INTER-UNIVERSITY COUNCIL FOR EAST AFRICA

BENCHMARKS

FOR THE BACHELOR OF COMPUTER SCIENCE AND THE BACHELOR OF INFORMATION TECHNOLOGY PROGRAMMES

March 2015

IUCEA Secretariat

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DAAD Deutscher Akademischer Austausch Dienst
German Academic Exchange Service

HRK German Rectors' Conference

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Acronyms

ABET:	Accreditation Board for Engineering & Technology
ACM:	Association for Computing Machinery
ASIIN:	Accreditation Agency for Engineering, Informatics, Physics and Mathematics
CATS :	Credit Accumulation and Transfer system
CS	Computer Science
CUE:	Commission for University Education (Kenya)
DAAD :	German Academic Exchange Services
DIES :	Dialogue on Innovative Higher Education Strategies
EAC	East African Community
EAQF :	East African Qualifications Framework
ECTS :	European Credit Transfer System
EQF:	European Qualifications Framework
HEIs :	Higher Education Institutions
HRK :	German Rectors Conference
IEE:	Institute of Electrical and Electronics Engineers
IUCEA :	Inter-University Council for East Africa
IT:	Information Technology
NQF:	National Qualifications Framework
MNC:	Multinational Corporation
NCHE :	National Council for Higher Education
NRA:	Higher Education National Regulatory Agencies
QA:	Quality Assurance
QAA :	Quality Assurance Agency for Higher Education, UK
TCU :	Tanzanian Commission for Universities

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The National Commissions/Councils of Higher Education of the EAC Partner States are highly acknowledged for their instrumental contribution in spearheading and coordinating the processes in their respective countries. The German Academic Exchange Service (DAAD) and the German Rectors Conference (HRK) through their DIES programme, are immensely appreciated for extending their collaborative, generous technical and financial support to facilitate this process

It is my expectation that these benchmarks will provide an important building block of harmonization of education as we strive to develop a common East African Higher education Area and therefore all stakeholders will use them in the various intended purposes such as curriculum development and review, assessing graduates competencies, and comparability, among others.

Prof. Mayunga H.H. Nkunya,
Kampala, March 2015
IUCEA, Executive Secretary

Foreword

The Inter-University Council for East Africa (IUCEA) is a strategic institution of the East African Community (EAC) responsible for the development and coordination of higher education and research in the region. The EAC considers higher education as critical for the attainment of socio-economic development and regional integration. As such, after having been recognized as the surviving institution of the former Community responsible for coordinating the networking of university institutions in the region, IUCEA has assumed a broader role as a building block for the achievement of sustainable socio-economic development and regional integration. In that regard, the mission of IUCEA now focuses on the promotion of strategic and sustainable development of higher education systems and research for supporting East Africa's socio-economic development and regional integration. The IUCEA has set its vision to become a strategic institution of the East African Community responsible for promoting, developing and coordinating human resources development and research in the region.

Hence, in 2006 IUCEA initiated a process aimed at harmonizing regional quality assurance by establishing A common East African quality assurance framework, regional quality assurance office at the IUCEA Secretariat, and setting regional higher education benchmark quality standards based on internationally recognized frameworks. The process would also prepare a use-friendly quality assurance handbook based on existing national benchmarks and systems, and streamline national and institutional quality assurance systems according to the local perspectives with the aim of promoting international competitiveness of universities in East Africa.

The initiative also focused on capacity building through providing appropriate training on the implementation of the quality assurance system to staff in universities and national commissions and councils for higher education in the Partner States. It is linked to the establishment of a regional qualifications framework. It was anticipated that the regional qualifications framework would facilitate harmonization of education and training systems, and qualifications thereby clearly indicating the programme learning outcomes, the different qualification levels, credit system and recognition of prior learning, among others. Therefore, the framework would easily facilitate mutual recognition of qualifications across the region as envisioned in the EAC Common Market Protocol. All these interventions were aimed at transforming East Africa into a common higher education area, as the ultimate goal of the Community.

In developing the regional quality assurance system in higher education in East Africa, IUCEA in collaboration with the German Academic Exchange Service (DAAD) and the Germany Rectors' Conference (HRK) within the framework of their joint Higher Education Management support programme referred to as "Dialogue on Innovative Higher Education Strategies (DIES)", started to work on this initiative through a consultative process involving various stakeholders of higher education in the region. The process involved a number of consultative meetings and workshops at country and regional level, aimed at building consensus and mapping out a strategy on how to establish a regional quality assurance framework. This included the development of an operational tool in the form of a Quality Assurance Handbook. The consultative forums were also aimed at ensuring that all performance indicators and quality benchmarks were agreed upon and owned by all end-user institutions. Additionally, IUCEA intended to develop specific subjects benchmarks as part of the tools for harmonization purposed academic programmes taught in higher education institutions in the region in addition to the development of The Handbook *A Roadmap to Quality*. The first benchmarks, formulated were Benchmarks for Bachelor of Business related studies. The current publication contains Benchmarks for the Bachelor of Computer Science and the Bachelor of Information Technology.

On behalf of the IUCEA secretariat, I wish to encourage all stakeholders involved to adopt and operationalize the Computer Science and/or IT benchmarks. It is therefore my sincere expectation that the higher education fraternity in the region will make use of these benchmarks in all educational processes and world of work to ensure that our programmes are of expected quality. Finally, I wish you all the best in the use of these benchmarks.

Prof.Mayunga H.H. Nkunya,
IUCEA, Executive Secretary

Kampala, March 2015

Preamble

The Benchmarks for Computer Science and Information Technology contained herein have been developed as one of the set milestones for the development of an East African Quality Assurance System. This will constitute the framework of the East African Common Higher Education Area that the EAC endeavours to realize by 2015. The process of developing these benchmarks commenced immediately after successful completion of developing the Benchmarks for Business Related Studies, which were printed in June 2013 and are currently in use. Although the Bachelor of Computer Science and the Bachelor of Information Technology are offered as separate programmes, they have a lot in common. Therefore, the benchmarks for the two programmes are published in one document.

As highlighted in the foreword, the benchmarks are aimed at providing an important process of harmonisation of the Bachelor of Computer Science and the Bachelor of Information Technology and should be beneficial to all the players in the higher education sector. Thus, the main objective of this process is to harmonise the Bachelor programs in order to provide a baseline for comparability in Computer Science and Information Technology within the region. The benchmarks are to be used as a yardstick or a point of reference, and not as absolute standards.

This document is structured in 4 parts:

- Part 1 presents the background, objectives and the justification for the formulation of the benchmarks. It also articulates the development process of the benchmarks and how they were formulated;
- Part 2 shows the relation between the benchmarks and the Qualification Frameworks, the Curriculum and the link with Quality Assurance;
- Part 3 presents the benchmarks for Computer Science.;
- Part 4 presents the benchmarks for Information Technology;

PART 1: INTRODUCTION

1.1. Background

One of the mandates of the IUCEA is to maintain high and comparable academic standards in higher education regionally and internationally, with special emphasis on the promotion of Quality Assurance (QA) and Quality Management. In that regard, IUCEA aspires to operate within the expectations of stakeholders to deliver services that enhance and harness QA in the region. In East Africa, the notion of QA in higher education is an issue of great concern among all stakeholders, including policy makers, parents, employers, and students. A number of factors have contributed to this phenomenon. East Africa has experienced rapid expansion of the number and enrollment levels in higher institutions of learning in recent times. This has been triggered by the exponential increase in demand of access to higher education in each of the countries in the region.

As a result, the IUCEA felt the need to ensure that the rapid expansion of higher education in the region did not compromise quality of the very education being delivered. Furthermore, in recent years student mobility within East Africa has increased tremendously, necessitating the need to institute mechanisms for comparability of the quality of education in universities in East Africa. It is important to note that education has become a tradable commodity across borders and hence there have been efforts to institute international safeguards that would ensure maintenance of international quality standards. These efforts are being implemented within regional and international Quality Assurance frameworks. The development of benchmarks therefore became a necessity.

The first formulated regional benchmarks focused on the Bachelor of Business related studies.[1] Based on the experiences with the benchmarks for Business related studies in the region in the framework of the Regional Quality Assurance Initiative, the IUCEA, supported by DAAD (German Academic Exchange Services), took the initiative to develop benchmarks for the Bachelor of Computer Science and the Bachelor of Information Technology offered in the region.

1.2. Objectives of the formulated benchmarks

The objectives of the formulated benchmarks are to:

- Act as a guide and tool for the HEIs in designing the curriculum for Computer Science or Information Technology
- Enable the National Commissions and councils for higher education to assess the quality of the Computer Science and/or Information Technology programmes;
- Promote harmonization of the specific programme in the region;

1 IUCEA *Benchmarks for Bachelor of Business related studies,* June 2013

- Support staff and student mobility;
- Enhance the regionalization of the labor market, which is one of the aims of the East African Community (EAC); and
- Guide the labour market in judging the quality of the graduates.

It should be noted that the document focuses on benchmarking in terms of the output rather than the process. This means focusing more on expected learning outcomes rather than the details of the content of the programmes. The outcomes and/or competencies approach was chosen because of the need to harmonize the programmes. The process of ensuring commensurate content, pedagogy and assessment for the achievement of the learning outcomes is left to the Higher Education Institutions (HEIs) and to individual National Commissions and Councils for Higher Education.

1.3. Justification

Following its revitalization and subsequent ratification of the Protocol in 2002, IUCEA initiated a reform process aimed at re-positioning itself in order to address its expanded mandate within the Community. Such reforms became necessary after the enactment of the IUCEA Act in 2009. The reforms prompted the need to establish an appropriate environment for harmonization of higher education systems, so as to promote the EAC regional integration agenda as envisioned in the Common Market Protocol. Among the important steps towards harmonization of higher education in the region was the setting up of a regional quality assurance system for universities that was initiated in 2006.

In light of the above regional dynamics, it was deemed necessary to develop the benchmarks that would then be used by the institutions in the region. In the process of establishing the regional QA system, the IUCEA piloted a QA handbook by subjecting selected academic programmes to internal and external review. It was on the basis of the analysis of peer review reports of all the academic programmes piloted by IUCEA that a decision to take Computer Science and IT as second discipline was arrived at.

1.4. The development process

The development of the benchmarks for Computer Science and Information Technology underwent a number of interactive processes that included data collection, analysis, and documentation on, the basis of which a consultative fore bringing together multiple stakeholders in a preparatory meeting and round table sessions to deliberate on the content of the benchmarks as follows:

- *Nairobi preparatory meeting held on November 26th -27th 2013.*
  IUCEA and DAAD organised a preparatory meeting in Nairobi to prepare the 1st roundtable session for the benchmarking process in Computer Science and/or

IT. The meeting was important, because it was necessary to decide which of the programs in computing should be the focus of the subject benchmark exercise. After extended deliberations involving stakeholders from academic institutions, professional bodies, employers, and national Commissions and Councils amongst others, it was decided that benchmarks for both Computer Science and Information Technology be developed first. At a later stage, attention would be paid to Computer Engineering. During the preparatory meeting, participants also discussed the need to find out the requirements of the labour market. The participants discussed and agreed on two questionnaires: one that was sent to universities; and another sent to employers for the purpose of establishing the needs of the labour market.

- *The first roundtable meeting (Kigali, July 2014)*
  The 1st roundtable meeting developed a set of benchmarks in the field of Computer Science and IT in line with the National Qualification Frameworks that could lead to harmonization of the programs in the region. The output of the 1st round table session was a draft document with programme goal, objectives and expected learning outcomes for Computer Science and IT.

- *2nd Roundtable meeting (Dar as Salaam, December 2014)*
  The 2nd roundtable session developed a benchmark document with programme content areas and their brief description, differentiation between core courses and respective specialisations, the role of project work and internship.

