
Software Quality	2	4	3	6	2	4	0	0	2	4	1	4	2	4	1	4
Comp. Systems Engineering	2	4	3	5	0	0	0	0	0	0	1	3	10	10	10	10
Digital logic	4	6	5	7	2	2	3	3	2	2	1	3	10	10	10	10
Embedded Systems	0	6	3	5	0	2	0	1	0	0	1	3	4	10	5	10
Distributed Systems	2	6	4	6	2	6	1	1	4	8	2	6	6	10	6	10
Security: issues and principles	2	8	4	7	2	6	4	6	4	6	2	5	4	6	4	6
Security implementation and Mgt	2	6	4	7	6	10	4	6	2	6	2	5	2	4	2	4
Systems administration	2	2	3	4	6	10			2	6	2	3	2	4	2	5
Management of Info Systems Org.	0	0	3	4	0	0	3	4	6	10	8	10	0	0	1	1
Systems integration	2	4	3	4	8	10	2	3	2	8	3	8	2	8	2	8
Digital media development	0	2	3	5	6	10	3	4	2	4	2	4	0	4	1	4
Technical support	0	2	3	4	10	10	2	2	2	6	4	6	0	2	1	2

Table 7.2: Knowledge Areas, ACM and National Weights

Topic	CS				IT				IS				CE			
	ACM		National		ACM		National		ACM		National		ACM		National	
	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX
NON-COMPUTING TOPICS																
	0	0	1	3	2	4	1	2	2	8	3	10	0	0	0	0
Decision	0	0	2	4	0	2	0	1	6	6	4	6	0	0	0	0
Organizational	0	0	1	3	2	4	2	4	6	10	6	8	0	0	0	0
Organizational	0	0	1	2	2	4	1	2	4	4	4	6	0	0	0	0
General Systems	0	0	2	4	2	4	1	1	4	4	4	6	0	0	0	0
Risk Management	2	2	3	5	2	8	1	2	4	6	6	8	4	8	4	8
Project	2	4	4	6	4	6	5	6	6	10	4	7	4	8	4	8
Circuits and	0	4	2	3	0	2	0	1	0	0	0	0	10	10	10	10
Electronics	0	0	2	4	0	2	0	1	0	0	0	0	10	10	10	10
Digital Signal	0	4	2	4	0	0	0	1	0	0	0	0	6	10	8	10
VLSI design	0	2	2	4	0	0	0	1	0	0	0	0	4	10	6	10
HW testing and fault	0	0	2	3	0	4	0	1	0	0	0	0	6	10	6	10
Math	8	10	5	8	4	8			4	8			6	10		
Discrete			6	8			2	3			3	3			8	10
Calculus			6	9			1	2			0	3			10	10
Probability and statistics			5	8			0	1			3	6			6	10
Business Fundamentals	2	8	5	7	6	8			6	10			6	8	0	1
Business			2	3			1	2			10	10			0	1
Functional Business Areas			1	2			1	1			8	10			0	0
Evaluation of Business			1	2			1	1			4	6			0	0
National											3	6				
History of	3	6	5	7			0	0	3	6	3	6			3	6
Islamic	3	6	5	7			7	8	3	6	3	6			3	6
Arabic	3	6	5	7			7	9	3	6	3	6			3	6
English	5	8	7	9			7	9	5	8	5	8			8	10

5.6 Capabilities and Skills

Representative Capabilities and skills expected from Computing Program Graduates are mentioned in Table 8. More details are included in appendix A.

