National Academic Reference Standards (NARS)

For

Computing and Information

October 2010

1st Edition

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Computing and Information

1- Introduction to Computing and Information

Computing and Information is concerned with the understanding, design, programming, and exploitation of computation, and computer technology - one of the most significant advances of the twentieth century. It is a discipline that blends theories (including those derived from a range of other disciplines such as mathematics, engineering, psychology, graphical design or well-founded experimental insight) with the solution of immediate practical problems; it combines the ethos of the scholar with that of the professional; it supports the development of both small scale and large scale systems that support organizational goals; it helps individuals in their everyday lives; it is everywhere and diversely applied to a range of applications, and yet important components are invisible to the eye.

Computing and Information Specialists are more in demand today than ever before. In fact, more and more fields, from the arts and humanities to music, medicine, linguistics and communication, architecture, and the natural sciences rely on computing to advance their inventions and powers of discovery. And where we are today is just the beginning!.

The information is that what computer systems can provide to aid a company, non-profit or governmental organization in defining and achieving its goals. Information system is concerned with the processes that an enterprise can implement and improve using information technology. IS professionals must understand both technical and organizational factors, and must be able to help an organization determine how information and technology-enabled business processes can provide a foundation for superior organizational performance. They serve as a bridge between the technical and management communities within an organization.

The computing and information discipline is important for the community because:

1. In the 21st century, computing and information is part of everything we do.
2. Skills in computing and information enables the graduates to solve complex, challenging problems.
3. Computing and Information drives innovation in the sciences and also in engineering, business, entertainment and education.
4. Computing and Information offers many types of profitable careers.
5. Computing and Information jobs are among the highest paid and have the highest job satisfaction.

6. Computing and Information jobs are here to stay, regardless of where graduates are located. Statistics say: future opportunities in computing and Information are without boundaries
7. Computing and Information is one of those fields where it is almost impossible to predict what will happen next. This is why we cannot even begin to imagine all the ways that student can make a contribution to it and it can make his life's work exciting and real.
8. Expertise in computing and Information helps student even if students primary career choice is something else.
9. Having a computing and Information major will provide student with a foundation of knowledge, problem solving and logical thinking that will serve as a competitive advantage to him in his career, in whatever field he chooses.
10. Computing and Information offers great opportunities for true creativity and innovativeness.
11. Creating high-quality computing solutions is a highly creative activity, and computing supports creative work in many other fields. The best solutions in computing exhibit high levels of elegance and beauty.
12. Computing and Information has a space for both collaborative work and individual effort.
13. Computing and Information is an essential part of well-rounded academic preparation.
14. An increasing number of universities and employers see successful completion of a computing and Information course as a sign of academic well-roundedness.

2- The Study of Computing and Information

The reasons for studying computing and information are as diverse as its domains of application. Some students are attracted by the depth and intellectual richness of the theory, others by the possibility of engineering large and complex systems; many study computing and Information because it gives them the opportunity to use a creative and dynamic technology. Besides being everywhere and diversely applied, computing and Information promotes innovation and creativity assisted by rapid technological change; it requires a disciplined approach to problem solving that brings with it an expectation of high quality; it approaches design and development through selection from a wide range of alternative possibilities justified by carefully crafted arguments based on insight; it controls complexity first through abstraction and simplification, and then by the integration of components. Above all, it is a product of human ingenuity, and provides major intellectual challenges; yet this limits neither the scope of computing and Information nor the complexity of the application domains addressed.

A traditional description of computing and Information presents a spectrum of activity ranging from theory at one end to practice at the other. It also describes aspects ranging from hardware through to software and from the study of computers and computation through to applications-oriented studies. The following headings give a high-level characterization of the whole area of computing and Information:

Hardware

- Computer architecture and construction
- Processor architecture
- Device-level issues and fabrication technology
- Peripherals and attachments.
- Computer networks, distributed systems, technologies

Software

- Programming languages
- Software tools and packages
- Computer applications
- Structuring of data and information
- Operating systems: the control of computers, resources and interactions

Theory

- Mathematics and Algorithms design and analysis
- Formal methods and description techniques
- Modeling and frameworks
- Analysis, prediction and generalization
- Human behavior and performance

Practice

- Problem identification and analysis
- Design, development, testing and evaluation
- Management and organization
- Professionalism and ethics
- Commercial and industrial exploitation

Communication and Interaction

- Human-computer interaction, involving communication between computers and people

It is difficult to define computing and information with any degree of precision given the dynamic change that is happening within it. Certain areas within the field such as Artificial Intelligence, Computer Science, Information Systems, Software Engineering, Multi-media, and Networks form familiar domains of activity which are represented strongly within computing and information. The overall field is wide ranging and it is important that those working in unusual and innovative areas recognize that they also reside within the field of computing and information.

