Information Booklet

For

Postgraduate Studies

Institute of Information & Communication Technology

Dhaka University of Engineering & Technology (DUET), Gazipur

Rules and Regulations for Postgraduate Programs

Dhaka University of Engineering & Technology (DUET), Gazipur

Academic Rules and Regulations for Postgraduate Programs

1. Definitions:

(i) 'University' means the Dhaka University of Engineering & Technology, Gazipur abbreviated as DUET, Gazipur.

(ii) 'Syndicate' means the Syndicate of the University.

(iii) 'Academic Council' means the Academic Council of the University.

(iv) 'Vice-Chancellor' means the Vice-Chancellor of the University.

(v) 'Pro-Vice Chancellor' means the Pro-Vice Chancellor of the University.

(vi) 'Institute' means the Institute of Information & Communication Technology (IICT) of the University.

(vii) 'Faculty' means the Faculty of the University.

(viii) 'Dean' means the Dean of the Faculty of the University.

(ix) 'Director' means the Director of the Institute of the University.

(x) 'Registrar' means the Registrar of the University.

(xi) 'Controller' means the Controller of Examinations of the University.

(xii) 'CASR' means the Committee for Advanced Studies and Research of the University.

(xiii) 'ECF' means the Executive Committee of the Faculty of the University.

(xiv) 'RAC' means the Research and Academic Committee for the Postgraduate Program of IICT of the University.

(xv) 'Equivalence Committee' means the Committee for determining the equivalency of Undergraduate and Postgraduate Degrees obtained from other Universities.

(xvi) 'Semester' means program of study to be completed within a specific period of time, an Academic Year will consist of two semesters.

2. Committee:

2.1 Committee for Advanced Studies and Research (CASR):

2.1.1 The CASR shall consist of the following members:

(i)	Vice-Chancellor or his/her nominated person;	Chairman
(ii)	Pro-Vice Chancellor	Member
(iii)	Three Professors of the University to be nominated by the Syndicate;	Member
(iv)	Three Teachers of the University having research capabilities and experience to be nominated by the Academic Council not below the rank of Associate Professor;	Member
(v)	Two Experts from outside the University to be nominated by the Vice-Chancellor;	Member
(vi)	Director (Research & Extension).	Member Secretary

2.1.2 At least 50% of members will fulfill the quorum.

2.1.3 The term of the nominated members shall be of three years. A nominated member shall continue to act as member till a nominated substitute takes over.

2.1.4 The functions of the Committee shall be as follows:

(i) to recommend the concerned authorities for promotion of research and development of advisory and extension services of the University;

(ii) to approve the proposals for research, advisory and extension services submitted by the different Departments/Institutes of the University;

(iii) to approve the Doctoral Committee;

(iv) to approve the Teacher/Expert's name for supervision of research;

(v) to recommend the Academic Council about the Board of Examiners for research evaluations;

(vi) to do such other acts as may be assigned or referred to it by the Vice-Chancellor, the Academic Council or the Syndicate.

2.2 Executive Committee of Faculty (ECF):

2.2.1 The ECF shall consist of the following members:

(i)	Dean of the Faculty;	Chairman
(ii)	All Heads and Directors under the Faculty;	Member
(iii)	All Professors and Associate Professors under the Faculty;	Member
(iv)	Three Teachers of the University from outside the Faculty (closely related to the subjects) nominated by the Academic Council;	Member
(v)	Two Experts, having experience in one or more relevant field but not working at the University to be nominated by the Academic Council.	Member

2.2.2 The Chairman will nominate one of the members as mentioned in Article no. 2.2.1(iii) to act as the Member Secretary.

2.2.3 At least 50% of members will fulfill the quorum.

2.2.4 The term of the nominated members shall be of three years. A nominated member shall continue to act as member till a nominated substitute takes over.