The discussions about the benchmarks were based on the following publications:

- Bachelor of Science in Computer Science and Information Technology in the East African Universities, an analysis[2]. This publication provided an overview on the state-of-the-art of CS and IT in the East African Universities and included the results of the questionnaires sent out to the universities and to the employers.
- Credit Accumulation and transfer system Computer Science Undergraduate (Kenya)[3]
- Credit Accumulation system Information Technology, Undergraduate (Kenya)[4]
- Minimum standards for the course of Study in Bachelor of Science in Computer Science (Uganda)[5]
- Minimum standards for the course of Study in Bachelor of Information Systems (Uganda)[6]
- What already is said….[7] This document contained requirements/benchmarks

2 *Vroeijenstijn, Ton, Bachelor od Science in Computer Science and Information Technology at the East African Universities, an analysis*
3 *Commission for Higher Education, Kenya, Credit Accumulation and transfer system Computer Science Undergraduate, September 2010*
4 *Commission for Higher Education, Kenya, Credit Accumulation and transfer system Information Technology, Undergraduate, September 2010*
5 *National Council for Higher Education (Uganda), Minimum standards for the course of Study in Bachelor of Science in Computer Science, November 2011*
6 *National Council for Higher Education (Uganda), Minimum standards for the course of Study in Bachelor of Information Systems, June 2012*
7 *Vroeijenstijn, Ton (ed.) What already is said……., A selection of texts you must have read before the roundtableVmeeting, September 2014*

concerning Computer Science and IT from:

- ABET(Accreditation Board for Engineering & Technology)
- ACM (Association for Computing Machinery)
- IEEE (Institute of Electrical and Electronics Engineers)
- ASIIN (Accreditation Agency for Engineering, Informatics, Physics and Mathematics)
- QAA (Quality Assurance Agency for Higher Education, UK)

1.5. Stakeholders involvement

Special efforts were made to involve key stakeholders including higher education experts, professional bodies, employers and industry. Therefore, participants were drawn from the Computer Science and IT departments of HEIs, Higher Education National Commissions and Councils, professional bodies, employers and industry representatives from all the EAC Partner States. International experts were brought on board as resource persons to provide an overview of the global initiatives in the harmonization of standards in university education.

During the preparatory meeting, the professional bodies and employers clarified what they expected from graduates in Computer Science and Information Technology. Also through questionnaires, employers provided input for the discussions. During the 1st and 2nd round table, representatives of the professional bodies and labour market contributed to the discussions.

PART 2: THE USE OF BENCHMARKS

2.1. The Benchmarks and the Qualifications Framework

As earlier mentioned, this document is not meant to replace the initiatives of the EAC Partner States and institutions, but rather to provide a regional benchmark with regard to the learning outcomes. Therefore, care has been taken to ensure that the benchmarks are in line with the various National Qualification Frameworks. Globally, in the last 10 years, there have been developments in which various countries have either formulated or are formulating National Qualifications Framework (NQF). Such National Qualifications Frameworks may be regarded as the policy framework that defines all qualifications recognized nationally in post-compulsory education and training within a country. In the same spirit, the East African countries are working on National Qualification Frameworks. The NQF of Tanzania[8] defines National Qualifications Framework (NQF) as *"a national instrument for the development and classification of qualifications according to a set of criteria for levels of learning and skills achieved."*

The East African Qualifications Framework[9] defines Qualifications Framework as *"an instrument for the development and classification of qualifications according to a set of criteria for levels of learning and skills and competences achieved."*

Looking at the NQFs in Europe and the European Qualifications Framework, and other NQFs in other parts of the world, it is clear that there are efforts to describe the different levels of education. Concerning Higher Education, 3 levels are described: Bachelors, Masters and Doctorate. For the purpose of this document, only Bachelors and Masters Degrees will be discussed. In all NQF's the levels of Bachelors and Masters Degrees are described. The level number may differ. In the European Qualification framework, it is level 6 and 7; in the EAQF it is level 8 and 9. However, the level descriptors are more or less the same:

- *Bachelor's Degree (level 8)*
  The holder of the qualification will be able to apply knowledge, skills and understanding in a wide and unpredictable variety of contexts with substantial personal responsibility for the work of others and responsibility for the allocation of resources, policy, planning, execution and evaluation.

- *Master's Degree (level 9)*
  The holder of the qualification will be able to display mastery of a complex and specialized area of knowledge and skills, employing knowledge and understanding to conduct research or advanced technical or professional activity, able to work autonomously and in complex and unpredictable situations.

8 *The Tanzanian Commission for universities, National Qualification framework, final draft March, 2010*
9 *IUCEA, The East African Qualifications Framework, draft August, 2014*

The description of both the Bachelors and the Masters Degree levels is very general. Clearly, in order to be operationalised, each level has to be filled in and elaborated with statements of expected learning outcomes formulated by the discipline. In most of the NQF's, the level descriptors are elaborated in *generic* learning outcomes. However, each programme/discipline has to translate the *generic* learning outcomes into specific course units within *specific* subjects. For example, one of the generic learning outcomes is ability to identify, pose and solve problems. This might become applied research concepts and techniques to solve computing problems or to solve emerging challenges in modern IT environment.

2.2. The benchmarks and curriculum design

One of the purposes of formulating benchmarks is to support the HEIs to design or redesign the curriculum. It is clear that the National Commissions and Councils in the five East African countries will apply their own criteria in the assessment of the curricula. The benchmarks are needed because learning outcomes guarantee:

- Comparable quality levels of the graduates;
- Comparable chances for the graduates in the labour market;
- Labour market understands the competencies that CS and IT graduates possesses;
- Increased national and international mobility of students; and
- Increased national and international mobility of lecturers.

2.2.1. Programme objectives

The Bachelor of Computer Science and IT should be designed in such a way that they address the concerns of different stakeholders. This should be reflected in the programme objectives. These objectives can be grouped into three categories:

- Academic ability
- Employability
- Personal development

The survey of the Bachelor programmes in Computer Science and Information Technology showed that the universities in general had formulated programme objectives, but not learning outcomes. What had not been put in place was the translation of the programme-oriented objectives into student-oriented learning outcomes: what the student is expected to learn through this programme.

2.2.2. Formulating the Expected Learning Outcomes

The first step in designing or redesigning a programme is the formulation of the learning outcomes. The purpose of the learning outcomes is to describe clearly what the student is

expected to demonstrate after completing the whole programme, a module or a course. HEIs are expected to compare their formulated learning outcomes with the benchmarks and see what is missing or what should be rephrased. For each learning outcome, one should describe how the outcome would be measured and assessed.

It is worth noting that benchmarks are based on the formulated learning outcomes. According to literature on benchmarking and learning outcomes, there are many different definitions of learning outcomes or competences. In the European Qualification Framework (EQF)[10] *Learning outcomes* are defined as: statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and competence. *Competence,* according to the EQF, is the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development. According to IUCEA[11] learning outcomes are viewed as what a learner is expected to know and understand, and be able to do or demonstrate, on completion of a learning process within a recognized qualifications framework.

In the discussion about learning outcomes, the problem is the concept of *Competencies.* Although the notion *Competency* is used regularly, it is unclear what competences are. In all the definitions there is a hint to knowledge, applying knowledge and skills. Furthermore, there is talk about abilities and attitudes. A graduate exhibiting competencies at a working place will have partly acquired the competencies as outcomes of his/her study. It should be noted that some of the competencies are acquired through non-formal and informal experiences and others are inborn. This means that not all competencies are taught at the universities. The Learning Outcomes form only a part of the competencies a graduate will show in his/her job.

As mentioned before, a learning outcome is a statement of the knowledge, skills and attitudes students should have acquired at the end of each course (module, unit) and programme. It has been observed that although universities are engaged in the practice of defining objectives and measuring outcomes in one form or another, many do not approach the process of formulating Learning Outcomes in a uniform way. It is important to note that focusing on and defining learning outcomes would create an opportunity to:

- Enhance students' learning and mobility;
- Provide guidance to instructors;
- Identify and overcome barriers to effective teaching;
- Facilitate collaboration among HEIs in the region and beyond;
- Improve students' learning, retention and completion;
- Produce quality graduates; and
- Increase students´ chances for employability.

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10 The European Qualification Framework for Life Long Learning, European Commission 2008
11 IUCEA, The East African Qualifications Framework, draft August, 2014

In this document, the following definition for Learning Outcomes is used:

***Learning outcomes*: statements of the knowledge, skills and attitude that a learner is able to demonstrate on completion of a learning process.**

Learning Outcomes can be separated in three domains

- Cognitive learning (Knowledge)
- Psychomotor learning (Skills)
- Affective learning (Attitude),

In the taxonomy of Bloom, the teaching and learning hierarchy is important for the correct

and consistent building of the knowledge side of the Learning Outcomes. The cognitive domain comprises six levels starting with the easiest level *remembering* and ending in the top with *creating as* the most complex level of the taxonomy.(see Figure 1)Formulating Expected Learning Outcomes one have to formulate actions, starting at the lowest level of the taxonomy. See, for examples, figure 2.

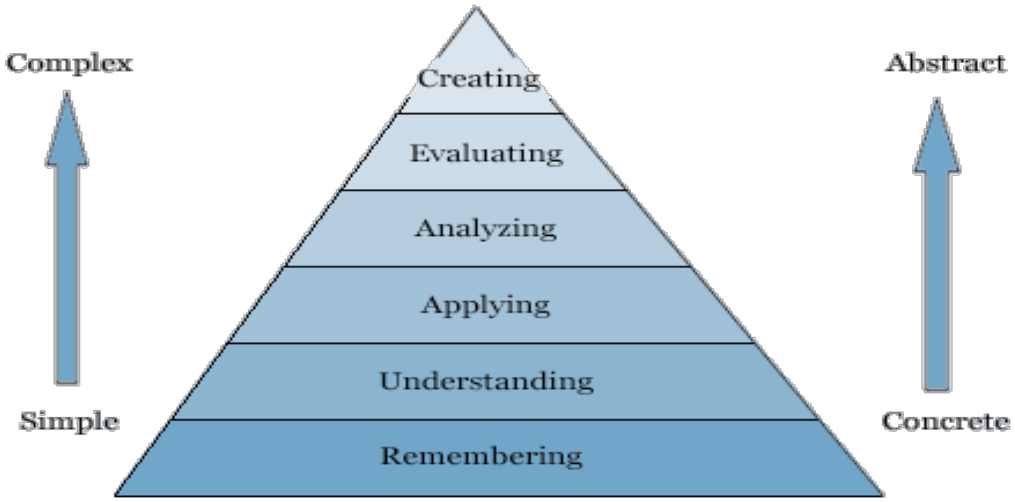

Fig 1: Revised Taxonomy of Bloom (Anderson and Krathwohl 2001)[12]

12 *Krathwohl, D.R., Bloom, B.S. and Masia, B.B. Taxonomy of Educational Objectives: Handbook II. The Affective Domain.N.Y., David McKay Company, Inc. 1964. In: Van der Klip Cees: Profession based education and training,A Teachers guide, Draft 2015*

Fig.2 Action words for the cognitive domain (Anderson and Krathwohl 2001)

Learning outcomes can be divided into:

- *Knowledge*
  Knowledge means the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study. Knowledge is described as theoretical and/or factual;

- *Skills*
  Skills mean the ability to apply knowledge and use know-how to complete tasks and solve problems. Skills are categorized as:
  - *Cognitive skills* (involving the use of logical, intuitive and creative thinking);
  - *Practical skills* (involving manual dexterity and the use of methods, materials, tools and instruments);
  - *Interpersonal skills* (the way of communication, cooperation, etc).

Attitude

Attitude means a settled way of thinking or feeling about something. Four major components of attitude are: affective (emotions or feelings), Cognitive (belief or opinions held consciously), Conative (inclination for action), Evaluative (positive or negative response to stimuli).

Figure 3 shows the relationships between knowledge, skills and attitude. The model is also used to categorize the learning outcomes for Computer Science and Information Technology.