Faculties and Institutions will produce aims and objectives that characterize their programs and indicate that their curricula are at degree level. Degree programs in computing and information can take various forms, each of which could prepare their students for different but valid careers.

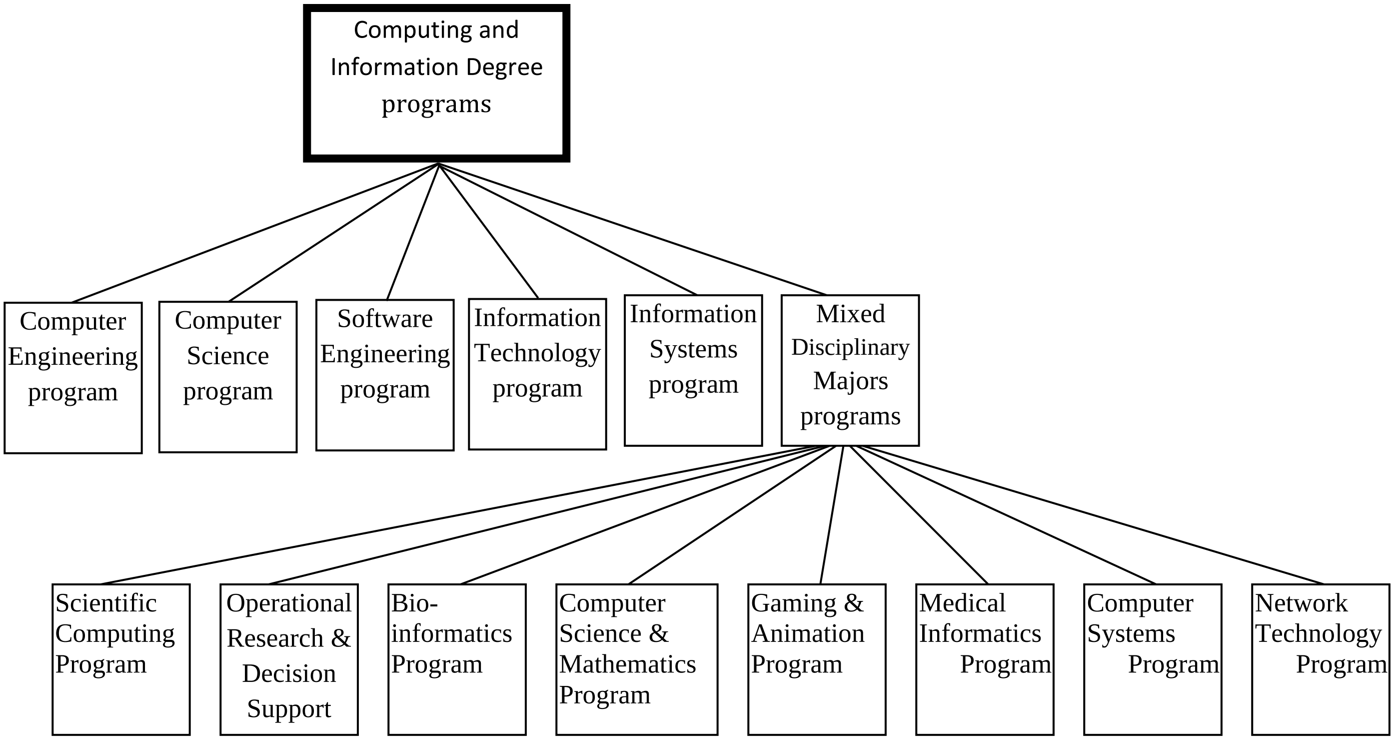
At one extreme a degree program might provide opportunities for its students to attend modules on a wide range of topics spanning the entire area of computing and information. Graduates from such courses would have great flexibility, and might be of especial value either in emerging areas where specialist courses may not be established or in contexts where their ability to span the field would be useful.

At another extreme there can be programs that take one very specific aspect of computing and information and cover it in great depth. The graduates from such programs will typically tend to seek opportunities in the specialist area which they studied, whether it be the development of multimedia systems, network design, the formal verification for safety-critical systems, electronic commerce or whatever other specialties emerge and become important. Program designers, students and stakeholders will need to be aware of this spectrum of program identity, and the balance of practice and theory are appropriate to the aims of the particular degree program, such that practical activity can be supported by an understanding of underlying principles.