2.2.5 The functions of the Committee shall be as follows:

(i) to select the courses, syllabuses and marks to award Postgraduate Degrees;

(ii) to recommend the Academic Council about the requirements for degree, diploma, certificate and other honors;

(iii) to recommend the Academic Council to create/restructuring posts for the Teacher and Researcher of the concerned Departments under the Faculty;

(iv) to take necessary actions as may be conferred on it by Academic Council.

2.3 Research and Academic Committee (RAC) for the Postgraduate Program:

2.3.1 The RAC shall consist of the following members:

(i)	The Director of the Institute;	Chairman
(ii)	All Professors and Associate Professors of IICT;	Member
(iii)	Any other teacher from the Institute or outside who offers a course in a semester will be the member for that semester;	Member
(iv)	One Professor to be nominated by the Vice-Chancellor from outside the University in the field of ICT Sector;	Member

(v)	One expert to be nominated by the BOG from outside the University from any National research organization, Industry or Business organization in the field of ICT Sector;	Member
(vi)	If the existing number of Professors and Associate professors of the Institute is less than 3 (three), Professors (maximum 03) from other relevant Departments/Institutes of DUET can be nominated as member by the Vice-Chancellor;	Member
(vii)	Postgraduate Course Coordinator of the Institute.	Member-Secretary

2.3.2 At least one-third of members will fulfill the quorum, fractions being counted as one.

2.3.3 The term of office of the nominated members shall be of two years but they shall continue in office till their successors are nominated.

2.3.4 The Chairman will nominate one of the members as mentioned in Article no. 2.3.1(iii) as Postgraduate Course Coordinator as well as the Member Secretary.

2.3.5 The functions of the Committee shall be as follows:

(i) To develop the syllabuses and courses for the postgraduate studies;

(ii) To deal with matters related to admission of students;

(iii) To suggest a panel of names of paper setters and examiners in the subject or subjects concerned;

(iv) To identify target groups for training, assess training needs and develop training strategies;

(v) To prepare annual program on short courses, training and workshop;

(vi) To identify the areas of research on the basis of national need and formulate research plan;

(vii) To review the research proposals submitted by teachers and technical personnel, or select experts for reviewing the proposal, if necessary;

(viii) To recommend the BoG for the appointment of exceptionally reputed technical personnel with vast experience as visiting fellow in the institute, if it feels that the appointment would help the research and human development activities of the institute, on such terms and conditions as the Board of Governors (BoG) may decide;

(ix) To do such other things as are assigned or referred to it by the Vice-Chancellor, the BoG, or the Syndicate.

2.4 Equivalence Committee:

2.4.1 The Equivalence Committee shall consist of the following members:

(i)	Vice-Chancellor or his/her nominated person;	Chairman
(ii)	Pro-Vice Chancellor;	Member
(ii)	Deans of the Faculties;	Member
(iii)	Director of the Institute concerned;	Member
(iv)	Two Professors of the University to be nominated by the Academic Council;	Member
(v)	One Professor of the University to be nominated by the Vice-Chancellor.	Member

2.4.2 The Chairman will nominate one of the members as mentioned in Article no. 2.4.1(iv) or (v) to act as the Member Secretary.

2.4.3 At least 50% of members will fulfill the quorum.

2.4.4 The term of the nominated members shall be of three years. A nominated member shall continue to act as member till a nominated substitute takes over.

2.4.5 The functions of the Committee shall be as follows:

(i) to assess the Degrees obtained from other Universities/Institutes;

3. Postgraduate Course Co-ordinator:

The Member Secretary of the RAC of the Institute will act as the Postgraduate Course Co-ordinator of that Institute. The Course Co-ordinator should coordinate all the related activities regarding the Postgraduate program and will preserve all the related documents and records.

Rules and Regulations for Postgraduate Programs

M Sc. Engg. / M Engg.