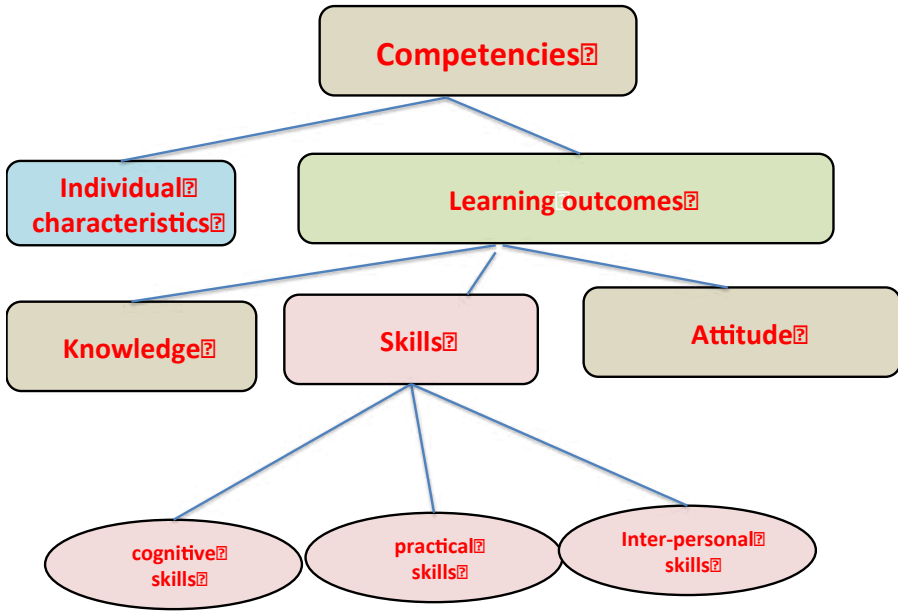

Figure 3: Categorisation of Learning Outcomes

In formulating learning outcomes, a distinction has to be made between *generic* learning outcomes and *subject specific* learning outcomes. *Generic learning outcomes* are those outcomes expected from all academic trained graduates. Examples of generic learning outcomes are: problem solving, communication skills, and ability to cooperate. A key characteristic of a *generic learning outcome* is that you have to practice it in a specific field. *Subject specific* learning outcomes are those that are typical to that discipline.

2.2.3. Translating learning outcomes into the programme

The next step in the process after the formulation of learning outcomes is to identify what courses[13] are needed to achieve the learning outcomes. A distinction has to be made between the core subjects and the supporting subjects. Establish what is already present in the programme (may be with another name) and what subjects should be added.

To check if the planned courses cover the learning outcomes, it is important to develop a curriculum alignment matrix, an example as shown in Table 1. For each course the specific learning outcomes have to be formulated and one must check how far this course contributes to the achievement of the programme learning outcomes.

Table 1: Curriculum alignment matrix

Bachelor programme of Computer Science					
Learning outcomes	*Course 1*	*Course 2*	*Course 3*	*Course 4*	*Course 5*
Communication skills	x		x		
Critical thinking		X		x	x
Problem solving					x
Cooperate/working together	x				
Etc					

2.2.4. Course description

In this document, the learning outcomes both for the basic programme and the major areas of specialisation in Computer Science and Information Technology are provided. Higher education institutions will have to develop the courses, starting with the formulation of the learning outcomes for that specific course. For each course, a clear description should be available. (An example can be found in appendix 1). An essential part of the programme is to assess how far the student has achieved the learning outcomes. Therefore, it is necessary for the HEIs to decide how each learning outcome will be assessed.

2.3. The Benchmarks and Quality Assurance

It is envisaged that the benchmarks will play a significant role in quality assurance of their respective programmes. Although each National Commission or Council applies its own criteria in assessing the quality of programmes, the benchmarks can play a significant role in harmonization of quality assessment and quality assurance at the region level. It is therefore expected that the National Commissions and Councils will ideally align their standards with these benchmarks. The benchmarks also offer external assessment teams a frame of reference in assessing the quality of a programme. For the HEIs, the benchmarks offer a good instrument for evaluating the quality of their own programmes.

13 *In this context Course also means modules and units*

2.4. Implementation of the Benchmarks

The implementation of these benchmarks is the responsibility of HEIs and the oversight responsibility is that of the National Commissions and Councils. The choice to follow either a modular or a course unit system is at the discretion of the university. IUCEA will provide the overall coordination and evaluation of the process.

2.5. Review of the Benchmarks

These benchmarks will be subject to review after every five-year period to take care of emerging trends in the environment.

PART 3: BENCHMARKS FOR A BACHELOR IN COMPUTER SCIENCE

3.1 Description of Computer Science

Computer Science is a discipline that uses Theoretical concepts, Principles, Innovation to logic based problem solving techniques to design algorithms and software systems based on sound mathematical foundations, Engineering and scientific procedures. It broadly covers theory of computing; architecture; system infrastructures; application technologies with design; and analysis of software methods and technologies. Several different tracks and specializations are offered as unique options based on a programme's or institution's focus.

Graduates of this programme will take up positions such as Computer and information scientists and researchers, programmers, software engineers, systems analysts, information system security, database system developers, information assurance, data modellers, computer specialists, game developers, mobile application developers. A sample of Course Outline, Modular Structure and Brief Descriptions of all Courses of the Programme are given in Appendices 1, 3 and 5 respectively. Specialization courses for the programme are given in Appendix 7.

3.2. Computer Science Programme Goal

The goal of a CS programme is to produce a computer science graduate capable of using computing principles, concepts, and techniques to design, implement, manage, and maintain computing and communication systems that address and provide solutions to various activities for benefit of humanity.

3.3 Programme objectives

The Bachelor of Computer Science programme should be designed in such a way that it addresses the concerns of different stakeholders. This can be achieved by focusing on the following grouped programme objectives:

3.3.1 Academic Ability

The programme objectives under this category are to equip learners with:

- Knowledge and skills for developing effective ways to solve computing problems;
- Knowledge in computer science, computing technologies and applications;
- Ability to design and implement software and software technologies;
- Ability to adapt and adopt emerging/evolving computing technologies;

- Ability to undertake research and to progress to higher levels of studies.

3.3.2 Employability

The programme objectives under this category are to equip learners with:

- Up-to-date computing skills for the industry;
- Problem-solving skills for computer related tasks;
- Analytical skills to understand impacts of computing on individuals, organizations and society;
- Ability to integrate theory and practice to work effectively and efficiently in organizations;
- Knowledge and skills that enable creativity, innovativeness and entrepreneurship in the field of computing.

3.3.3 Personal development

The programme objectives under this category are to:

- Prepare learners for life-long learning and research;
- Empower students to progress in their personal career; impart professional ethics to the learner; equip the learner with skills and attitude to work in multicultural and global environments;
- Equip the learner with knowledge and skills to work as a team in the computing field;
- Enable the learner to develop skills to perform effectively in technical and non-technical environments.

3.4 Expected Learning Outcomes (ELO's)

To harmonise the Bachelor programme in Computer Science and to make it more coherent and consistent for East Africa, the following learning outcomes have been formulated to be used as benchmarks. The formulated ELO's are the threshold: all graduates of the bachelor's programme in computer science must achieve them. Besides these, a graduate also has to achieve the ELO's for their chosen specialisation (see section 3.7) .The HEIs may consider adding Learning Outcomes as and when necessary in line with their mission and vision or other identified need(s). Table 2 outlines the expected learning outcomes for a Bachelor in Computer science.

Table 2: Expected Learning Outcomes for Bachelors degree in Computer Science

Knowledge	*The graduate should be able to*: 1. Demonstrate knowledge and an understanding of essential concepts, principles, and theories relating to computer science and software applications. 2. Demonstrate knowledge and understanding of Mathematics and Natural Sciences relevant to computer science. 3. Demonstrate knowledge and understanding of the impact of computing on society and the environment. 4. Demonstrate understanding of quality standards and benchmarks in computer software development.
Skills	
Cognitive skills	*The graduate should be able to:* 5. Model, design, implement and evaluate computer-based systems; 6. Develop computer software/ applications using modern platforms; 7. Analyze the impact of local and global trends of computing on individuals, organizations, and society; 8. Demonstrate creativity and innovativeness in developing computing solutions to real world problems 9. Assess risk related to computing activities. 10. Evaluate the extent to which a computer-based system meets the criteria defined for its current use and scale up to future development 11. Analyze a problem and then identify and define the computing requirements appropriate to the problem solution
Practical Skills	*The graduate should be able to:* 12. Deploy appropriate tools for the specification, design and implementation, of computer-based systems 13. Specify, plan, manage, conduct and report on a computer science research project. 14. Prepare technical reports and deliver technical presentations; 15. Plan, design, deploy and document appropriate security for computer systems 16. Evaluate, verify, trouble-shoot, test and analyze an existing computer-based system, process, component or program
Interpersonal Skills	*The graduate should be able to:* 17. Work effectively in a team; 18. Communicate effectively with experts and non-experts; 19. Demonstrate an understanding of professional, ethical, legal, security, social issues and responsibilities in computing
Attitude	*The graduate should be able to:* 20. Adapt to, and work in a multi-cultural and global computing environment; 21. Show awareness and understanding of the ethical standards of the profession; 22. Act professionally in the work environment; 23. Demonstrate commitment to lifelong learning self and professional development; and 24. Show self-awareness and ability to adapt to new situations. 25. Be creative and innovative in developing computing solutions to real world problems

3.5. Translating the Learning outcomes into the basic phase of the Computer Science

The learning outcomes need to be translated into the programme. In this document, the programme is defined at Bachelors level. A programme is seen as a coherent set of courses leading to a degree, in this case a Bachelor degree in Computer Science. A Bachelor programme is commonly divided into:

- *The basic phase:* This phase is common for all Computer Science program students and consists of core and supporting courses.
- *The specialisation phase:* This allows students to choose certain specialisations according to their interests.

The programme may be organized in courses, modules or units. In the basic/ foundation phase, 3 types of areas can be distinguished as follows:

- *Core courses (or subject areas)*
  These are the essential courses offering a thorough foundation of the discipline. The core courses are the backbone of the discipline. They are the typical Computer Science courses mandatory for every student.

- *Supporting courses (or subject areas)*
  These are courses for backing up the core courses. Without these courses it will be difficult to understand the core courses, for example "Mathematics", "Basics of Computer Studies". Those courses are also compulsory for all students.

- *Elective courses (or subject areas)*
  These are courses that can be taken by a student, to deepen or to broaden the knowledge, but they are not compulsory. However, a student has to make a choice to meet the minimum credit requirements for graduation.

Table 3 shows the core subject areas and the supporting subject areas in the basic phase of a Bachelor of Computer science programme. Based on the core and supporting courses in Table 3, the following remarks apply:

- The titles of the courses may differ from HEI to HEI. The emphasis should be on content rather than title. In Appendix 3 for each core course a short description is given for a better understanding of the subject.
- The autonomy and the uniqueness of HEIs will be taken into consideration in formulating the core courses for the basic phase. The HEIs will have the choice to add their own courses beyond the core and supporting courses.
- The core and supporting courses may be designed in form of modules, course units as per HEIs' systems.

Table 3: List of Core subject areas and supporting subject areas for the basic phase of the CS programme

• Algorithms and Complexity • Architecture and Organization • Discrete structures • Foundations of Logic • Formal languages and Automata Theory • Electronics • Data structures and Algorithms • Databases Management System • Relational Databases • Operations Research and Optimization • Principles of Programming	• Social and Professional issues • Communication Skills • Human Psychology • Research Skills • Linear Algebra • Calculus • Probability and Statistics • Numerical Analysis • Complex Analysis • Computational science • Discrete structures • Foundations of Logic • Physics • Emerging trends in Computer Science • Computer Literacy • Innovation and Entrepreneurship • Life Skills

3.6 The learning outcomes and the curriculum alignment matrix

As already mentioned in 2.2.3, to check if the planned courses cover the learning outcomes, it is important to develop a curriculum alignment matrix. For each course one has to formulate the specific learning outcomes for that course and have to check how far this course contributes to the programme learning outcomes.

Table 4 gives an example of a curriculum alignment matrix for the Expected Learning outcomes of the Bachelors in Computer Science. For each subject the contribution to the Expected learning outcomes are given.