3- Computing and Information Programs

The scope of what we call computing and information has broadened to the point that it is difficult to define it as a single program. Recent curriculum approaches divide such program into: **computer science, computer engineering, information systems, information technology, and software engineering**. These address major sub-programs, but additional possibilities still exist. Some **Mixed Disciplinary Majors** are introduced in this NARS for computing and information programs. This introduction has been produced in an attempt to characterize these sub-programs and also to characterize graduates from such degree programs. There is no question that computing and information in the 21st century will encompass many vital programs with their own integrity and educational practices.

It is hardly surprising that the diversity of computing and information is reflected in the varied titles and curricula that institutions have given to their computing and information -related degree courses. While this benchmarking standards, NARS, aims to capture the nature of computing and information as a discipline, individual institutions may need to draw on a wider range of materials and resources including other benchmarking standards to capture fully the specific character of their particular degree programs.



The common computing and information subprograms are listed in the following:

1. **Computer Engineering**
   Typically involves software and hardware and the development of systems that involve software, hardware, and communications.
2. **Computer Science**
   Tends to be relatively broad and with an emphasis on the underlying science aspects.
3. **Information Systems**
   Essentially, this is computing and information in an organizational context, typically in businesses.
4. **Information Technology**
   Focuses on computing infrastructure and needs of individual users; tends to involve a study of systems (perhaps just software systems, but perhaps also systems in support of learning, of information dissemination, etc.).
5. **Software Engineering**
   Focuses on large-scale software systems; employs certain ideas from the world of engineering in building reliable software systems.
6. **Mixed Disciplinary Majors**
   Because computing and information is such an important and dynamic field, many interdisciplinary majors, some are very recent developments, exist at some faculties. Here are just a few examples of these opportunities.
   a. **Scientific Computing**. Scientific Computing (SC) is the focal point of computational science activities at the sector of computing. Computational science involves the invention, implementation, testing, and application of algorithms and software used to solve large-scale scientific and engineering problems.

Scientific computing is now widely accepted, along with theory and experiment, as a crucial third mode of scientific investigation and engineering design. Aerospace, automotive, biological, chemical, semiconductor, and other industrial sectors now rely on simulation for technical decision support. For government agencies also, scientific computing has become an essential support for decisions on resources, transportation, and defense. Finally, in many new areas such as medicine, the life sciences, management and marketing, and finance, techniques and algorithms from computational science are of growing importance.

The field of scientific computing combines simulation, visualization, mathematical modeling, programming, data structures, networking, database design, symbolic computation, and high performance computing with various scientific programs. Hence, scientific computing may be defined as a broad multidisciplinary area that encompasses applications in science/engineering, numerical analysis, and computer science. Computer models and computer simulations have become an important part of the research repertoire, supplementing (and in some cases replacing) experimentation. Going from application area to computational results requires domain expertise, mathematical modeling, numerical analysis, algorithm development, software implementation, program execution, analysis, validation and visualization of results. Scientific computing involves all of this. Although it includes elements from computer science, engineering and science, scientific computing focuses on the integration of knowledge and methodologies from all of these programs, and as such is a subject which is (in some sense) distinct from any of them.

b. **Operation Research and Decision Support.** Operations Research (OR) and Decision Support (DS) emphasize optimizing organizational and system performance using advanced analytical methods to help make better decisions. Operations Research is used in many different industry segments—from health care to logistics to financial services. It is also applied in different business functions from finance to manufacturing and marketing. It helps solve diverse business problems such as identifying best product placements in retail establishments to ensuring appropriate inventory levels in spare parts manufacturing. Technology, computing, and information science all leverage OR's historical and current intellectual thought to enhance practical application. Operations Research employs high-performance computing capabilities to achieve its objectives.

   This program aims to produce a graduate capable of analyzing and developing models and supporting complex decisions in different systems and operations at all managerial levels. The program graduates should be able to play an effective role when it comes to decision formulation in the corporate as well as the wider societal setting, identify the salient parameters that are necessary for decision making, and utilizing information and techniques from diverse fields. The program aims to produce a problem solver with a sufficient grasp of the fundamental techniques and approaches to decision support and a broad intellectual outlook that would enable him/her to effectively contribute in a wide variety of settings.