Dhaka University of Engineering & Technology (DUET), Gazipur

Academic Rules and Regulations for M Sc. Engg. and M Engg. Degree

1. Degrees Offered

The Masters Degrees to be offered by the Institute of Information & Communication Technology (IICT) under this Rules and Regulations are as follows:

1.1 Master of Science in Information & Communication Technology abbreviated as M Sc. Engg. (ICT)

1.2 Master of Engineering in Information & Communication Technology abbreviated as M Engg. (ICT)

1.3 Any other Masters Degree in other branches of the Institute approved by the Syndicate on the recommendation of Academic Council may also be offered under the Rules and Regulations.

2. Eligibility for the Applicant

2.1 In order to get admission to the Masters Degree Program an applicant

(a) must have a minimum GPA of 3.00 out of 5.00; or 2.75 out of 4.00; or a first division at least in one of SSC, HSC, Diploma in Engg. or equivalent examinations; and,

(b) must have a B Sc. Engg. in Computer Science and Engineering / Electrical and Electronic Engineering / Computer Science / Electrical, Electronic and Communication Engineering / Software Engineering / Electrical and Telecommunication Engineering / Information and Communication Technology / Electrical and Communication Engineering / Information and Communication Engineering / Electrical, Electronic and Telecommunication

Engineering / Information Technology / Robotics and Mechatronics Engineering or an equivalent Degree from any recognized University/Institute. The Equivalence Committee shall examine the equivalence and suitability of an applicant's Degree for admission; and must have a minimum CGPA of 2.75 out of 4.00 in mentioned Bachelor degrees in the relevant branch; or,

(c) applicants having PG. Dip. (ICT)/ PG. Dip. (IT) with a minimum GPA of 2.65 out of 4.00 or its equivalent from any recognized university plus must have a 4-year B Sc. Engg. / Bachelor of Science / BBA; or, Masters of Science/MBA with 3-year Bachelor of Science.

(d) The above requirements may be relaxed for applicants on deputation or sponsored by Academic Institutions / Research Organizations/ IT Industries / DUET Graduates. Such relaxation shall be recommended by the Admission Committee of the Institute for approval of Academic Council.

3. Admission and Registration Procedures

3.1 Applications for admission to the above programs shall be invited through regular means of advertisement and shall be received by the Registrar office.

3.2 On the recommendation of the RAC through ECF, the rules for admission into the University for Postgraduate Program shall be framed by the Academic Council from time to time. CASR on its own may, if it deems fit, recommend such rules for admission for approval of the Academic Council.

3.3 There shall be an Admission Committee in each Institute as constituted by the RAC on the recommendation of the Director of the Institute.

3.4 Before being finally selected for admission an applicant may require to sit for an oral and/or written test before the Admission Committee. S/he may require to take pre-requisite course(s) as may be prescribed by the Admission Committee.

3.5 The selected applicants should complete their course registration and related tasks as per the announcement of the Registrar office of the University.

4. Academic Requirements and Regulations

4.1 The minimum duration of M Sc. Engg. / M Engg. Program shall be three semesters and generally not more than 5 (five) Academic Years starting from the date of first registration. Each Academic Year shall consist of two semesters. The duration of a semester will be of minimum 13 (thirteen) weeks.

4.2 The courses of a Program in an Institute shall be proposed by the RAC and approved by the Academic Council on the recommendation of ECF.

4.3 The courses to be offered by an Institute in any semester shall be determined by the Institute.

4.4 Academic progress of students shall be assessed in terms of credit hours earned by them. In a semester 1 (one) contact hour per week for theory courses or 3 (three) contact hours per week for Thesis/Project represent(s) 1 (one) credit hour. The number of credit hours for each course shall be specified in the syllabus of the Institute.

4.4.1 For the Degree of M Sc. Engg., a student must earn a minimum of 36 credit hours of which 18 credit hours shall be assigned for a Thesis.

4.4.2 For the Degree of M Engg., a student must earn a minimum of 36 credit hours of which 6 credit hours shall be assigned for a Project.

4.5 A student may be allowed to switch from M Sc. Engg. to M Engg. on the recommendation of the RAC through Director of the Institute before the commencement of a semester.