Table 4: curriculum alignment matrix for Bachelor in Computer Science

	Expected Learning Outcomes (*for explanations of the numbers, see table 2)*																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Core subject areas																									
Algorithms and Complexity	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐						
Architecture and Organization	☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐									
Discrete structures		☐		☐	☐	☐	☐	☐	☐	☐	☐														
Foundations of Logic	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐														
Formal languages and Automata Theory					☐	☐	☐	☐	☐	☐	☐														
Electronics					☐	☐	☐	☐	☐	☐	☐														
Data structures and Algorithms	☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐									
Databases Management System	☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐									☐
Relational Databases				☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐									
Operations Research and Optimization	☐				☐	☐	☐	☐	☐	☐	☐														☐
Principles of Programming	☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐									
Supporting subject areas																									
Social and Professional issues			☐																	☐	☐	☐	☐	☐	
Communication Skills			☐																	☐	☐	☐	☐	☐	☐
Human Psychology			☐																				☐	☐	☐
Research Skills			☐														☐	☐	☐	☐	☐	☐	☐	☐	☐
Linear Algebra	☐	☐	☐																☐				☐		
Calculus	☐	☐	☐																☐				☐		
Probability and Statistics		☐	☐																☐				☐		
Numerical Analysis	☐	☐	☐																☐				☐		
Complex Analysis	☐	☐	☐																						
Computational science	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐														

Table 5: Explanation of the numbers in table 4

1.	Demonstrate knowledge and an understanding of essential concepts, principles, and theories relating to computer science and software applications.
2.	Demonstrate knowledge and understanding of Mathematics and Natural Sciences relevant to computer science.
3.	Demonstrate knowledge and understanding of the impact of computing on society and the environment.
4.	Demonstrate understanding of quality standards and benchmarks in computer software development.
5.	Model, design, implement and evaluate computer-based systems;
6.	Develop computer software/ applications using modern platforms;
7.	Analyze the impact of local and global trends of computing on individuals, organizations, and society;
8.	Demonstrate creativity and innovativeness in developing computing solutions to real world problems
9.	Assess risk related to computing activities.
10.	Evaluate the extent to which a computer-based system meets the criteria defined for its current use and scale up to future development
11.	Analyze a problem and then identify and define the computing requirements appropriate to the problem solution
12.	Deploy appropriate tools for the specification, design and implementation, of computer-based systems
13.	Specify, plan, manage, conduct and report on a computer science research project.
14.	Prepare technical reports and deliver technical presentations;
15.	Plan, design, deploy and document appropriate security for computer systems

16. Evaluate, verify, trouble-shoot, test and analyze an existing computer-based system, process, component or program

17. Work effectively in a team;

18. Communicate effectively with experts and non-experts;

19. Demonstrate an understanding of professional, ethical, legal, security, social issues and responsibilities in computing

20. Adapt to, and work in a multi-cultural and global computing environment;

21. Show awareness and understanding of the ethical standards of the profession;

22. Act professionally in the work environment;

23. Demonstrate commitment to lifelong learning self and professional development; and

24. Show self-awareness and ability to adapt to new situations.

25. Be creative and innovative in developing computing solutions to real world problems

3.7 Benchmarks for Specializations in Computer Science[14]

After the basic phase, a student may choose to deepen their knowledge in one of the following specialisations:

1. Multimedia Systems, Game Programming and Animation
2. Artificial Intelligence and Knowledge based systems
3. Parallel, networking and Distributed systems
4. Software Engineering
5. Mobile computing
6. Systems and Information Security

Table 6 up to table 11 shows the Expected Learning Outcomes for each specialisation and the core subject area for that specialisation.

Table 6: Multimedia Systems, Game Programming and Animation

Expected Learning Outcomes	Core Subjects
1. Design appropriate Human Computer Interfaces and multimedia systems 2. Design and implement game applications 3. Use multimedia data formats, protocols, and compression techniques on digital images, video and audio content. 4. Apply design principles of hypermedia/interactive multimedia 5. Design, create and implement computer graphics and animations, create and implement computer graphics and animations	• Computer Graphics • Human Computer Interaction • Modeling and Simulation • Multimedia systems • Virtual Reality and Emerging Technologies • Games Development

Table 7: Artificial Intelligence and Knowledge based systems

Expected Learning Outcomes	Core Subjects
1. Design appropriate Human Computer Interfaces and multimedia systems 2. Design and implement game applications 3. Use multimedia data formats, protocols, and compression techniques on digital images, video and audio content. 4. Apply design principles of hypermedia/interactive multimedia 5. Design, create and implement computer graphics and animations	• Knowledge based Systems • Artificial Intelligence • Data Mining and Warehousing • Machine learning • Neural networks • Natural Language Processing • Intelligent Agents

Table 8: Parallel , networking and Distributed systems

Expected Learning Outcomes	Core Subjects
1. Design appropriate networking and communication solutions. 2. Manage system resources using appropriate operating system resources 3. Design, configure and implement computer networks 4. Apply fundamental network architectures (Client/ server based computer networks) to computer networks 5. Demonstrate understanding of the principles of parallel and distributed systems 6. Design and build parallel & distributed systems 7. Understand parallel hardware constructs 8. Understand language design issues related to parallel programming, distributed programming. 9. Configure, implement and manage operating systems for distributed computing	• Networking and communications • Operating Systems • Parallel and Distributed computing • Systems Programming • Distributed Computing • Systems Administration • Cloud Computing

More about specializations see appendix 5

Table 9: Software Engineering

Expected Learning Outcomes	Core Subjects
1. Demonstrate an understanding on Software Development Fundamentals, software engineering and platform based development 2. Use computational theories for requirements analysis and design of software programs 3. Use a programming language to implement, test and debug computer programs 4. Apply principles of compiler construction and be able to build simple structures 5. Design and implement large scale software systems	• Systems Analysis and Design • Programming Languages • Platform based Development • Software Engineering • Principles of Programming • Object Oriented Programming • Structured Programming • Software Project Management

Table 10: Mobile computing

Expected Learning Outcomes	Core Subjects
1. Apply the principles of mobile computing and its enabling technologies, 2. Handle and resolve the problems and solutions introduced by wireless networks and mobile computing 3. Compare mobile networking to traditional networking, operating systems, human-computer interface, architecture, and security. 4. Design, create and implement mobile applications using emerging technologies	• Mobile Communications and Computing • Mobile platforms • programming • Mobile computing programming methodologies

Table 11: Systems and Information Security

Expected Learning Outcomes	Core Subjects
1. Demonstrate an understanding of the underlying principles of Information Assurance and Information Security 2. Design and implement solutions and security techniques that mitigate against the risks involved in information security 3. Demonstrate skills for security forensics and evaluation 4. Implement security in a distributed system and in databases	• Information Assurance • Information and network Security • System security • Systems *and Information Security* • Digital Forensics • Cryptology

3.8 The role of internship and project work

3.8.1 Internship

The internship program is intended to have students gain work experience in the study of computer science and sometimes provide employment opportunities. The internship should be compulsory and last for a reasonable period. During this time the students link their learning with the real world experience to provide exposure to the practical and daily operations of an information technology environment. Students are placed within a private firm, government institution or agency, corporation, industrial/commercial organizations so that they can relate what they have learnt in the classrooms with actual

work situations. At the end of the internship a report is submitted documenting the experience acquired by the student.

3.8.2 Project Work

The objective of the project work is to give students an opportunity to apply the subject matter learnt to a practical problem under supervision of an academic staff. The project work should be compulsory and graded. The project can be done at industry or at the University. Inter-disciplinary projects (involving Computer science and other disciplines) and teamwork are encouraged. At the end of the programme, students should be required to submit a final project report , make an oral presentation and demonstrate a working prototype.

PART 4: BENCHMARKS FOR A BACHELOR IN INFORMATION TECHNOLOGY

4.1 Description of Information Technology

Information Technology is a field of ICT that aims at equipping the learners with the knowledge and competencies to learn, design, develop, install, and implement all types of computer information technologies and systems. Emphasis of this programme is on the ability of graduates to develop conceptual and practical IT skills and its application in communication, business problem solving and integration of business/organizational functions (such as financial, marketing and production/service) with the overall business strategy.

Graduates of this programme will take up positions in Information and Communication Technology (computing and ICT-based) sectors, and other positions such as Web-Designers, Web-Programmers, Information Technology Planners, Systems Analysts, IT Project Managers, IT systems auditors, Information Systems Specialists, Security Specialists, Systems Administrators, Network Developers, Network Engineer and Forensics. A sample of Course Outline, Modular Structure and Brief Descriptions of all Courses of the Programme are given in Appendices 2, 4 and 6 respectively. Specialization courses for the programme are given in Appendix 7.

4.2 Programme Goal

The goal of this programme is to equip learners with the knowledge and skills to create and apply information technology in problem solving as well as in lifelong learning and research. This goal entails the mastery of the following:

1. *Information technology-specific skills*: the ability to use contemporary Information technology applications to solve business problems;
2. *Fundamental and enduring information technology concepts*: the how and why of information technology and they give insight into its opportunities and limitations.
3. *General intellectual capabilities:* These skills allow learners to apply information technology to complex tasks in effective and useful ways and to advance in this field of study.

4.3 Programme objectives

The Bachelor of IT programme should be designed in such a way that it addresses the concerns of different stakeholders. This is achieved by focusing on the following grouped programme objectives:

4.3.1. Academic Ability

The programme objectives under this category are to:

- Equip learners with IT knowledge, skills and competences;
- Enable learners to be innovative in the development and application of IT in a dynamic environment;
- Enable the learner to adapt and adopt emerging/evolving ICT technologies
- Prepare and develop the learners to undertake research and to progress to higher levels of studies.

4.3.2 Employability

The programme objectives under this category are to:

- Equip learners with IT technical skills, entrepreneurial and managerial skills;
- Prepare learners to meet the requirements of the labour market and have competitive advantage.

4.3.3 Personal Development

The programme objectives under this category are to:

- Impart professional ethics to learners;
- Prepare learners for life-long learning and research;
- Empower learners to progress in their personal career;
- Equip the learner with skills and attitude to work in multicultural and global environments;
- Equip the learner with knowledge and skills to work as a team in the IT field;
- Enable the learner to develop skills to perform effectively in technical and non-technical environments.

4.4 Expected Learning Outcomes (Table 12)

To harmonize the Bachelor program in IT and make it more coherent and consistent for East Africa, the following learning outcomes have been formulated to be used as benchmarks. The formulated ELO's are the threshold: all graduates of the bachelor's programme in information technology must achieve them. Besides these, a graduate also has to achieve the ELO's for their chosen specialisation (see section 4.7) . HEIs may consider adding Learning Outcomes as and when necessary in line with their mission and vision or identified need(s).

Table 12: Expected Learning Outcomes for a Bachelor of Information Technology

Knowledge	*The graduate should be able to:* 1. Demonstrate knowledge and an understanding of the facts, concepts, principles, and theories relating to IT; 2. Identify any risks (including any safety or security aspects) that may be involved in the operation of IT equipment within a given context; 3. Demonstrate knowledge of existing and emerging IT technologies. 4. Demonstrate knowledge of the ethical standards of ICT profession 5. Demonstrate knowledge and understanding of the impact of computing on society and the environment.
Skills	
Cognitive skills	*The graduate should be able to:* 6. Use knowledge and understanding in the modelling and design of computer-based systems; 7. Identify and analyze criteria and specifications appropriate to specific problems, and plan strategies for their solution; 8. Evaluate critically and analyze the extent to which a computer-based system meets the criteria defined for its current use and future development; 9. Deploy appropriate theory, practices, and tools for the specification, analysis, design, implementation, and maintenance of IT systems. 10. Evaluate systems in terms of general quality attributes and possible trade-offs among alternative systems; and 11. Identify and analyze user needs and take them into account in the selection, creation, evaluation and administration of computer-based systems
Practical Skills	*The graduate should be able to:* 12. Apply the principles of effective management and retrieval of information of various types; 13. Apply the principles of human-computer interaction to the evaluation and construction of a wide range of applications including user interfaces, web pages, multimedia systems and mobile systems; 14. Deploy effectively the tools used for the development and documentation of software; 15. Manage computing equipment, software systems and projects effectively and efficiently; 16. Integrate IT-based solutions into user environment; 17. Make clear presentations to a range of audiences about technical problems and their solutions.
Interpersonal Skills	*The graduate should be able to*: 18. Act professionally and ethically in the work environment; 19. Be an effective team player
Attitude	*The graduate should be able to:* 20. Adapt to and work in a multicultural and global IT environment; 21. Work effectively as a member of a team 22. Demonstrate commitment to lifelong learning self and professional development 23. Demonstrate self-confidence and ability to adapt to new situations.

4.5 Translating the learning outcomes into the basic/ foundation phase of IT

The learning outcomes need to be translated into the programme. In this document, the programme is defined at Bachelors level. A programme is seen as a coherent set of courses leading to a degree, in this case a Bachelor degree in Information technology. A Bachelor programme is commonly divided into:

- *the basic phase*: This phase is common for all IT program students and consists of core and supporting courses .
- *the specialisation phase*: This allows students to choose certain specialisations according to their interests.

The programme may be organized in courses, modules or units. In the basic/ foundation phase, 3 types of areas can be distinguished as follows:

- *Core courses(or subject areas)*
  - These are the essential courses offering a thorough foundation of the discipline. The core courses are the backbone of the discipline. They are the typical IT courses mandatory for every student.
- *Supporting courses(or subject areas)*

  These are courses for backing up the core courses. Without these courses it will be difficult to understand the core courses, for example "Mathematics", "Basics of Computer Studies". Those courses are also compulsory for all students.