c. **Bioinformatics** combines elements from at least biology, biochemistry, and computer science, and prepares students for careers in the biotechnology and pharmaceutical industries, or for graduate school in informatics. Some programs may also include elements from information systems, chemistry, mathematics, and statistics. In the newer interdisciplinary areas, different faculties use different names for the same subject. For example, one faculty' “bioinformatics” may be another faculty “computational biology.”
d. **Computational Science (or Scientific Computing)** means science done computationally, and serves as a bridge between computing technology and basic sciences. It blends several fields including computer science, applied mathematics, and one or more application sciences (such as physics, chemistry, biology, engineering, earth sciences, business and others). Some programs also include information systems.
e. **Computer Science and Mathematics** combines computer science with mathematics of course. Some of these programs are found at faculties that do not have a full major in computer science; some are found at universities with very large computer science departments.
f. **Gaming and Animation**. Majors for students interested in creating computer games and computer animations are being developed at a number of faculties. These majors have various flavors and may combine either or both of computer science and information technology work with either or both of art and (digital) media studies.
g. **Medical (or health) Informatics** programs are for students interested in students who want to work in a medical environment. Some students will work as technology experts for hospitals; some in public health; some students may be premed or pre-dental. Coursework may be drawn from any or all of computer science, information systems, or information technology in combination with biology, chemistry, and courses unique to this interdisciplinary field.
h. **Computer Systems.** Computer systems program is concerned with the design and construction of computers and computer-based systems. It involves the study of hardware, software, communications, and the interaction among them. Its 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.

   Computer systems students study the design of digital hardware systems including communications systems, computers, and devices that contain computers, software development, focusing on software for digital devices and their interfaces with users and other devices. Computer System study may emphasize hardware more than software or there may be a balanced emphasis.

   Computer System has a strong engineering flavor, and currently, a dominant area within computing engineering systems is embedded systems, the development of devices that have software and hardware embedded in them. This program is very similar in every aspect with the computer engineering program presented before.

i. **Network Technology:** Networks technology is the knowledge of the technologies involved in network management and operating, network & information security, embedded networks systems, and internet and web technology, gained by study, experience and practice, applied with judgment to develop ways to utilize, ethically and economically, the advances in modern technology and communication for the benefit of mankind. It is the ability to initiate and conduct activity associated with networking processes, systems, problems, opportunities, future, impacts, ethics and consequences. It involves knowledge, ways of thinking and acting, and theoretical and practical networking skills. It helps preparing individuals to make well-informed choices in their means of communication as consumers, workers, citizens and members of the global community.

4- Career Paths

Let us consider what is involved in a career path in each area.

- **Career Path 1: Designing and Implementing Software.** This refers to the work of software development which has grown to include aspects of web development, interface design, security issues, mobile computing, and so on. This is the career path that the majority of computer science graduates follow. Career opportunities occur in a wide variety of settings including large or small software companies, large or small computer services companies, and large organizations of all kinds (industry, government, banking, healthcare, etc.). While a bachelor's degree is generally sufficient for entry into this kind of career, many software professionals return to school to obtain a terminal master's degree (Rarely is a doctorate involved). Degree programs in software engineering also educate students for this career path.

- **Career Path 2: Devising New Ways to Use Computers.** This refers to innovation in the application of computer technology. A career path in this area can involve advanced graduate work, followed by a position in a research university or industrial research and development laboratory; it can involve industrial activity or it can involve a combination of the two.

- **Career Path 3: Developing Effective Ways to Solve Computing Problems**. This refers to the application or development of computer science theory and knowledge of algorithms to ensure the best possible solutions for computationally intensive problems. As a practical matter, a career path in the development of new computer science theory typically requires graduate work to the Ph.D. level, followed by a position in a research university or an industrial research and development laboratory.

- **Career Path 4: Planning and Managing Organizational Technology Infrastructure.** This is the type of work for which the new information technology (IT) programs explicitly aim to educate students.

- **Career Path 5: Applications.** This is the type of work in organizations for which the new programs such as: operations research, scientific computing, bioinformatics, medical applications, networking and gaming and animation, explicitly aim to educate students.

Career path 1 is suitable for graduates from CE and computer systems programs.

Career paths 2 and 3 are undeniably in the domain of computer science and software engineering graduates. Career paths 1 and 4 have spawned the new majors in software engineering and information technology, respectively, and information systems graduates often follow Career path 1, too. Computer scientists continue to fill these positions, but programs in software engineering, information technology, and information systems offer alternative paths to these careers.

Career path 5 is suitable for graduates from computer application programs. Graduates from other major programs can offer another alternative.

In general, a CS degree from a respected program is the most flexible of degrees and can open doors into the professional worlds of CS, SE, IT, and sometimes CE. A degree from a respected IS program allows entry to both IS and IT careers.

5- Computing and Information Disciplines Characteristics

Computing and Information is a highly diverse subject with aspects that overlap with areas of interest to a number of adjacent subjects. Examples of such areas are: engineering, especially parts of electrical and electronic engineering; communications engineering, physics, with concern for multimedia and device-level development of computing components; mathematics (logic and theoretical models of computation); business (information services, systems management, project management); philosophy and psychology (human computer interaction and aspects of artificial intelligence); physiology (neural networks); linguistics; and signal processing. Faculties and Institutions will produce aims and objectives that characterize their programs and indicate that their curricula are at degree level. As the field of Computing and Information develops it can be expected that other areas of overlap will emerge.