4.6 A student may be allowed to switch from M Engg. to M Sc. Engg. on the recommendation of the RAC through Director of the Institute and concerned Supervisor upon having the approval of the CASR before the commencement of a semester.

4.7 There shall be two categories of student, namely, full-time student and part-time student.

4.8 A full-time student must register a minimum of 12 (twelve) credit hours and a maximum of 15 (fifteen) credit hours per semester. If a full-time student gets an employment while continuing the program, s/he can continue the program as a part-time/full-time student with the written permission or leave from the employer.

4.9 A student, serving in different organizations, may be admitted as part-time student with a written consent of the employer. A part-time student may be allowed to register a maximum of 9 (nine) credit hours in a semester.

4.10 A student may be allowed to switch from part-time to full-time or vice versa on the recommendation of the RAC through the Director of the Institute before the commencement of a semester.

4.11 A student may be permitted to withdraw and/or change their registered courses within 3 (three) working weeks from the commencement of that semester on the recommendation of the Course Co-ordinator and the Director of the Institute. The concerned course Teacher and authorities will be informed of the decision.

4.12 On the recommendation of the relevant RAC through CASR and by the approval of the Academic Council, a student may be allowed to transfer a maximum of 9 (nine) credits for M Sc. Engg. and 15 (fifteen) credits for M Engg. of the required theory courses of this University completed

by the student at a recognized University/Institute provided that the courses were not taken earlier than 3 (three) calendar years from the date of their first enrollment in the respective program of the Institute at the University. In addition, the student must obtain a minimum GPA of 3.00 out of 4.00 or its equivalent and those courses should be equivalent to the theory courses offered at the Institute of the University.

4.13 If a student is unable to complete the final examination of a semester due to serious illness or serious accident or official commitment, s/he may apply to the Registrar in a prescribed form through Director of the Institute for total withdrawal from the semester within a week after the end of the semester final examination. The application must be supported by a medical certificate from the Chief Medical Officer (CMO), DUET or relevant Official documents. The Academic Council will take the final decision about such application on the recommendation of the RAC.

4.14 The qualifying requirement for graduation is that a student must earn a minimum CGPA of 2.65 based on the weighted average of their course work.

4.15 2 (two) courses may be repeated for improvement with the prior approval of the Director of the Institute on the recommendation of the Course Co-ordinator, provided that the student has a CGPA less than or equal to 2.65. In such cases, the better grade(s) amongst the previous examination and improvement examination would be retained.

4.16 A student shall not be allowed to continue the Program if s/he obtains a total of 4 (four) or more 'F' grades during the period of their studies.

4.17 If at the end of the second or any subsequent semester, the cumulative GPA falls below 2.50, s/he shall not be allowed to continue the Program.

4.18 In addition to the successful completion of theory course work, each student shall have to submit a Thesis on their research work or a Report on their Project work, as

applicable, fulfilling the requirements as detailed in the subsequent Article no. 7 or 8.

5. Grading System

5.1 The grading system for assessing the performance of a student in credit courses shall be as follows:

Numerical grade	**Letter grade**	**Grade point**	**Merit description**
90% and above	A plus	4.00	Excellent
≥80% but <90%	A regular	3.50	Very good
≥70% but <80%	B plus	3.00	Good
≥60% but <70%	B regular	2.50	Average
≥50% but <60%	C	2.00	Pass
below 50%	F	0.00	Failure
	I		Incomplete
	S		Satisfactory
	U		Unsatisfactory
	X		Continuation

All the final grades for the course of M Sc. Engg. / M Engg. will be recorded in letter grade system. The Grade Point Average (GPA) shall be computed for each semester. The GPA will be calculated as follows:

$$GPA = \frac{\sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{n} C_i}$$

where, n is the number of courses passed by the student during the semester, C_i is the number of credits allotted to a particular course and G_i is the grade point corresponding to the grade awarded for that course(s). The overall or Cumulative GPA gives the cumulative performance of the student from first semester up to any other semester to which it refers and is computed by dividing total grade

points ($\sum C_i G_i$) accumulated up to the date by the total credit hours ($\sum C_i$). Both GPA and Cumulative GPA will be rounded off to the second place of decimal for representing/reporting.