- *Elective courses(or subject areas)*

  These are courses that can be taken by a student, to deepen or to broaden the knowledge, but they are not compulsory. However, a student has to make a choice to meet the minimum credit requirements for graduation.

Table 13 shows the core courses and the supporting courses in the basic phase of a Bachelor of IT programme.

Based on the core and supporting courses in Table 13, the following remarks apply:

- The titles of the courses may differ from HEI to HEI. The emphasis should be on content rather than title. In appendix 4 for each core course a short description is given for a better understanding of the subject.
- the autonomy and the uniqueness of HEIs will be taken into consideration in formulating the core courses for the basic phase. The HEIs will have the choice to add

their own courses beyond the core and supporting courses.

- The core and supporting courses may be designed in form of modules, course units as per HEIs' systems.

Table 13: List of Core Subject areas and supporting subject areas

Core Subjects	Supporting Subjects
• Introduction to Information Technology • Human Computer Interaction • Information security • Network security • Databases • System analysis and design • Information systems fundamentals • Systems administration • Computer networks and data communication • Structured programming • Object oriented programming • Operating systems • Software engineering • Social and professional issues in computing • IT project planning and management • Industrial training • IT Project • Web systems and technologies • Computer organization and maintenance • Information systems management • Distributed and Mobile computing • Business Intelligence • Multimedia and computer graphics	• Basic statistics • Mathematics for IT • Communication skills • Research method • IT entrepreneurship • Fundamentals of accounting • Fundamentals of management • Ethical Hacking

4.6 The learning outcomes and the curriculum alignment matrix

As already mentioned in 2.2.3, to check if the planned courses cover the learning outcomes, it is important to develop a curriculum alignment matrix. For each course one has to formulate the specific learning outcomes for that course and have to check how far this course contributes to the programme learning outcomes.

Table 14 gives an example of a curriculum alignment matrix for the Expected Learning outcomes of the Bachelors in Information Technology. For each subject the contribution to the Expected learning outcomes are given.

Table 14: curriculum alignment matrix for Bachelor in Information Technology

			Expected Learning Outcomes *(for explanations of the numbers, see table 15 on the next page)*																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Core subjects																							
• Introduction to Information Technology	√																						
• Human Computer Interaction		√																					
• Information assurance and security		√						√															
• Network security		√																					
• Databases						√																	
• System analysis and design						√		√		√													
• Information systems fundamentals	√																						
• Systems administration									√		√												
• Computer networks and data communication									√														
• Structured programming							√		√														
• Object oriented programming							√		√														
• Operating systems			√																				
• Software engineering			√																				
• Social and professional issues in computing				√	√			√		√													

• IT project planning and management											√	√						√		√	√	√	
• Industrial training										√				√	√	√	√		√	√	√	√	√
• IT Project														√	√	√	√		√	√	√	√	√
• Web systems and technologies						√																	
• Computer organization and maintenance															√								
• Information systems management												√											
• Distributed and Mobile computing			√																				
• Business Intelligence and data Minng					√																		
• Multimedia and computer graphics													√										
• Animation	√		√																				
• Data modelling	√					√																	
• Cyber Security	√		√																				
• Applied Information systems	√						√		√		√	√	√			√							
• Basic statistics			√																				
• Mathematics for IT																				√	√	√	
• Communication skills																	√	√	√	√	√	√	√
• Research method										√													
• IT entrepreneurship													√			√				√	√	√	√
• Fundamentals of accounting							√		√														
• Fundamentals of management												√				√							
• Ethical Hacking		√		√														√					

Table 15 Explanation of the numbers in Table 14

1. Demonstrate knowledge and an understanding of the facts, concepts, principles, and theories relating to IT;
2. Identify any risks (including any safety or security aspects) that may be involved in the operation of IT equipment within a given context;
3. Demonstrate knowledge of existing and emerging IT technologies.
4. Demonstrate knowledge of the ethical standards of ICT profession
5. Demonstrate knowledge and understanding of the impact of computing on society and the environment.:
6. Use knowledge and understanding in the modelling and design of computer-based systems;
7. Identify and analyze criteria and specifications appropriate to specific problems, and plan strategies for their solution;
8. Evaluate critically and analyze the extent to which a computer-based system meets the criteria defined for its current use and future development;
9. Deploy appropriate theory, practices, and tools for the specification, analysis, design, implementation, and maintenance of IT systems.
10. Evaluate systems in terms of general quality attributes and possible trade-offs among alternative systems;
11. Identify and analyze user needs and take them into account in the selection, creation, evaluation and administration of computer-based systems
12. Apply the principles of effective management and retrieval of information of various types;
13. Apply the principles of human-computer interaction to the evaluation and construction of a wide range of applications including user interfaces, web pages, multimedia systems and mobile systems;
14. Deploy effectively the tools used for the development and documentation of software;
15. Manage computing equipment, software systems and projects effectively and efficiently;
16. Integrate IT-based solutions into user environment;
17. Make clear presentations to a range of audiences about technical problems and their solutions.
18. Act professionally and ethically in the work environment;
19. Be an effective team player
20. Adapt to and work in a multicultural and global IT environment;
21. Work effectively as a member of a team
22. Demonstrate commitment to lifelong learning self and professional development
23. Demonstrate self-confidence and ability to adapt to new situations.

4.7 Benchmarks for the Specialization / Concentration

After the basic phase, students may choose to depeen their knowledge in one of the following specialisations:

1. Programming and Software Development
2. Information Systems Engineering
3. Networking and Telecommunication
4. Databases
5. Information Security
6. Web Systems and Technologies
7. Multimedia and Computer Graphics

Tables 16 - 22 show the Expected Learning outcomes for each specialization/ concentration area and the core subjects.

Table 16: Programming and Software Development

Expected Learning Outcomes	Core Subjects
1. Understand design methods for large scale software systems; 2. Appreciate Principles of package cohesion and coupling; 3. Analyse, design, implement, and evaluate software-based systems, components, or programs of varying complexity that meet desired needs, satisfy realistic constraints, and demonstrate accepted design and development principles; 4. Understand user requirements in relation to software development and the need for user interfaces; and 5. Knowledge of the various development languages and platforms currently in use in the market, ability to exhibit ethical values while on professional grounds.	• Human Computer Interaction • System analysis and design • Information systems fundamentals • Structured programming • Object oriented programming • Software engineering • Mobile applications development

Table 17: Information Systems Engineering

Expected Learning Outcomes	**Core Subjects**
1. Develop an understanding of information technology (IT) as a strategic resource for an Enterprise; 2. Develop an understanding of the nature of business in competitive markets; 3. Show how information systems (IS) strategies can be developed to enable IT to contribute to the strategic growth and provide competitive advantage for an enterprise; and 4. Demonstrate the ability to manage IT resources effectively and efficiently in an enterprise.	• Applied Information systems • Systems administration • Operating systems • IT project planning and management • Web systems and technologies • Information systems management • Business Intelligence

Table 18: Networking and Telecommunication

Expected Learning Outcomes	Core Subjects
1. Identify and describe the structure of global telecommunication systems; 2. Use network management tools effectively and efficiently; 3. Design, configure, implement, administer and manage computer networks; and 4. Implement computer network security.	• Network security • Systems administration • Computer networks and data communication • Operating systems • Distributed and Mobile computing

Table 19 : Databases

Expected Learning Outcomes	Core Subjects
1. Implement transaction management and distributed database management systems; 2. Implement recent database developments such as object oriented databases; 3. Design, develop, deploy, administer and manage a database system; 4. Apply business intelligence and data mining techniques; and 5. Implement database security.	• Databases systems management • Data modelling • Database design • Business intelligence and data mining

Table 20: Information Security

Expected Learning Outcomes	Core Subjects
1. Identify points of weakness in information systems and means of deterring them; 2. Implement key information security measures in the dynamic work environment; 3. Conduct an information systems audit; and 4. Discuss the implications of fraud and its impact on society.	• Information security • Ethical Hacking • Operating systems • Social and professional issues in computing • Cyber security • Information systems auditing and assurance • computer forensics

Table 21:Web Systems and Technologies

Expected Learning Outcomes	Core Subjects
1. Use web technology tools efficiently and effectively; 2. Analyse, design, develop and manage web based systems in a dynamic work place environment; and 3. Demonstrate capacity to apply and implement web based systems security.	• Web application development • Web design and technologies

Table 22: Multimedia and Computer Graphics

Expected Learning Outcomes	Core Subjects
1. Understand hypermedia/interactive multimedia related design principles; 2. Describe the ways in which multimedia information is captured, processed and implemented; 3. Understand multimedia data formats, protocols, and compression techniques of digital images, video and audio content; 4. Create multimedia presentations; 5. Demonstrate the ability to apply the technical multimedia standards and compression techniques; and 6. Create interactive computer graphics.	• Human Computer Interaction • Multimedia design • Graphics design • Animation

4.8. The role of Internship and Project Work

4.8.1 Internship

The internship program is intended to have students gain work experience in the study of computer science and sometimes provide employment opportunities. The internship should be compulsory and last for a reasonable period. During this time the students link their learning with the real world experience to provide exposure to the practical and daily operations of an information technology environment. Students are placed within a private firm, government institution or agency, corporation, industrial/commercial organizations so that they can relate what they have learnt in the classrooms with actual work situations. At the end of the internship a report is submitted documenting the experience acquired by the student.

4.8.2 Project Work

The objective of the project work is to give students an opportunity to apply the subject matter learnt to a practical problem under supervision of an academic staff. The project work should be compulsory and graded. The project can be done at industry or at the University. Inter-disciplinary projects (involving IT and other disciplines) and teamwork are encouraged. At the end of the programme, students should be required to submit a final project report , make an oral presentation and demonstrate a working prototype.

GLOSSARY[15]

Attitude	Attitude means a settled way of thinking or feeling about something.
Bachelor degree	It is a degree in which the holder of the qualification will be able to apply knowledge, skills and understanding in a wide and unpredictable variety of contexts with substantial personal responsibility, responsibility for the work of others and responsibility for the allocation of resources, policy, planning, execution and evaluation.
Basic phase	The first phase of the Bachelor programme, compulsory for all students (2 in a 3 years bachelor and 3 years in a 4 years Bachelor.
Benchmark	Point of reference against which something may be measured.
Benchmark standards	Subject benchmark 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 abilities and skills needed to develop understanding or competence in the subject. (T)
Competencies	Is a product of individual characteristics and achieved learning outcomes
Core subject	These are the essential subjects offering a thorough foundation of the discipline. The core subjects are the backbone of the discipline.
Course(unit)	A self-contained, formally structured learning experience. It should have a coherent and explicit set of learning outcomes and appropriate assessment criteria. Course /units can have different numbers of credits.
Curriculum alignment matrix	An instrument for checking the contribution of a course, unit or module to the achievement of the programme learning outcomes.
Curriculum	See programme
Elective subjects	These are subjects out of which a student has to make a selection, to deepen or to broaden their learning experience in the programme.
Equivalency	Having the same value, without being uniform.
Generic learning outcomes	Generic Learning outcomes are those learning outcomes, expected from all academic trained graduates, irrespective of the study programme. Examples of generic learning outcomes are problem solving, communication skills, and ability to cooperate.
Harmonization	Harmonization of programmes means that the programmes in the region are comparable based on agreed benchmarks.
Internship	Is a period of supervised training *at the workplace* and is an important part of the programme. It offers the student the opportunity to become acquainted with his /her future job. It provides the student with experiences at working floor level.
Knowledge	Is the body of facts, principles, theories and practices that is related to a field of work or study. It is the outcome of the assimilation of information through learning and is described as theoretical and/or factual
Learning outcomes	Statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and attitude.
Master degree	It is a degree in which the holder of the qualification will be able to display mastery of a complex and specialized area of knowledge and skills, employing knowledge and understanding to conduct research or advanced technical or professional activity, able to work autonomously and in complex and unpredictable situations.
Module	A formal learning experience encapsulated into a block of study, usually linked to other modules to create a programme of study.
Module description	Module description is statement of the aims, objectives/learning outcomes, content, learning and teaching processes, mode of assessment of students and learning resources applicable to a block of study.
National Qualification Framework (NQF)	The policy framework that defines all qualifications recognized nationally in post-compulsory education and training within a country. The NQF comprises titles and guidelines, which define each qualification, together with principles and protocols covering articulation and issuance of qualifications, and Statements of Attainment. *See also Qualifications framework.*
Programme	A set of coherent educational components, based on learning outcomes, that are recognized for the award of a specific qualification through the accumulation of a specified number of credits and the development of specified competences.(T)(IUCEA definition)
Programme objectives	Overall specification of the intention or purpose of a programme of study (T)
Project work	Is a form of study, which is problem oriented. The project is normally based on an actual existing problem, which may be linked to internship and leads to possible solutions. The project may be practical or research oriented.
Qualifications framework	Is an instrument for the development and classification of qualifications according to a set of criteria for levels of learning and skills and competences achieved
Skills	The ability to apply knowledge and use know-how to complete tasks and solve problems.