A degree program, or a program component in the case of a mixed degree, will count as lying within the area of computing and information if the existence of computers and associated technology is seen as a central driving force in its motivation. The mere fact that computers are deployed to solve problems in a certain area does not of itself make that area fall within the field of computing and information. It is expected that degree programs in computing and information have some concern with the nature of computation, with effective ways to exploit computation, and with the practical limitations of computation in application terms. There will often be a pervading concern with analysis and design, with problem solving, with the nature of information and its processing, and with the wide range of levels of abstraction from which computation can be viewed.

Degree programs in computing and information can take various forms, each of which could prepare their students for different but valid careers. At one extreme a degree program might provide opportunities for its students to attend modules on a wide range of topics spanning the entire area of computing and information. Graduates from such courses would have great flexibility, and might be of especial value either in emerging areas where specialist courses may not be established or in contexts where their ability to span the field would be useful. At another extreme there can be programs that take one very specific aspect of computing and information and cover it in great depth. The graduates from such programs will typically tend to seek opportunities in the specialist area which they studied, whether it be the development of multimedia systems, network design, the formal verification for safety-critical systems, electronic commerce or whatever other specialties emerge and become important.

5.1 Common Requirements of Computing and Information Degrees

As we have seen, each of the computing and information disciplines has its own character. Each one is somewhat different from its siblings in the emphasis, goals, and capabilities of its graduates. Yet they have much in common. Any reputable computing and information degree program should include each of the following elements.

1) Essentials supporting of its discipline. The foundations must highlight those essential aspects of the discipline that remain unaltered in the face of technological change. These may be for example: formal theory rooted in mathematics, or they may address professional values and principles. Students must have a thorough grounding in that foundation.

2) A foundation in the concepts and skills of computer programming. The foundation has five layers:

   a) An intellectual understanding of, and an appreciation for, the central role of mathematics, algorithms and data structures;

   b) An understanding of computer hardware from a software perspective, for example, use of the processor, memory, disk drives, display, etc.

   c) Fundamental programming skills to permit the implementation of algorithms and data structures in software;

   d) Skills that are required to design and implement larger structural units that utilize algorithms and data structures and the interfaces through which these units communicate;

   e) Software engineering principles and technologies to ensure that software implementations are robust, reliable, and appropriate for their intended audience.

3) Understanding of the possibilities and limitations of what computer technology (software, hardware, and networking) can and cannot do. There are three levels:

   a) An understanding of what current technologies can and cannot accomplish;

   b) An understanding of computing and information limitations, including the difference between what computing and information and Information is inherently incapable of doing vs. what may be accomplished via future science and technology;

   c) The impact on individuals, organizations, and society of deploying technological solutions and interventions.

4) Understanding of the concept of the lifecycle, including the significance of its phases (planning, development, deployment, and evolution), the implications for the development of all aspects of computer-related systems (including software, hardware, and human computer interface), and the relationship between quality and lifecycle management.

5) Understanding of the essential concept of process, in at least two meanings of the term:

   a) Process as it relates to computing and information especially program execution and system operation;

   b) Process as it relates to professional activity especially the relationship between product quality and the deployment of appropriate human processes during product development.

6) Study of advanced computing and information topics that permit students to visit and understand the frontiers of the discipline. This is typically accomplished through inclusion of learning experiences that lead students from elementary topics to advanced topics or themes that pervade cutting-edge developments.

7) The identification and acquisition of skill sets that go beyond technical skills. Such skill sets include interpersonal communication skills, team skills, and management skills as appropriate to the discipline. To have value, learning experiences must build such skills (not just convey that they are important) and teach skills that are transferable to new situations.

8) Exposure to an appropriate range of applications and case studies that connect theory and skills learned in academia to real-world occurrences to explicate their relevance and utility.

9) Attention to professional, legal, and ethical issues so that students acquire, develop, and demonstrate attitudes and priorities that honor, protect, and enhance the profession's ethical stature and standing.

10) Demonstration that each student has integrated the various elements of the undergraduate experience by undertaking, completing, and presenting a capstone project.

6- National Academic reference Standards (NARS) for Computing and Information Disciplines

6.1 Attributes of Computing and Information Programs Graduates

The graduates of the computing and Information programs should be able to:

1. Apply the fundamental theories and principles of computing and information applications.
2. Integrate and evaluate the computing tools and facilities.
3. Apply knowledge of mathematics and science.
4. Design a computing system, component and process to meet the required needs within realistic constraints
5. Exploit the techniques, skills and up-to-date computing tools, necessary for computing and information practice.
6. Display professional responsibilities and ethical, societal and cultural concerns
7. Use, compare and evaluate a range of formal and informal techniques, theories and methods to develop computing and information applications.
8. Consider and deal with the individual, social, environmental, organizational and economic implications of the application of computing and information.
9. Carry out a work plan with minimal supervision.
10. Communicate effectively.
11. Hold knowledge and skills required by the computing and information industry.
12. Engage in self and life-long learning and research in computing and information.
13. Fulfill requirements of potential employers.