5.2 Course(s) in which a student gets 'F' grade shall not be counted towards credit hour requirements and for the calculation of GPA. Students may repeat the 'F' graded course(s) if it is offered again.

5.3 The 'B' and 'C' grades, up to a maximum of two courses, may be ignored for calculation of GPA on the written request of the student to the Director of the Institute and on the recommendation of the Course Co-ordinator, provided that the student has to fulfill the total course credit hour requirements in the remaining courses with a minimum GPA of 2.65.

5.4 The performance in all the courses including all the 'F' grades shall be reflected in the transcript.

5.5 Grade 'I' will be given only when a student is unable to sit for the examination of a course at the end of the semester because of circumstances beyond of their control. To get 'I' grade, s/he must apply to the Director of the Institute through the respective course Teacher within 1 (one) week after the examination of the respective course. S/he has to complete the course within the next 2 (two) consecutive semesters; otherwise s/he will get 'F' grade in that course. If that course is not offered within the next 2 (two) consecutive semesters, the student can take any other offered course as a replacement on the recommendation of RAC. An M Sc. Engg. student can apply for an 'I' grade for a maximum of 4 (four) different courses and an M Engg. Student can apply for an 'I' grade for a maximum of 6 (six) different courses.

5.6 Satisfactory ('S') and Unsatisfactory ('U') shall be used for final grading of the performance of Thesis/Project and non-credit courses. An 'X' grade shall be recorded for Thesis/Project continuation.

5.7 A student may enroll for non-credit course(s) termed as audit course(s) on the recommendation of their Thesis/Project Supervisor and Director of the Institute.

6. Conduct of Examination

6.1 In addition to class tests, assignments, term papers, etc. there shall be a written examination on all theoretical courses at the end of each semester. The respective course Teacher will be solely responsible for the performance evaluation of a student. The dates of the examinations shall be announced by the Controller of Examinations as advised by the Director of the Institute at least 2 (two) weeks before its commencement. The final grade in a theoretical course shall be based on the performance of all class tests, assignments, term papers, etc. and written examination.

6.2 The Controller of Examinations shall keep the up-to-date record of all the grades obtained by students and shall publish the results at the end of each semester. A student may collect a copy of the grade sheet from the office of the Controller of Examinations at the end of each semester. In addition, each student is entitled to 1 (one) official academic transcript after the completion of their academic program from the office of the Controller of Examinations on production of document of clearance from the Institute and payment of the prescribed fees.

6.3 The Director of the Institute shall recommend the names of the paper setters and examiners for the semester final examinations at least 2 (two) weeks before the date of the commencement of the examination to the Vice-Chancellor for approval.

7. Thesis

7.1 The research work for a thesis shall be carried out under the Supervision of a full-time teacher, who should be the member of RAC of the Institute. A Joint-supervisor/Co-supervisor within or outside the Institute may be appointed (if necessary). The Supervisor, Joint-supervisor/Co-supervisor and the research topic shall be approved by the CASR on the recommendation of RAC after completion of at least 9 (nine) credit hours of course work and having a minimum CGPA of 2.65.

7.2 A student shall submit a Thesis proposal to the RAC through Supervisor. The RAC shall examine the proposal and recommend it for the approval of the CASR through the Director of the Institute. In special circumstances, the RAC may recommend any subsequent changes in the research topic and forward it through the Director of the Institute to CASR for further approval.

7.3 If any change is necessary on the approved Thesis (Cost, Supervisor, Joint-supervisor/Co-supervisor, etc.), it shall be approved by the CASR on the recommendation of the RAC. However, the Examination Board can suggest and allow only minor changes (if necessary for Title or Content) and it should be further reported to the CASR.

7.4 The research work should normally be carried out at the University. However, if necessary, with the approval of the RAC, the Supervisor can allow their student to carry out the research work outside the University.