15 *Use is made from the Tuning glossary in Tuning, A Guide to Formulating Degree Programme Profiles, Bilbao/The Hague, 2010 (chapter 3, page 51-57). The descriptions of Tuning are marked with (T).*

Standards	Explicit levels of academic attainment, which are used to describe and measure academic requirements and achievements of individual students and groups of students.
Subject specific learning outcomes	Are those learning outcomes that are typical for that discipline. See also generic learning outcomes
Supporting subjects	These are subjects for backing the core subjects. Without these subjects it will be difficult to understand the core subjects.
Tuning	Tuning is a collaborative, consultative process involving academics working in subject groups with employers and other stakeholders in curriculum development to enhance student competences. Tuning projects which are funded by the European Commission in higher education have been successfully completed in over sixty countries around the world

Appendix 1: Sample Computer Course Outline

Course Code	**Course Title**
CSC 3090	**CRYPTOGRAPHY AND NETWORK SECURITY**
Credit Units (L=2, P=2)	3 credits
Prerequisite	CSC2050: Computer Network and Telecommunication
Course Description	The course introduces the core techniques of cryptography around which security and trust can be constructed, and highlights the implications of using such techniques. It also looks at the entire key management lifecycle, and examines the differing requirements and methodologies for managing cryptographic keys of different types. The course ends by looking at how these techniques are applied in various applications and standards, from VPNs to secure email. The applications and techniques described are accompanied by a description of their strengths and limitations and the necessary supporting infrastructure.
Purpose of the course	The ability to protect the confidentiality of information, to prevent unauthorized access to data or services and to prevent the unauthorized modification of data is fundamental elements of security. Similarly, the ability to know whom you are talking to and where something has come from, and to be able to bind parties to previous commitments or actions, is essential for trust. In the electronic world, these services typically rely on the use of cryptographic techniques. However, it is imperative that these techniques are used in the correct fashion if they are to satisfy their objectives. In particular, it is crucial that cryptographic keys are managed in an appropriate way.
Learning Outcomes	Upon successful completion of this course, the students should be able to: 1. Appreciate the different services provided by the various cryptographic techniques, and understand their differences and how they are constructed 2. Understand the implications of using such techniques 3. Appreciate the different key management requirements and methodologies 4. Understand how these techniques are applied in various applications and standards, from VPNs to secure email
Content	The cryptographic services; Symmetric key ciphers, from historical examples through to modern ciphers; Cryptographic key management: the life-cycle of cryptographic keys from generation through to destruction, and including digital certificates and Certification Authorities; cryptographic algorithms, and protocols for authentication and signature analysis, public key systems, confidentiality, integrity and non-repudiation. Internet and Web security concepts and protocols including SSL, SHTTP, TSP, SET, Electronic Money, Email Security, WAP security discussed in detail. Network security: fire walls, IP security, and Virtual Private Networks (VPNs). Cryptographic applications

Mode of Delivery	Lectures, Presentations by members of the class, Case discussions, Tutorials, Assignments, Continuous assessment tests, Practical, library sessions, appropriate software, manual/notes, use of learning management systems (e-platforms); Visit to Public Key Infrastructure Center.
Instructional Materials/ Equipment	Course text, Hand-outs, White board/Smart board, Presentation slides, Journals;
Course Assessment:	**Type**
	Examination
	Labs
	Continuous Assessment
	Total
Recommended Reference Material	1. Introduction to Modern Cryptography by Jonathan Katz and Yehuda Lindell 2. Image Pattern Recognition: Synthesis and Analysis in Biometrics S. Yanushkevich, M. Gavrilova, P. Wang and S. Srihari (Eds), World Scientific Publishers, 2007 3. Handbook of Face Recognition Editors: Stan Z. Li and Anil K. Jain Springer, New York, 2005 4. Handbook of Multibiometrics (International Series on Biometrics) Arun A. Ross, Karthik Nandakumar, and Anil K. Jain, Hardcover - May, 2006

No/Code of Module	CSC 3202
Name of Module	Information System Management
Semester	6
Course objectives	The course unit aims: • To introduce students to the basic concepts of information systems management. • To ensure that every students can basically develop an Information Systems management plan. • etc.
Learning outcomes	Upon successful completion of this course students should be able to:- • Explain the role of information system Management in an organization. • Develop an information system management plan. • etc.
Duration of module	13 weeks
Type of module (i.e. mandatory/elective)	Mandatory
If necessary, courses of the modules	
Frequency of the module offered	Annually
Prerequisites	
Applicability of module for other study programs	n.a.

Person responsible for module	N.N
Language of teaching	English
EACTS (based on 30 hrs workload)	45
Workload calculation	
Contact hours per week	
Methods and duration of examination	1. Test (two tests) 6th and 12th weeks 2. Individual course work 4th week 3. Class presentation 4. End of semester closed book examination
Percentage of the final grade	1: 20% ; 2: 20 %; 3: 10%; 4: 50%
Contents of the module	The module will define the Information Systems management; concepts, strategic importance of Information Systems management to Business; information systems planning; aligning IS strategy with business goals. It covers the aspect of management and security of IS resources; and how IS can enhance decision making in an organisation.
Teaching and learning methods	• Lectures, • Discussions, • Case Studies, • Independent study, • Class presentations
Special features (online work, guest speaker, practice)	Relevant case studies, slides, lap top, projector.
Literature (compulsory reading)	1. Laudon, K.C and Laudon, J.A. (2007). Management Information System: Managing the Digital Firm, Prentice Hall. 2. James, A.O'Brein. (1999). Managing Information Systems: Managing Information Technology in the Internet Worked Enterprise, 4th Edition, Irwin MCgraw Hill Boston USA. 3. Lucey,T. (1995). Managing Information System, 7th Edition, DP Publishers, London. etc.
Literature (recommended literature)	

Appendix 2: Example of a Course Outline

Appendix 3: Example of Modular Structure of a Programme in Bachelor of Computer Science

Color Annotation

Core courses	**Life Skills**
Supporting Courses	**Electives**

	Mathematics & Science Foundations	***Computer Systems and Architectures***	***Applications Development Methodologies & tools***	***Computer Applications***	***Humanities, and generic Skills***
1. Semester	Calculus	Telecommunications services architectures	Principles of Programming	Introduction to computer applications	Communications Skills
	Physics				
2 Semester	Linear Algebra	Electronics	Data structures and algorithms		Human Psychology
	Numerical Analysis				Life Skills
3 Semester	Discrete mathematics	Operating Systems	Object Oriented Design & programming	Computer graphics and Web technologies	
	Probability and Statistics	Algorithms and Complexity	Systems analysis and design		
4. Semester	Complex Analysis	Computer Organization and architecture	Relational Databases		
	Computational Science	Introduction to data Communication	Principles of programming languages		
	Foundations of Logic				
5 Semester	Formal languages and Automata Theory	Computer Networks architectures and protocols	Web programming	Database management systems	
		Multimedia systems			
		System integration architecture			

	Mathematics & Science ***Foundations***	***Computer Systems*** ***and Architectures***	***Applications Development Methodologies & tools***	***Computer Applications***	***Humanities, and generic Skills***
6. Semester	Algorithms and Complexity	Client/server and distributed systems	Introduction to artificial intelligence	Microprocessor applications	Social and Professional issues
		Introduction to human computer interactions		Operations Research and Optimization	Research Skills
		Elective	**Elective**	Elective	
7. Semester		Introduction to wireless technologies and programming devices using	Project		Innovation and Entrepreneurship
		Elective	**Elective**	**Elective**	
8 Semester		**Elective**	**Elective**	**Elective**	
		Special topics in Computer Science			
	Internship				

ELECTIVES					
		Network Security Systems	**Software Engineering**	**Distributed Systems**	
			Advanced database management	Network design management	
		Fundamentals of cryptography	Integrative programming and technologies	Broadband and wireless mobile communication	
6. Semester		Information security technologies	Software analysis and design	Network and telecommunication systems administration	
			Decision support systems	Distributed operating systems	
			Human computer interface		
		Information security forensics and incidence response	Data warehouse and data mining design	Distributed systems design development	
		Biometric identification and authentication	Wireless systems communications		
			Advanced object oriented applications development	Data warehouse and data mining design	
7. Semester			Internet technologies and applications		
			Software quality assurance, testing and validation		
			Web design, development and integration		
			Multimedia development	Embedded systems	.
8. Semester			Digital image processing	Neutral networks	
				Real time and embedded systems	

Appendix 4: Example of Modular Structure of a Programme in IT

Semester 1	Introduction to Information Technology	Information systems fundamentals	Operating systems	Mathematics for IT	Database Design	Communication skills
Semester 2	Structured programming	Database	Systems administration	Computer organization and maintenance	Information assurance	Human psychology
Semester 3	Object oriented programming	System analysis and design	Computer networks and data communication	Business Intelligence	Fundamentals of accounting	IT entrepreneurship
Semester 4	Distributed and Mobile computing	Multimedia and computer graphic	Web systems and technologies	Research method	Basic statistics	Data Modelling
Recess	**Industrial training**					
Semester 5	Information security	Human Computer Interaction	Social and professional issues in computing	IT project planning and management	Applied Information Systems	Fundamentals of management
Semester 6	Human Computer Interaction	Network security	Software engineering	Information systems management	IT Project	Ethical Hacking

	Core courses (basic and specialization)
	Supporting courses
	Skills

Appendix 5: Brief Course Descriptions of Computer Science Programme

Computational Fundamentals

Algorithms and Complexity

The design of various algorithms such as searching algorithms, sorting algorithms and graph algorithms is discussed. This course also addresses topics such as recursive algorithms and complexity analysis.

Computer organization and Architecture

This course introduces the principles of computer organization and the basic architecture concepts. The course emphasizes performance and cost analysis, instruction set design, pipelining, memory technology, memory hierarchy, virtual memory management, and I/O systems.

Computational science

Computational science (also scientific computing or scientific computation) is concerned with constructing mathematical models and quantitative analysis techniques and using computers to analyze and solve scientific problems. It is typically the application of computer simulation and other forms of computation from numerical analysis and theoretical computer science to problems in various scientific disciplines. The scientific computing approach is to gain understanding, mainly through the analysis of mathematical models implemented on computers.

Discrete structures

The course entails systematic study of data structures encountered in computing problems; structure and use of storage media; methods of representing structured data; and techniques for operating on data structures. Topics include stacks, queues, lists, multi-linked lists, priority queues, trees, graphs, sorting & searching mechanisms, and recursion.

Foundations of Logic

This is an introductory course on logic in the context of computing: introduction to formal notations; basic proof techniques; sets, relations, and functions.

Linear Algebra

This course includes the study of vectors in the plane and space, systems of linear equations, matrices, determinants, vectors, vector spaces, linear transformations, inner products, eigenvalues and eigenvectors.

Calculus

This course is designed to develop the topics of differential and integral calculus. Emphasis is

placed on limits, continuity, derivatives and integrals of algebraic and transcendental functions of one variable. Upon completion, students should be able to select and use appropriate models and techniques for finding solutions to derivative-related problems with and without technology.

Probability and Statistics

The course is to effectively expose students to basic concepts of probability and statistics through well-organized lectures that focus on: a survey of descriptive statistics and a study of probability distributions (discrete and continuous), mathematical expectation, moment generating functions (mgf), sampling theory, statistical inference, and their applications in problems solving.

Numerical Analysis

This course is an introduction to the numerical analysis. The primary objective of the course is to develop the basic understanding of numerical algorithms and skills to implement algorithms to solve mathematical problems on the computer.