Table 8: Capabilities & Skills, ACM and National Weights

Topics	CS				IT				IS				CE			
	ACM		National		ACM		National		ACM		National		ACM		National	
	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX	TH	EX
ANALYTICAL & CRITICAL THINKING (GROUP 1)																
Organizational Problem Solving	0	4	2	5			4	5	6	10	6	10			0	2
Ethics and Professionalism	2	6	3	6			3	4	6	10	6	10			2	4
Creativity			3	6			2	4			4	8			5	8
INTERPERSONAL, COMMUNICATION, & TEAM SKILLS	4	8							6	10			7	10		
Interpersonal			4	7			6	10			6	10			6	10
Team Work and Leadership			4	7			5	8			6	10			6	8
Communication			4	7			5	8			4	8			8	10
TECHNOLOGY (Group 3)																
Application Development			4	7			6	8			6	8			4	6
Internet Systems Architecture and Development			5	7			6	8			10	10			2	4
Database Design and			5	8			6	8			5	8			5	7
Systems Infrastructure and			4	6			8	10			10	10			3	5
TECHNOLOGY-ENABLED BUSINESS DEVELOPMENT (Group 4)																
Systems Analysis and Design	6	10	6	9			7	9	6	8	10	10			6	10
Business Process Design	2	4	2	4			2	3	10	10	10	10			2	4
Systems Implementation	6	10	5	8			4	5	5	8	8	10			6	8
IS Project Management	0	4	3	6			5	7	10	10	10	10			2	4

6- Electrical Engineering Benchmarks

Hereafter are the details of the knowledge areas and skills that the professionals in our Universities have judged as primordial to the education of engineering defined according to the output of the educational system that supplies the engineering profession with the necessary manpower. How the University achieves those goals, i.e., teaching methods, resources, infrastructure, and conditions of enrolment are entrusted to each institution. In addition all the following is set as the minimum requirements for any relevant program of study and must not constitute limits that hinder innovation but must be considered as a framework agreed upon by the different experts of the field from the different Palestinian Universities at the time when it was developed.

This document is a framework and details a method that can be used for the design and development of any type of engineering program. It must not be considered as a schoolbook for an accreditation process but rather more generally as a guidebook on how to come up with an engineering program the contents of which provide information to the different stakeholders about the output of this program.

6.1. Scope of Electrical Engineering

Electrical Engineering is a profession whose activities encompass several issues such as design, production, construction, operation, and disposal[17]. In many cases management (especially in our country where businesses are of medium or small scales) is also an activity to be added for the engineering profession; in other words, the profession of engineering combines the rigor of science with the pragmatism of business[18]. The engineering curriculum has to be designed to prepare the graduate for such professional requirements and obligations. But one must not imagine that all graduates will be of the same level or that they will have the identical spans of knowledge and skills. This has to be function of the work environment the engineer is trained to work in according to the regulations and standards of the Association of Engineers; but one must not forget that we are now living in a world rapidly evolving towards globalization, and therefore engineering as a profession is becoming more demanding. To challenge this evolution, emphasis is to be put on the learning outcomes that support professional engineering aptitudes, which is at present the international trend in designing study programs.

6.2. Main characteristics of graduates

The strength of the program is evaluated by its yield: the graduate. This evaluation is done by measuring the outcomes. These are clustered into knowledge/understanding based ones and skills based ones. Knowledge/understanding wise, graduates are required to take hold of theories and principles relevant to their discipline, and have a broad notion about the other fields of engineering. Skills are grouped into two sub-clusters (detailed in the following tables):

- Practical skills, such as group work, engineering analysis, and design.
- Transferable skills, such as communication, IT literacy, and undertaking of continuous life-long learning.

[17] United Kingdom Standard for Professional Engineering Competence (UK-SPEC)

[18] Engineering Council – UK, www.engc.org.uk

According to the volume of study and nature of knowledge/understanding areas and skills, a program is designed to fulfill a certain level of requirements that can be classified on a threshold to an excellent level scale.

6.3. Knowledge Areas

The following tables (9.a, 9.b, 9.c) cover the basic studies requirements for the Electrical, Electronics/Communications, and Computer engineering programs. Basic studies represent 80% of the volume of studies for these engineering programs. Tables 10 (10.a, 10.b, 10.c) cover the specialization for the Electrical, Electronics/Communications, and Computer engineering programs. They represent 20% of the volume of studies for these engineering programs. The ratings for the topics mentioned in the tables are the national averages of the ratings given by the experts in the fields.