7.5 At the end of a student's research work and with the consultation of the Supervisor, the student has to submit a Thesis which must be an original contribution to Engineering/Science and worthy of publication. Each student must submit at least 5 (five) numbers of printed copies of their Thesis in the prescribed format to the Director of the Institute on or before a date to be fixed by

the Supervisor concerned in consultation with the Director of the Institute.

7.6 The student shall have to declare that the research work was carried out by them and has not been submitted elsewhere for the award of any other Diploma or Degree.

7.7 The Thesis should reflect a satisfactory knowledge in the field of research undertaken by the student.

7.8 Each student submitting a Thesis in the partial fulfillment of the requirements of a Degree, shall be required to take an oral examination, on a date or dates fixed by the Supervisor concerned in consultation with the Director of the Institute and must satisfy the examiners that s/he is capable of intelligently applying the results of their research to the solution of problems, of undertaking independent work, and also shows evidence of satisfactory knowledge related to the theory and technique used in their research work.

7.9 An Examination Board for each student for Thesis and oral examination shall be approved by the Academic Council through the RAC and CASR on the recommendation of the Thesis Supervisor. The Supervisor shall act as the Chairman and the Director of the Institute will be an Ex-officio member of the Examination Board. The Board shall consist of at least 5 (five) members including the Director of the Institute and the Supervisor. The Examination Board shall be constituted as follows:

(i)	Supervisor	Chairman
(ii)	Joint/Co-supervisor (if any)	Member
(iii)	Director of the Institute	Member (Ex-officio)
(iv)	At least one Teacher from the RAC of the Institute	Member
(v)	One external member from outside	Member

the University/Institute (External)

7.10 If any examiner is unable to accept the appointment or has to relinquish their appointment before the examination, the Vice-Chancellor shall appoint another examiner in their place, on the suggestion from the Supervisor in consultation with the Director of the Institute. This appointment will be reported to the CASR.

7.11 In case a student fails to satisfy the Examination Board in Thesis and/or oral examination, the student shall be given one more chance to resubmit the Thesis and/or take an oral examination as recommended by the Board.

8. Project

8.1 The Project work shall be carried out under the supervision of a full-time Teacher, who should be the member of RAC of the Institute. The Supervisor and the topic of the Project work shall be approved by the CASR on the recommendation of RAC after completion of at least 9 (nine) credit hours of course work and having a minimum CGPA of 2.65.

8.2 A student shall submit a Project proposal to the RAC through Supervisor. The RAC shall examine the proposal and recommend it for the approval of the CASR through the Director of the Institute. In special circumstances, the RAC recommend any subsequent changes in the Project topic and forward it through the Director of the Institute to CASR for approval.

8.3 If any change is necessary on the approved Project (Cost, Supervisor, Joint-supervisor/Co-supervisor, etc.), it shall be approved by the CASR on the recommendation of the RAC. However, the Examination Board can suggest and allow only minor changes (if necessary for Title or Content) and it should be further reported to the CASR.

8.4 The Project work should normally be carried out at the University. However, if necessary, with the approval of the RAC, the Supervisor can allow their student to carry out the Project work outside the University.

8.5 At the end of a student's Project work and with the consultation of the Supervisor the student has to submit a Project report. Each student must submit at least 5 (five) number of printed copies of their Project in the prescribed format to the Director of the Institute on or before a date to be fixed by the Supervisor concerned in consultation with the Director of the Institute.

8.6 The student shall have to declare that the Project work was carried out by them and has not been submitted elsewhere for the award of any other Diploma or Degree.

8.7 Each student submitting a Project report in partial fulfillment of the requirements of a Degree, shall be required to take at an oral examination, on a date or dates fixed by the Supervisor concerned in consultation with the Director of the Institute and must satisfy the examiners that s/he has gained satisfactory knowledge related to the Project work.