Complex Analysis

The course covers the basic principles (both theory and applications) of differentiable complex-valued functions of a single complex variable. Topics include the complex number system, Cauchy-Riemann conditions, analytic functions and their properties, special analytic functions including linear fractional transformations, roots, exponential, Log, trigonometric and hyperbolic functions of a complex variable; Complex integration and line integrals, Cauchy's theorem, Cauchy representation, conformal mapping, Taylor and Laurent Series expansions; the calculus of residues and various applications. Matlab graphics will be used to provide 4-D graphical representations of analytic functions.

Assembly Language Programming

The course introduces concepts of assembly language and the machine representation of instructions and data of a modern digital computer: study of machine addressing, stack operations, subroutines, and programmed and interrupt driven I/O, basic concepts of machine organization; also included is the study computer architecture at the register level and micro-operation components of instructions.

Formal languages and Automata Theory

The course presents a study of formal languages and the correspondence between language classes and the automata that recognize them. Formal definitions of grammars and acceptors, deterministic and nondeterministic systems, grammar ambiguity, finite state and push-down automata, and normal forms and are discussed.

Optimization

This course provides an introduction to the theory and algorithms for optimization problems with an emphasis on modern computational considerations. Topics covered include: Convex sets and functions, examples of convex optimization problems; Duality, Lagrangian function, Lagrangian dual; Optimality conditions for unconstrained convex optimization, gradient methods, Newton's

method, self-concordance; Linear equality constraints, optimality conditions, solution methods; Inequality constraints, barrier functions, the central path, interior-point methods; Nonconvex optimization problems, line-search methods, trust-region methods, sequential quadratic programming.

Data structures and Algorithms

The purpose of this course is to provide students with solid foundations in the basic concepts of programming: data structures and algorithms. The main objective of the course is to teach the students how to select and design data structures and algorithms that are appropriate for problems that they might encounter. This course is also about showing the correctness of algorithms and studying their computational complexities.

Physics

This course introduces concepts, methods, and applications of physics. Topics include a description of motion, Newton's Laws, conservation principles (energy and momentum), waves, thermodynamics, electricity, magnetism, optics, and modern physics.

Electronics

An introduction to electric circuit elements and electronic devices and a study of circuits containing such; devices. Both analog and digital systems are considered.

Multimedia

Computer Graphics

Computer Graphics is a study of the hardware and software principles of interactive raster graphics. Topics include an introduction to the basic concepts, 2-D and 3-D modelling and transformations, viewing transformations, projections, rendering techniques, graphical software packages and graphics systems. Students will use a standard computer graphics API to reinforce concepts and study fundamental computer graphics algorithms.

Human Computer Interaction

Human-Computer Interaction (HCI) is a rapidly expanding research and development area that has transformed the way we use computers nowadays. This course introduces fundamental methods, principles and tools for designing, programming and testing interactive systems. The course covers topics such as usability and affordances, user-centered design, human cognitive and physical ergonomics, information and interactivity structures, interaction styles, interaction techniques, and user interface software tools with a special focus on mobile user interfaces.

Multimedia Systems

This course provides an introduction to Multimedia Systems. Students will use multimedia environments to design and develop multimedia applications that combine text, images, sound, video, and animation. Topics will also include theories of interactivity, hypertext, and instructional technology.

Modelling and Simulation

This course covers the use of simulation as a tool for analyzing business and engineering problems. The primary goals of the course are to learn how to plan, build and use simulation models, and to develop an understanding of when simulation is an appropriate tool for analysis. Much of the work in the course involves learning the mathematical and software tools for building simulation models, performing experiments with them, and interpreting the results

Virtual Reality and Emerging Technologies

The course aims at new and emerging technologies for 3D visual scene capture, processing and visualization as well as their use in applications such as 3D video and virtual reality. The course provides in-depth knowledge about the creation, processing, delivery and visualization of 3D moving scenes. The students will be able to design application-specific multi-camera and multi-sensor capture systems.

Games Development

This course covers aspects of computer games development process, from programming to design and production, with emphasis on the technical and creative skills required to compete in the games and entertainment industry. Programming, Mathematics and Physics, games level design, 3D modelling and animation, algorithms for real-time graphics, games production, and simulation techniques are all highly suited to computer games, which the course gives to the student the necessary expertise for the development of such systems.

Distributed Systems

Cloud Computing

This course provides a hands-on comprehensive study of Cloud concepts and capabilities across the various Cloud service models including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), and Business Process as a Service (BPaaS). IaaS topics start with a detailed study the evolution of infrastructure migration approaches from VMWare/Xen/KVM virtualization, to adaptive virtualization, and Cloud Computing / on-demand resources provisioning.

Software Engineering

Systems Analysis and Design

This course introduces established and evolving methodologies for the analysis, design, and development of an information system. Emphasis is placed on system characteristics, managing projects, prototyping, CASE/OOM tools, and systems development life cycle phases. Upon completion, students should be able to analyze a problem and design an appropriate solution using a combination of tools and techniques.

Principles of Programming Languages

The course is aimed at making the student familiar with the general concepts common to all programming languages so as to facilitate learning new languages. Language paradigms (i.e., logic, functional, procedural, object-oriented) are compared and implementation strategies are discussed.

Introduction to Software Engineering

Software engineering is the branch of computer science that creates practical, cost-effective solutions to computing and information processing problems. This course covers the fundamentals of software engineering, including understanding system requirements, finding appropriate engineering compromises, effective methods of design, coding, and testing, team software development, and the application of engineering tools.

Platform based Development

This course entails looking at fundamental differences that Platform-Based Development has over traditional software development. Topics include: Overview of platforms (e.g., Web, Mobile, Game, Industrial); Programming via platform-specific APIs; Overview of Platform Languages (e.g., Objective C, HTML5, etc.); Programming under platform constraints.

Principles of Programming

This course extends the study of programming principles developed in earlier programming courses, including use of defensive programming, debugging, testing, coding standards and practices; this material is presented using a suitable programming language such as C as a vehicle for instruction. This course may serve as a foundation for further studies in Computer Science and Software Engineering.

Object Oriented Programming

This course is aimed at students who wish to learn how to develop applications in Java. This course will also provide an overview of Object Oriented Programming concepts using Java.

Structured Programming

This course introduces programming principles, with emphasis on good programming style, structured approach to program development, testing and documentation. On completion, students should be able to use a high-level programming language to develop a structured program, with an awareness of the importance of programming style, programming testing and documentation, and program development methodology.

Logic Programming

Logic programming supports the declarative programming paradigm, which describes the solution logically rather than how to compute it. This introductory course covers the fundamental topics of logic programming such as rule-based syntax, procedural and declarative semantics, negation, the logic programming language PROLOG, and answer set programming.

Web platforms

The course aims to deepen the student's knowledge of creating web applications with focus on implementation of specialized frameworks, techniques and concepts. This knowledge forms a technical basis, which is required to be able to create media technical productions out of an idea.

Software Project Management

This course introduces a number of aspects of software projects including software requirements specifications, software life-cycle models, software project scheduling, and risk management. Other topics include teamwork, software testing, and software configuration management.

Mobile Applications Programming

This course involves a careful examination of mobile device programming. Emphases are on developing applications as a community that run on the Android platform. Students planning to enroll in this course should be familiar with Java, XML, and unix. This course will also give students insight to today's common procedures for getting their mobile application work academically published.

Information Security

Information Assurance

This course surveys the broad fields of enterprise security and privacy, concentrating on the nature of enterprise security requirements by identifying threats to enterprise information technology (IT) systems, access control and open systems, and system and product evaluation criteria. Risk management and policy considerations are examined with respect to the technical nature of enterprise security as represented by government guidance and regulations to support information confidentiality, integrity and availability.

Information and network Security

In this course, students will study security issues in Information Technology and Networking. Students will be introduced to practical solutions for identifying, assessing, and preventing external and internal threats to networks. Key components include authentication methods, communication security, infrastructure security, cryptography basics, and security implementation.

Digital Forensics

This course introduces the study of forensics by outlining integrative aspects of the discipline with those of other sciences. The course focuses on applying basic forensic techniques used to investigate illegal and unethical activity within a PC or local area network (LAN) environment and then resolving related issues.

System security

This subject explores the study of security policies, models and mechanisms for secrecy, integrity, availability and usage. Topics include operating system models and mechanisms for mandatory and discretionary controls, basic cryptography and its applications, telecommunication and network system security.

Cryptology

This course features an introduction to modern cryptography, with an emphasis on the fundamental cryptographic primitives of public-key encryption, digital signatures, pseudo-random number generation, and basic protocols and their computational complexity requirements.

Humanities

Social and Professional issues

This course will deal with social, ethical, and professional issues facing computing professionals; ethical principles and discussion of case studies will be presented.

Communication Skills

This course is designed to give the students general written and oral communication skills. The writing skills focus on accuracy, clarity and conciseness in the various types of reading and writing which a professional is required to do. The oral skills focus on gathering, interpreting and relaying information to others, including listening and discussion skills when working with others in a team and when handling clients.

Human Psychology

This course surveys the major principles of psychology. It introduces the history of psychology, human development, personality, abnormal behavior, social psychology, feelings and emotions, psychophysiology, learning and memory, altered states of awareness, sleep and dreams, and industrial and organizational psychology.

Research Skills

This course provides an opportunity for students to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches. The course introduces the language of research, ethical principles and challenges, and the elements of the research process within quantitative, qualitative, and mixed methods approaches. Students will use these theoretical underpinnings to begin to critically review literature relevant to their field or interests and determine how research findings are useful in informing their understanding of their environment (work, social, local, global).

Artificial Intelligence

Machine learning

Machine Learning is the study of how to build computer systems that learn from experience. As part of Artificial Intelligence it intersects with statistics, cognitive science, information theory, and probability theory, among others. The course will explain how to build systems that learn and adapt using real-world applications from industry and science.

Neural networks

This course explores the organization of synaptic connectivity as the basis of neural computation and learning. Perceptrons and dynamical theories of recurrent networks including amplifiers, attractors, and hybrid computation are covered. Additional topics include back propagation and Hebbian learning, as well as models of perception, motor control, memory, and neural development.

Natural Language Processing

This is an introduction to natural language processing, the goal of which is to enable computers to use human languages as input, output, or both. Possible topics include parsing, grammar induction, information retrieval, and machine translation.

Knowledge based Systems

This course deals with the Theory and practice of knowledge based system construction with particular emphasis on rule-based expert systems. Topics include KBS fundamentals, knowledge representation, knowledge base construction, knowledge integration in databases, inference engines, reasoning from incomplete or uncertain information, intelligent decision support, and user tools & interfaces.

Artificial Intelligence

In this course students are introduced to artificial intelligence, its languages, hardware, application of languages and use of fuzzy rules for commercial projects. It shows the relationships between Cognitive Science and AI and gives an overview of some key underlying ideas. Demonstration of the need for different approaches for different problems is discussed.

Databases

Database Systems

The main aim of this course is to introduce the fundamental concepts necessary for designing, using, and implementing database systems and applications. The course stresses the fundamentals of database modelling and design, the languages and facilities provided by database management systems, and system implementation techniques.

Data Mining and Data Warehousing

The course allows you to explore the principles and practice of up-to-date conceptual and practical knowledge on recent developments in database technology, specifically data warehousing. Topics include overview of data warehousing, Data warehouse design, OLAP technologies, Data warehousing in practice, and Data mining in data warehouses.

Mobile platforms

Students will be exposed to technologies in the following areas: Mobile application programming. Java 2 Micro edition. CLDC, MIDP MIDLets, High level User Interface. Displayable command. Canvas graphics, MMAPI, WMA, Android platform. Sybian platform.

Special Topics

Emerging trends in Computer Science

The students will be exposed to emerging and relevant areas in ICT. These includes the following fields: Intelligent agents, Embedded systems, Grid computing, Game development, Digital media technology, Big data computing, Data mining and visualization.

Industrial training / Internship

This 10-week internship/Industrial/Attachment links the students' learning with the real world experience to provide exposure to the practical and daily operations of an information technology system, support team, or equivalent. Students are placed within a private firm, government institution or agency, corporation, industrial/commercial organizations so that that they can relate what they have learnt in the classrooms with actual work situations.

Final Year Project

This course provides an opportunity to integrate knowledge and skills to design a software system for solving a real-world problem including the oral presentation and report writing about the design. Application of software engineering techniques to specify, design and implement a large system is considered. The students will work in teams and will produce a system that can be used by a department in an institution. Each development team will present a complete project report at the end of the course.