6.2 National Academic Reference Standards (NARS) for Computing and Information Programs.

Graduates are expected to develop a wide range of abilities and skills. These may be divided into four broad categories:

- Knowledge and Understanding
- Computing and Information -related cognitive abilities and skills, i.e. abilities and skills relating to intellectual tasks;
- Computing and Information -related practical skills;

- Additional transferable skills that may be developed in the context of computing and information but which are of a general nature and applicable in many other contexts

Knowledge and Understanding, cognitive, practical and generic skills need to be placed in the context of the program of study as designed by the institution and/or the possible pathways selected by the individual student.

1- Knowledge and Understanding

The graduates of the computing and information programs should acquire the knowledge and understanding of:

1. Essential facts, concepts, principles and theories relating to computing and information and computer applications as appropriate to the program of study.
2. Modeling and design of computer-based systems bearing in mind the trade-offs.
3. Tools, practices and methodologies used in the specification, design, implementation and evaluation of computer software systems.
4. Criteria and specifications appropriate to specific problems, and plan strategies for their solution.
5. The extent to which a computer-based system meets the criteria defined for its current use and future development.
6. The current and underlying technologies that support computer processing and inter-computer communication.
7. Principals of generating tests which investigate the functionality of computer programs and computer systems and evaluating their results.
8. Management and economics principles relevant to computing and information disciplines.
9. Professional, moral and ethical issues involved in the exploitation of computer technology and be guided by the appropriate professional, ethical and legal practices relevant to the computing and information industry.
10. Current developments in computing and information research.
11. Requirements, practical constraints and computer-based systems

2- Intellectual Skills

The graduates of the computing and Information programs should be able to:

1. Analyze computing problems and provide solutions related to the design and construction of computing systems.
2. Realize the concepts, principles, theories and practices behind computing and information as an academic discipline.

3. Identify criteria to measure and interpret the appropriateness of a computer system for its current deployment and future evolution.
4. Analyze, propose and evaluate alternative computer systems and processes taking into account limitations, and quality constraints.
5. Make ideas, proposals and designs using rational and reasoned arguments for presentation of computing systems.
6. Evaluate the results of tests to investigate the functionality of computer systems.
7. Achieve judgments considering balanced costs, benefits, safety, quality, reliability, and environmental impact
8. Familiar with the professional, legal, moral and ethical issues relevant to the computing industry.
9. Evaluate research papers in a range of knowledge areas

3- Professional / Practical

The graduates of the computing and information programs should be able to:

1. Operate computing equipment, recognizing its logical and physical properties, capabilities and limitations.
2. Implement comprehensive computing knowledge and skills in projects and in deployment of computers to solve position practical problems.
3. Deploy the equipment and tools used for the construction, maintenance and documentation of computer applications.
4. Apply computing information retrieval skills in computing community environment and industry**.**
5. Develop a range of fundamental research skills, through the use of online resources, technical repositories and library-based material
6. Design, implement, maintain, and manage software systems.
7. Assess the implications, risks or safety aspects involved in the operation of computing equipment within a specific context.
8. Handle a mass of diverse data, assess risk and draw conclusions.

4- Transferable skills

Graduates of the computing and information programs should be able:

1. Demonstrate the ability to make use of a range of learning resources and to manage one's own learning.
2. Demonstrate skills in group working, team management, time management and organizational skills.
3. Show the use of information-retrieval.
4. Use an appropriate mix of tools and aids in preparing and presenting reports for a range of audiences, including management, technical, users, industry or the academic community.

5. Exhibit appropriate numeracy skills in understanding and presenting cases involving a quantitative dimension.
6. Reveal communication skills, public speaking and presentation skills, and delegation, writing skills, oral delivery, and effectively using various media for a variety of audiences.
7. Show the use of general computing facilities.
8. Demonstrate an appreciation of the need to continue professional development in recognition of the requirement for life-long learning.