Table 9.a: Complementary topics

	Topics	Areas					
		Electrical Eng.		Electronics Eng. (Communications)		Computer Eng. (Covered above)	
		TH	EX	TH	EX	TH	EX
	COMPLEMENTARY (13%)						
Group 1 (10%)	Foreign language (English)	9	10	9	10	7	9
	Communication	8	9	9	10	6	8
	Technical writing	8	10	8	10	7	9
	Ethics (codes of conduct, human security, society,	8	10	9	10	6	7
	Fundamentals of research methods					5	6
Group 2 (10%)	Engineering/project management	5	7	8	9	6	7
	Risk management	5	7	5	6	4	6
	Product engineering	5	6	7	8	5	6
	Engineering drawing	5	6	3	5	3	4
	Elements of accounting	5	6	4	5	3	4
	Elements of Economics (Eng. Economics for SW)	5	6	5	7	4	5
	Elements of commercial and industrial laws	7	9	5	7	6	8
	Engineering foundations for SW	5	7	8	9	6	7

Table 9.b: Sciences

Topics	Areas					
	Electrical Eng.		Electronics Eng. (Communications)		Computer Eng. (Covered above)	
	TH	EX	TH	EX	TH	EX
MATHEMATICS (11%)						
Calculus	9	10	9	10	7	8
Algebra	9	10	9	10	7	9
Analysis (real and complex)	9	10	7	9	6	7

Table 9.b: Sciences

Topics	Areas					
	Electrical Eng.		Electronics Eng. (Communications)		Computer Eng. (Covered above)	
	TH	EX	TH	EX	TH	EX
Geometry	8	9	6	8	6	7
Probability and random variables	8	10	8	10	7	9
Statistics	8	10	9	10	7	8
Transforms	9	10	8	10	5	7
Numerical analysis	6	7	9	10	7	9
Discrete mathematics	6	8	5	7	7	8
Scientific computing (numerical methods)	7	9	6	8	8	9
PHYSICS (4%)						
Electricity and magnetism	9	10	8	10	4	6
Electromagnetism	7	8	7	10	3	5
Statics and dynamics	6	9	4	7	2	4
Thermodynamics	8	10	5	7	2	3
Electromagnetic compatibility	9	9	7	9	2	4
Antennas and waveguides	6	8	8	10	3	5
Microwaves	5	8	8	10	3	4
Optical fibers	6	8	8	10	3	5

Table 9.c: Common core

	Topics	Areas					
		Electrical Eng.		Electronics Eng. (Communications)		Computer Eng. (Covered above)	
		TH	EX	TH	EX	TH	EX
ELECTRICITY/ELECTRONICS (31%)							
Group 1 (18%)	Analysis of passive circuits	10	10	10	10	5	6
	Analysis of active circuits	10	10	10	10	5	6
	Analysis and synthesis of networks	9	10	10	10	5	6
	Circuits, devices, systems	10	10	9	10	5	7
	Power electronics	10	10	8	9	2	4
	Electrical machines	10	10	6	7	2	4
	Instrumentation and measurement	10	10	10	10	5	7
Group 2 (5%)	Digital logic	10	10	10	10	8	9
	Digital electronics	10	10	10	10	6	9
	Processors	10	10	9	10	8	10
	Computer architecture &	9	10	6	8	8	10
	Computer systems engineering	6	8	4	6	8	10
	Embedded systems	8	9	5	7	7	9
	Distributed systems	7	7	4	6	7	9
	Interfacing	8	10	5	7	8	9
	VLSI design	6	7	6	8	6	8
	Platform technologies	6	6	6	7	7	8
	Hardware testing and fault tolerance	8	8	7	9	5	7
Group 3 (8%)	CAD tools	10	10	10	10	7	8
	Programming fundamentals	10	10	10	10	9	10
	Software engineering	5	6	3	6	8	10