Innovation and Entrepreneurship

The course aims to provide an understanding of entrepreneurship, creativity and innovation and how they can be applied to contemporary issues in various industries and markets.

Life Skills

In this course, students learn how to lay a foundation for successful, responsible adulthood by using time effectively, setting goals, avoiding procrastination, overcoming feelings of inadequacy, and developing self-motivation.

Appendix 6: Brief Course Descriptions Information Technology Programme

Core subjects

Introduction to Information Technology

Introduce students to the computer, their applications to computing, underlining theories and concepts, history and basic data communication.

Human Computer Interaction

This subject involves the study, planning, design, testing usability and uses of interfaces between people (users) and computers.

Network security

This subject involves current and continuing information security threats, vulnerabilities, and their trends and covers to network architectures and protocols, Botnets, E-mail security, IP security, Web security, network attack propagation modelling (traffic analysis, trace back mechanisms), and Network security management techniques such as Firewalls and IDS; and recommends practices in securing information assets on an organization's computer systems as well as Data, host, network/intranet, & Internet security issues and tools.

Databases

This subject introduces the conceptual, logical and physical organization of large set of related data, to database descriptions, data models data definition and manipulation languages, query languages, relation algebra and database oriented projects

System Analysis and Design

This subject deals with the concepts, skills, methodologies, techniques, tools, and perspectives essential for systems analysts.

Systems administration

The aim of this course is to give the students an overview of operating system and how OS works with other hardware in a computer system.

Computer networks and data communication

Data communications is a rigorous treatment of advanced topics in the technology of communicating digital information over public and private communications facilities. Topics to be covered include data signals (timing, codes); simple data communications; simplex, duplex, semi-duplex, telephone lines, modems, multiplexers and concentrators, circuit switching, message switching; packet switching; standards and protocols:-OSI model. Basic concepts: band

width, protocols, architectures, types of network – LAN, MAN, WAN, Intranet, extranet, Internet, peripheral and data communication equipment.

Structured Programming

This course is covers structure programming concepts for undergraduate students. It also covers the modern day concepts of conceptualizing and writing programs which students will encounter in many computer science courses.

Object Oriented Programming

This course is an introduction to the fundamental principles of graphic communication. Instruction incorporates traditional hand-rendering methods as well as use of the computer. In this class the fundamental principles and elements of design are identified and applied to two and three dimensional projects. This course is intended for students majoring in graphic design and anyone interested in basic graphic design.

Operating Systems

This course is an introduction to the theory and practice behind modern computer operating systems. Topics will include what an operating system does (and doesn't) do, system calls and interfaces, processes, concurrent programming, resource scheduling and management (of the CPU, memory, etc.), virtual memory, deadlocks, distributed systems and algorithms, networked computing and programming, and security. We will approach the subject from both a theoretical perspective (what are the abstractions and algorithms?) as well as a practical one (what are the mechanisms and how are they built?).

Software Engineering

Software engineering is the branch of computer science that creates practical, cost-effective solutions to computing and information processing problems, preferentially by applying scientific knowledge, developing software systems in the service of mankind. This course covers the fundamentals of software engineering, including understanding system requirements, finding appropriate engineering compromises, effective methods of design, coding, and testing, team software development, and the application of engineering tools. The course will combine a strong technical focus with a capstone project providing the opportunity to practice engineering knowledge, skills, and practices in a realistic development setting with a real client.

Social and Professional Issues in Computing

Provide students with knowledge and skills in professional communication, social and organizational context of computing, teamwork, intellectual property, legal issues, professional and ethical issues, privacy and civil liberties.

IT Project Planning and Management

This course develops a foundation of concepts and solutions that supports the planning, scheduling, controlling, resource allocation, and performance measurement activities required for successful completion of a project.

Industrial Training

This is intended to have students gain real-world experience of study of IT and sometimes provide employment opportunities. It lasts between 8-12 weeks; during this time the students link the learning with the real world experience to provide exposure to the practical and daily operations of an information technology environment.

IT Project

The project work is to give students an opportunity to apply the subject matter learnt to a practical problem under supervision of an academic staff. It can be done at industry or at the University. Inter-disciplinary projects (involving IT, other disciplines) and teamwork are encouraged.

Web Systems and Technologies

This course covers the design, implementation and testing of web-based applications and social software, and the incorporation of a variety of digital media into these applications. Students are exposed to a range of web technologies, both client-side and server-side.

Computer Organization and Maintenance

The goal of this course is to develop a clear understanding of the basic organization of computing systems as well as acquire the skills for Software and application installation, basic computer maintenance and repair.

Information Systems Management

This course provides a broad overview of the issues managers face in the selection, use, and management of information technology (IT). The course covers information technology and strategy, information technology and organization, and information technology assets management. The course takes a management rather than a technical approach to the material presented.

Distributed and Mobile Computing

The aim of this module is to provide an understanding of the fundamental software engineering and computer systems issues raised by programming networked and distributed applications in a secure manner. The course will enable students to develop applications for distributed systems and to understand the networked computer systems support that is desirable and necessary to allow such applications to be developed and implemented securely.

Mobile Applications Development

This course focuses on the development of applications on mobile and wireless computing platforms. Android will be used as a basis for teaching programming techniques and design patterns related to the development of standalone applications and mobile portals to enterprise and m-commerce systems. Emphasis is placed on the processes, tools and frameworks required to develop applications for current and emerging mobile computing devices. Students will work at all stages of the software development life-cycle from inception through to implementation and testing. In doing so, students will be required to consider the impact of user characteristics, device capabilities, networking infrastructure and deployment environment.

Applied Information Systems

This course describes the study of complementary networks of hardware and software that people and organizations use to collect, filter, and process, create and distribute data.

Data Modelling

This course covers relational databases from conceptual design to implementation. The course will include logical and physical design, normalization, as well as the definition of tables and indexes. The use of Structured Query Language (SQL) for data retrieval and manipulation will be emphasized

Database Design

This course covers fundamentals of database architecture and database systems. Principles and methodologies of database design and techniques for database application development. Installation and configuration of a relational database management system (RDBMS). Security Management. Database Files Management. Backing up Databases. Restoring databases. Automating administrative tasks. Transferring data. Monitoring performance. Replication.

Business Intelligence and Data Mining

This course involves learning the concepts and methods designed to improve the business decision-making process through collection and analysis of customer data. The course details the critical variables needed to implement an effective BI programme that maximizes the organization's business opportunities.

Cyber Security

Cyber Security focuses on hands-on skills to secure and protect the confidentiality, availability, and integrity of networked systems. This cyber security training course also reviews cyber terminology, emerging rules, and regulatory compliance requirements that cyber business professionals need to know.

Information Assurance and Security

The course introduces students to the fundamental aspects of IAS, vulnerabilities, attacks and defence mechanisms and security services. It exposes students to IAS in terms of operational issues, policies and procedures, domain security, forensics, information states, risk analyses and recovery.

Computer Forensics

This course deals with the processes of conducting a computer forensics investigation, the principles surrounding the collection of evidence, together with the forensic tools associated with forensic analysis.

Web Application Development

This course introduces concepts in programming web application servers. It includes the study of the fundamental architectural elements of programming web sites that produce content dynamically.

Multimedia Design

Multimedia Design is very much on the cutting edge of technological and industry developments. As the name suggests, designers working in the field of multimedia use imagery, typography, video, sound and computer-based interactivity to communicate. The field includes basic digital animation, computer graphics, storyboarding and digital interfaces for web design and design for interactivity.

Graphics Design

This course is an introduction to the fundamental principles of graphic communication. Instruction incorporates traditional hand-rendering methods as well as use of the computer. In this class the fundamental principles and elements of design are identified and applied to two and three dimensional projects. This course is intended for students majoring in graphic design and anyone interested in basic graphic design.

Animation

This course a fusion of art and technology designed to help students develop a good understanding of the relationship between aesthetic, perceptual and technical factors involved in the development of animation productions.

Supporting subjects

Basic Statistics

The course is an introduction to statistics. Students are introduced to organizing data and descriptive statistics for problem solving and critical thinking skills to real life situations

Mathematics for IT

The course enhances understanding of mathematical concepts underlying current development in IT modelling. It focuses on the fundamental concepts of applying mathematics in information systems knowledge and emphasizes the introductory mathematics required for a student to take advanced topics in mathematics in later stages of the course.

Communication Skills

This course focuses on communication: definition; elements; process; purposes and barriers. Principles of effective communication-audiences, audience expectations, use of appropriate stylistic devices. Presentation skills: Effective presentation through multimedia and web pages; Questions handling; Questioning techniques; checking understanding. Reading skills: Efficient

reading; Barriers; Skimming; Scanning; Study reading. Facilitation: Facilitation skills. The role of the facilitator; Communication techniques; Facilitating groups and individuals; Gaining consensus and group agreement; Dealing with groups and difficult members; Benefits and limitations in using facilitation. Writing skills: Essay; Reports; Summary, process of good writing, forms of writing, writing references and bibliographies. Sources of information: Interviews; Questionnaires; Library; Observation; Experiments

Research Method

This course exposes the student to the theoretical and practical concepts of research. It provides the skills, methods and competences that are necessary to collect, analyses, summarize and present quantitative and qualitative data. The course equips students with the necessary tools to due develop and present data-based projects proposals and undertake a scientific research.

IT Entrepreneurship

This course provides an overview of the entrepreneurial process. It reviews the significant economic and social contributions entrepreneurs provide to society, the intense lifestyle commitment, and the skills necessary for entrepreneurial success.

Fundamentals of Accounting

The subject delves into terminologies employed in the financial circles, the principles used in basic accounting and systems put in place to ensure financial control is maintained, therefore creating awareness of the importance of prudent financial management and the factor it plays in the success and failure of the businesses and organizations.

Fundamentals of Management

This course introduces management concepts, exploring the different types of management structures, and behavior in the business world today.

Ethical Hacking

In this course students learn how to scan, test, hack and secure their own systems. No real network is harmed. The lab intensive environment gives each student in-depth knowledge and practical experience with the current essential security systems.

Special Topics

Industrial training / Internship

This 10-week internship/Industrial/Attachment links the students' learning with the real world experience to provide exposure to the practical and daily operations of an information technology system, support team, or equivalent. Students are placed within a private firm, government institution or agency, corporation, industrial/commercial organizations so that that they can relate what they have learnt in the classrooms with actual work situations.

Final Year Project

This course provides an opportunity to integrate knowledge and skills to design a software system for solving a real-world problem including the oral presentation and report writing about the design. Application of software engineering techniques to specify, design and implement a large system is considered. The students will work in teams and will produce a system that can be used by a department in an institution. Each development team will present a complete project report at the end of the course.

Appendix 7: Specializations in Computer Science and IT

In many programs, the first 2 years cover the basic courses/subjects common for all students. In the 3rd year, the students often have the possibility to choose courses for a specialization. The analysis of the state-of-the-art Bachelor of Computer Science and the Bachelor of Information Technologyshowed that the universities offer many specialisations with different names. It was not clear if specialisations with a different name covered the same content or should be treated as a new specialisation. See Table 23 for the different specialisations that were mentioned in the survey.

Table 23: Specialisations in Computer Science and IT , mentioned in the questionnaire by the universities

Computer Science	Information Tchnology
1. Computer engineering /computer hardware 2. Knowledge based systems 3. Distributive computing/distribute systems 4. Applied computing 5. Computer intelligence/ Artificial Intelligence 6. Computer software/ Software Engineering 7. Networking /Network management 8. Compression 9. Multimedia Technologies 10. Mobile computing 11. Parallel computing 12. Neural networks 13. Human-Computer Interaction 14. Databases/ Database Design, Development, Implementation and Optimization 15. Communication engineering 16. Information technology management 17. Security	1. Hardware 2. Software engineering/ Programming and software development 3. Information Systems engineering 4. Distributive computing 5. Applied computing 6. Computer intelligence 7. Networking 8. Multimedia and computer graphics 9. Human-Computer Interaction 10. Management Information Systems 11. Databases 12. Telecommunication 13. E-service & informatics 14. Business Intelligence & data mining 15. Information Security 16. Mobile Technology 17. Integrative Programming & Technologies 18. Platform Technologies 19. System Integration & Architecture 20. Web Systems and Technologies 21. ICT Business

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