7- Curricula Contents for Computing and Information Disciplines

Table 1: Indicative curricula content by subject area

	Subject Area	Tolerance %
A	Humanities, ethical and Social Sciences (Univ. Req.)	8-10
B	Mathematics and Basic Sciences	16-18
C	Basic Computing Sciences (institution req.)	26-28
D	Applied Computing Sciences (specialisation)	28-30
E	Training	3-5
F	Projects	3-5
	Subtotal	84-96
G	Optional (Institution character-identifying subjects)	16-4
	Total	100

National Academic Reference Standards

1- NARS CHARACTERIZATION OF INFORMATION TECHNOLOGY

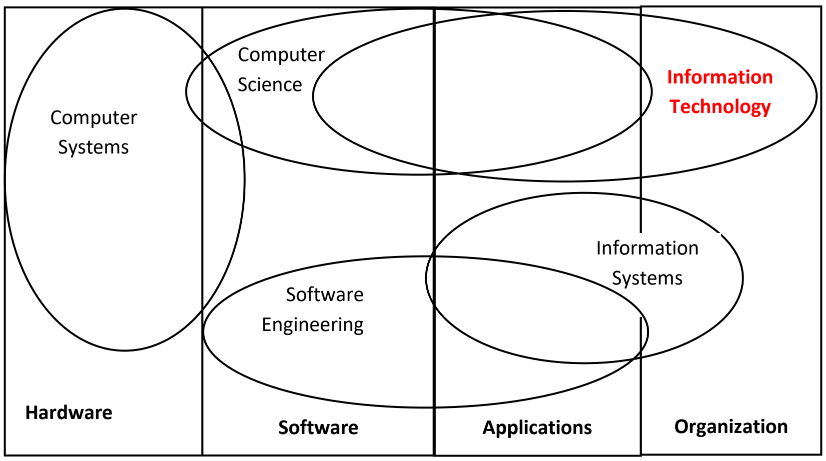
6.1 Introduction

Today, organizations of every kind are dependent on information technology. They need to have appropriate systems in place. These systems must work properly, be secure, and upgraded, maintained, and replaced as appropriate. Disciplines are established to reflect these needs. While the Information Technology and Information Systems disciplines both include a focus on software and hardware, they use technology as critical instruments for addressing organizational needs. Information Technology can be seen as the complement of Information Systems: its emphasis is on the technology itself more than on the information it conveys. IT is a new and rapidly growing field that started as a grassroots response to the practical, everyday needs of business and other organizations.

Information Technology focuses on ensuring that the organization's infrastructure is appropriate and reliable and using computing to meet the needs of technology-dependent organizations. Information technology refers to undergraduate degree programs that prepare students to meet the computer technology needs of business, government, healthcare, faculties, and other kinds of organizations. In some nations, other names are used for such degree programs.

IT programs exist to produce graduates, who possess the right combination of knowledge and practical expertise to take care of both an organization's information technology infrastructure and the people who use it, planning and management of the technology lifecycle by which an organization's technology is maintained, upgraded, and replaced. Graduates of information technology programs address these needs. 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 programs aim to provide IT graduates with the skills and knowledge to take on appropriate professional positions in Information Technology upon graduation and grow into leadership positions or pursue research or graduate studies in the field.



6.2 The Attributes of The Information Technology Graduates

According to the ACM, and the IEEE Computer Society – for four-year programs in Information Technology, Computing Curricula, Information Technology Volume, Version: Aug 22, 2008, an IT graduate must therefore acquire a skill set that enables him or her to successfully perform integrative tasks, including the ability to:

1. Knowledge of computing and mathematics appropriate to the discipline
2. Analyze a problem, and identify and define the computing requirements appropriate to its solution
3. Design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs
4. Demonstrate independent critical thinking and problem solving skills and function effectively on a team to accomplish a common goal.
5. An understanding of professional, ethical, legal, security and social issues and responsibilities
6. Communicate effectively with a range of audiences
7. Analyze the local and global impact of computing on individuals, organizations, and society
8. Recognition of the need for and an ability to engage in continuing professional development
9. Use current techniques, skills, and tools necessary for Information technology practice and in the creation of an effective project plan
10. Use and apply current technical concepts and practices in the core information technologies subjects.
11. Identify and analyze user needs and take them into account in the selection, creation, evaluation and administration of computer-based systems.
12. Address information technologies problems of organizations or individuals.

13. Effectively integrate IT-based solutions into the user environment
14. Understand the best practices and standards and their application

6.3. National Academic Reference Standards for Information Technology Graduates

6.3.1 Knowledge and Understanding

In addition to Knowledge and Understanding of computing and information graduate, the Information Technology graduate should be able to

1. Demonstrate basic knowledge and understanding of fundamental principles of core computing.
2. Demonstrate strong knowledge of fundamentals of programming and the construction of computer-based systems, data structures and algorithms, software engineering techniques and information retrieval.
3. Provide a deeper understanding of some aspects of the subject, such as multimedia, computer and communication network, data mining and knowledge discovery, information storage and retrieval systems, mobile Communication Systems, pattern recognition, artificial Intelligence, cryptography and network security.
4. Show the understanding of technologies for the design, development and management of database systems, systems analysis and design and of information retrieval systems.
5. Know the role of human factors in the design of Information Technology systems.
6. Apply tools and techniques for the design and development of applications.
7. Know methods for the construction of web-based materials and systems, design of internet-based systems.
8. Provide an understanding of legal, professional and moral aspects of the exploitation of IT.
9. Understand the broad context within computer information technology such as quality, reliability, enterprise, employment law, accounting and health.
10. Understand the challenges inherent in the maintenance and evolution of IT-based systems, and the techniques and best practices currently available for dealing with them.