Table 9.c: Common core							
	Topics	Areas					
		Electrical Eng.		Electronics Eng. (Communications)		Computer Eng. (Covered above)	
		TH	EX	TH	EX	TH	EX
	Computer networks	6	7	7	9	9	10
	Human-computer interaction	5	5	3	4	7	9
	Software design	5	5	3	5	7	9
	Systems integration (industrial)	8	9	6	7	6	8
Group 4 (4%)	Control	10	10	7	8	5	7
	Actuators	10	10	5	6	4	5
	Sensors	10	10	6	7	4	6
	Robotics					4	7

Table 10.a: Electrical Engineering Track (26%)						
Topics	Areas					
	Electrical Eng.		Electronics Eng. (Communications)		Computer Eng. (Covered above)	
	TH	EX	TH	EX	TH	EX
ELECTRICAL ENGINEERING						
Electrical insulation	9	10	3	5	2	3
Electric power generation	10	10	4	5	2	2
Electric power transmission and distribution	10	10	4	5	1	2
Network and service management	9	10	4	5	2	3
Renewable energy	9	10	4	8	1	2
Energy conversion	10	10	2	5	1	2

Table 10.b: Communications Track (26%)						
Topics	Areas					
	Electrical Eng.		Electronics Eng. (Communications)		Computer Eng. (Covered above)	
	TH	EX	TH	EX	TH	EX
ELECTRONICS/COMMUNICATIONS ENGINEERING						
Digital Signal Processing	9	9	10	10	5	7
Communications	9	9	10	10	5	7
Digital communications	9	9	10	10	5	7
Mobile communications	7	8	10	10	5	7
Data communications	7	8	10	10	7	8
Wireless multimedia	7	8	10	10	7	8
Information theory	6	8	10	10	6	8
Microwave and wireless components	7	8	10	10	4	7
Radar, sonar, GPS	7	8	8	10	3	5
Remote sensing	8	9	8	9	3	5

Table 10.c: Computer Engineering Track (26%)						
Topics	Areas					
	Electrical Eng.		Electronics Eng. (Communications)		Computer Eng. (Covered above)	
	TH	EX	TH	EX	TH	EX
COMPUTER ENGINEERING						
Integrative programming	6	7	3	5	7	8
Algorithms and complexity	6	7	5	7	7	9
Operating systems	7	8	8	9	9	10
Net Centric	6	8	9	10	6	7
Theory of programming languages	5	6	5	7	6	8
Graphics and visualization	5	8	5	7	7	8
Intelligent systems	7	7	5	6	7	9
Information management (DB)	4	5	8	7	7	9
Information systems development	3	4	3	5	6	8
Analysis of technical requirements	8	8	8	9	7	9
Software modeling and analysis	4	5	3	5	6	9
Software verification and validation	4	5	1	3	7	8
Software evolution (maintenance)	3	5	1	3	6	7
Software process	3	5	1	3	6	8
Software quality	3	5	2	4	6	8
Security: issues and principles	5	7	5	7	7	9
Security: implementation and management	4	5	5	7	7	8
Systems administration	3	5	3	5	7	8
Digital media development	3	4	5	7	7	8
Technical support	4	5	1	3	7	8
Analysis of business requirements	1	3	2	4	4	6
Real time applications					8	10

6.4. Capabilities and Skills

In the following table 11 are detailed the different capabilities and skills. More facts are included in appendix A.

Table 11: Capabilities and Skills						
Topics	Areas					
	Electrical Eng.		Electronics Eng. (Communications)		Computer Eng. (Covered above)	
	TH	EX	TH	EX	TH	EX
SUBJECT-RELATED COGNITIVE ABILITIES (GROUP 1)						
Engineering thinking	7	8	5	7	8	9
Knowledge and understanding	7	7	4	5	7	8
Modeling and design	7	7	8	10	6	8
Problems' solving	7	7	5	6	7	8
Critical evaluation and testing	6	6	4	5	6	7
Methods and tools	6	6	6	7	6	8
Reflection and communication	6	6	7	8	5	6
Professional considerations	7	7	7	8	5	7

Table 11: Capabilities and Skills						
Topics	Areas					
	Electrical Eng.		Electronics Eng. (Communications)		Computer Eng. (Covered above)	
	TH	EX	TH	EX	TH	EX
SUBJECT-RELATED PRACTICAL ABILITIES (GROUP 2)						
Design & construction of systems	7	7	7	8	6	8
Evaluation of systems	6	6	5	6	6	8
Safety aspects	7	7	4	5	5	7
Solving practical problems	6	6	5	7	6	8
Operating equipment	6	6	6	7	6	7
ADDITIONAL TRANSFERABLE SKILLS (GROUP 3)						
Effective information-retrieval	7	7	5	5	6	8
Understanding and presenting cases	7	7	6	9	6	8
Effective use of general information	6	6	7	8	7	8
Team work	7	8	6	7	7	9
Management and organizational skills	7	8	6	7	6	8
Recognition of the need for lifelong learning	7	7	4	5	6	7

6.5. The Intended Learning Outcomes of a program courses by level of study

Each set of program (subject area) courses should have its ILOs. The relevant competences are to be developed and assessed. The ILOs of the individual courses (units) or a set / group of courses (modules) add to the overall ILOs and to the development of the level of competences, taking into full consideration the ILOs to be achieved in other courses (units)[19].

Table 12: ILOs of one program courses detailed by level of study.

Outcomes (competences)	A	B	C	D	E	F	G	H	I	J	K	L	M
Course 1													
Course 2													
Course 3													
Course 4													

Example: a student must be able to work autonomously, work in a team, organize, plan, communicate (orally and in writing) in Arabic and English, apply knowledge in practice, analyze, synthesize, solve problems, use CAD, modeling and simulation, and adapt to new situations. On top of this the student has to demonstrate concern to quality and information management skills.

6.6. Program Characteristics (Body of Knowledge)

The curriculum combines professional requirements with general education requirements and electives to prepare students for a professional career in the Electrical/Electronics (Communications)/Computer engineering fields, for further

[19] Tuning Methodology, ETF, EC.

study, and for functioning in modern society. The following table summarizes the minimal percentage of main areas that should be included in the program**.**

Table 13: EE/CE – Volume of Study

SUBJECT AREAS	PERCENTAGE	CREDIT HOURS
General education	10%	16
Complementary	13%	22
Mathematics	11%	18
Physics	4%	7
Electricity/Electronics	31%	53
Specialization track	26%	42

5% is left to be used by the university according to its philosophy, excellence, and policy. For the engineering programs, the typical level credit hours requirement as agreed upon is 166. The excellent level credit hours requirements should not exceed 180; 15 additional credit hours for the core courses and 15 additional credit hours for the specialization track.

7- Appendices

Appendix A

A.1. Subject-related cognitive abilities:

- Computational thinking including its relevance to everyday life.
- Knowledge and understanding: demonstrate knowledge and understanding of essential facts, concepts, principles and theories relating to computing and computer applications as appropriate to the program of study.
- Modeling: use such knowledge and understanding in the modeling and design of computer-based systems for the purposes of comprehension, communication, prediction and the understanding of trade-offs.
- Requirements, practical constraints and computer-based systems (and this includes computer systems, information systems, embedded systems and distributed systems) in their context: recognize and analyze criteria and specifications appropriate to specific problems, and plan strategies for their solution.

- Critical evaluation and testing: analyze the extent to which a computer-based system meets the criteria defined for its current use and future development.
- Methods and tools: deploy appropriate theory, practices and tools for the specification, design, implementation and evaluation of computer-based systems.
- Reflection and communication: present succinctly to a range of audiences (orally, electronically or in writing) rational and reasoned arguments that address a given information handling problem or opportunity. This should include assessment of the impact of new technologies.
- Professional considerations: recognize the professional, economic, social, environmental, moral and ethical issues involved in the sustainable exploitation of computer technology and be guided by the adoption of appropriate professional, ethical and legal practices.