6.3.2 Intellectual Skills

In addition to intellectual of computing and information graduate, the Information Technology graduate should be able to

1. Information technology systems problems, set goals towards solving them, observe results, reason and apply judgment.

2. Identify attributes, components, relationships, patterns, main ideas, and errors.
3. Summarize the proposed solutions ad their results.
4. Restrict solution methodologies upon their results.
5. Establish criteria, and verify solutions
6. Identify a range of solutions and critically evaluate and justify proposed design solutions.
7. Solve information technology problems with pressing commercial or industrial constraints.
8. Generate an innovative design to solve a problem containing a range of commercial and industrial constraints.
9. Perform problem analysis from written descriptions; derive requirements specifications from an understanding of problems (analysis, synthesis).
10. Create and/or justify designs to satisfy given requirements (synthesis, evaluation, application).
11. Recognize the professional, moral and ethical issues of involved in the exploitation of Information Technology and be guided by their adoption, reflect on issues of professional practice within the discipline.

6.3.3 Professional and Practical Skills

In addition to Professional and Practical Skills of computing and information graduate, the Information Technology graduate should be able to

1. Specify, investigate, analyze, design and develop computer-based systems using appropriate tools and techniques.
2. Evaluate systems in terms of their quality and possible trade-offs , evaluate appropriate hardware and software solutions for given scenarios.
3. Recognize risks or safety aspects involved in the operation of computer-based systems.
4. Deploy tools for the implementation and documentation of computer-based systems.
5. Work as part of a development team and to recognize the different roles of its members.
6. Operate computing equipment efficiently, taking into account its logical and physical properties.
7. Recognize and address professional, moral and ethical issues within the discipline.
8. Effectively employ information-retrieval skills, (including the use of browsers, search engines, and on-line library catalogues), communicate effectively using a variety of communication methods, communicate effectively with team members, managers and customers.
9. Make effective use of general IT facilities, plan and manage a project to complete within budget and schedule

10. Manage one's own learning and development, including time management and organizational skills.
11. Present their work in the form of reports, oral presentations or an internet web site.

Glossary

1. **Institution**

   A University, faculty or higher institute providing education programs leading to a first university degree or a higher degree (Master's or Doctorate).

2. **Graduate Attributes**

   Competencies expected from the graduate based on the acquired knowledge and skills gained upon completion of a particular program.

3. **National Academic Reference Standards (NARS)**

   Reference points designed by NAQAAE to outline / describe the expected minimum knowledge and skills necessary to fulfill the requirements of a program of study.

4. **Academic Standards**

   Reference points prescribed (defined) by an institution comprising the collective knowledge and skills to be gained by the graduates of a particular program. The academic standards should surpass the NARS, and be approved by NAQAAE.

5. **Subject Benchmark Statements**

   Guideline statements that detail (enumerate) what can be expected of a graduate in terms of the learning outcomes to satisfy the standards set for the program. They enable the outcomes to be compared, reviewed and evaluated against agreed upon standards.

6. **The Program**

   A set of educational courses and activities designed by the institution to determine the systematic learning progress. The program also imparts the intended competencies required for the award of an academic degree.

7. Intended Learning Outcomes (ILOs)

Subject-specific knowledge, understanding and skills intended by the institution to be gained by the learners completing a particular educational activity. The ILOs emphasize what is expected that learners will be able to do as a result of a learning activity.

8. Knowledge and Understanding

Knowledge is the intended information to be gained from an educational activity including facts, terms, theories and basic concepts. Understanding involves comprehending and grasping the meaning or the underlying explanation of scientific objects.

9. Intellectual Skills

Learning and cognitive capabilities that involve critical thinking and creativity. These include application, analysis, synthesis and evaluation of information.

10. Professional and Practical Skills

Application of specialized knowledge, training and proficiency in a subject or field to attain successful career development and personal advancement.

11. General and Transferable Skills

Skills that are not subject-specific and commonly needed in education, employment, life-long learning and self development. These skills include communication, team work, numeracy, independent learning, interpersonal relationship, and problem solving... etc.

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