A.2. Subject-related practical abilities:

- The ability to specify, design and construct computer-based systems.
- The ability to evaluate systems in terms of general quality attributes and possible trade-offs presented within the given problem.
- The ability to recognize any risks or safety aspects that may be involved in the operation of computing equipment within a given context.
- The ability to deploy effectively the tools used for the construction and documentation of computer applications, with particular emphasis on understanding the whole process involved in the effective deployment of computers to solve practical problems.
- The ability to operate computing equipment effectively, taking into account its logical and physical properties.

The extent to which students acquire these abilities will depend on the emphasis of individual degree programs. It is expected, however, that the student will be able to deploy these abilities to a greater and deeper extent than someone who is merely an interested practitioner.

A.3. Additional transferable skills:

- Effective information-retrieval skills (including the use of browsers, search engines, and catalogues).

- Numeracy and literacy in both understanding and presenting cases involving a quantitative and qualitative dimension.
- Effective use of general information technology (IT) facilities.
- The ability to work as a member of a development team, recognizing the different roles within a team and different ways of organizing teams.
- Managing one's own learning and development including time management and organizational skills.
- Appreciating the need for continuing professional development in recognition of the need for lifelong learning.

Appendix B

B.1. Analytical and Critical Thinking:

Organizational Problem Solving:
- Problem solving models, techniques, and approaches
- Personal decision making
- Critical thinking
- Methods to collect, summarize, and interpret data
- Statistical and mathematical methods

Ethics and Professionalism Creativity:
- Codes of conduct
- Ethical theory
- Leadership
- Legal and regulatory standards
- Professionalism - self directed, leadership, time management
- Professionalism - commitment to and completion of work

Creativity:
- Creativity concepts
- Creativity techniques
- The systems approach

B.2. Interpersonal, Communication, and Team Skills:

Interpersonal:
- Listening
- Encouraging
- Motivating
- Operating in a global, culturally diverse environment

Team Work and Leadership:
- Building a team
- Trusting and empowering

- Encouraging
- Developing and communicating a vision/mission
- Setting and tracking team goals
- Negotiating and facilitating
- Team decision making
- Operating in a virtual team environment
- Being an effective leader

Communication:
- Listening, observing, interviewing, and documenting
- Abstraction and precise writing
- Developing multimedia content
- Writing memos, reports, and documentation
- Giving effective presentation

B.3. Technology:

Application Development
- Programming principles, objects, algorithms, modules, testing
- Application development – requirements, spec's, development
- Algorithmic design, data, object, and file structures
- Client-server software development

Internet Systems Architecture and Development:
- Web page development
- Web architecture design and development
- Design and development of multi-tiered architectures

Database Design and Administration:
- Modeling and design, construction, schema tools, and DB Systems
- Triggers, stored procedures, design and development of audit controls
- Administration: security, safety, backup, repairs, and replicating

Systems Infrastructure and Integration:
- Computer systems hardware
- Networking (LAN/WAN) and telecommunications
- LAN/WAN design and management
- Systems software
- Operating systems management
- Systems configuration, operation, and administration

B.4. Technology-enabled Business Development:

Systems Analysis and Design, Business Process Design, Systems Implementation, IS Project Management

1. Strategic utilization of information technology and systems
2. IS planning
3. IT and organizational systems
4. Systems analysis
5. Logical and physical design
6. Design execution
7. Testing
8. Deployment
9. Maintenance
10. Use of IT
11. Customer service

Appendix C

BUSINESS FUNDAMENTALS **Business Models** Contemporary and emerging business models Organizational theory, structure, and functions System concepts and theories **Functional Business Areas** Accounting Finance Marketing Human Resources Logistics and Manufacturing **Evaluation of Business Performance** Benchmarking Value chain and value network analysis Quality, effectiveness, and efficiency Valuation of organizations Evaluation of investment performance