8.8 An Examination Board for each student for Project and oral examination shall be approved by the Academic Council through the RAC and CASR on the recommendation of the Project Supervisor. The Supervisor shall act as the Chairman and the Director of the Institute will be an Ex-officio member of the Examination Board. The Board shall consist of at least 5 (Five) members including the Director of the Institute and the Supervisor. The Examination Board shall be constituted as follows:

(i)	Supervisor	Chairman
(ii)	Director of the Institute	Member (Ex-officio)
(iii)	At least one Teacher from the RAC of	Member

	the Institute	
(iv)	One external member from outside the University/ Institute	Member (External)

8.9 If any examiner is unable to accept the appointment or has to relinquish their appointment before the examination, the Vice-Chancellor shall appoint another examiner in their place, on the suggestion from the Supervisor in consultation with the Director of the Institute. This appointment will be reported to the CASR.

8.10 In case a student fails to satisfy the Examination Board in Project report and/or oral examination, the student shall be given one more chance to resubmit the Project report and/or take an oral examination as recommended by the Board.

9. Cancellation of Admission

The admission of a student shall be cancelled from the University on the following grounds:

(i) Non-payment of fees of the University and the Halls of residence within a prescribed period.

(ii) If the requirements in Article no. 4.16 and 4.17 are not fulfilled by the student.

(iii) Forced to discontinue their studies by the Board of Discipline.

(iv) Withdrawn officially from all the courses including Thesis/Project.

10. Academic Fees

Academic tuition and fees will be declared and reviewed by the appropriate authority of the University from time to time.

11. Extension of Time for Completion of Degree

The application for extension of time span of a student should be approved by the Academic Council through CASR on the

recommendation of the RAC. A prescribed form may be used for this purpose. The application must be submitted before the normal time span has elapsed.

12. Admission Test

A descriptive type written test will be conducted for the admission. The topics that will be covered are as follows but not limited to:

- Programming Languages
- Computer Networks
- Data Structures and Algorithms
- Database Management System
- Computer Architecture
- Operating Systems
- Digital Logic Design
- Communication Theory
- Electrical and Electronic Circuits
- Microprocessor & Microcontroller

The admission test generally takes place on a pre-announced date as per the University Postgraduate academic.

Syllabus for M Sc. Engg. /M Engg. (ICT)

Course No.	Course Title	Credit
ICT 6000	Thesis	18
ICT 6001	Project	6
ICT 6101	Research Methodology	3
ICT 6102	ICT Project Management	3
ICT 6103	ICT Basics and Programming	3
ICT 6104	Graph Theory and Application	3
ICT 6105	Advanced Algorithm and Optimization	3
ICT 6106	Software Engineering	3
ICT 6107	Software Quality Assurance	3
ICT 6201	Advanced Database Management Systems	3
ICT 6202	Big Data Analysis and Design	3
ICT 6203	Advanced Information Theory and Coding	3
ICT 6204	Information Retrieval	3
ICT 6205	Distributed Systems	3
ICT 6206	Smart Mobile Data Management	3
ICT 6301	Cloud Computing	3
ICT 6302	Fog Computing	3
ICT 6303	Internet of Everything	3
ICT 6304	ICT Advancement towards Industrial Revolution	3
ICT 6305	Advanced Cyber Physical System	3
ICT 6306	Bioinformatics Computing	3
ICT 6307	Biomedical Image Processing	3
ICT 6401	Intrusion Management and Ethical Hacking	3
ICT 6402	Applied Cryptography	3
ICT 6403	Internet and Cyber security	3
ICT 6501	Computational Linguistics	3
ICT 6502	Statistical Machine Translation	3
ICT 6503	Advanced Artificial Intelligence	3
ICT 6504	Machine Learning	3
ICT 6505	Automated Planning	3
ICT 6506	Neuro-Fuzzy Systems	3

ICT 6601	Speech Processing	3
ICT 6602	Antennas and Propagation	3
ICT 6603	Radar Engineering	3
ICT 6604	Advanced Digital Signal Processing	3
ICT 6605	Advanced VLSI Design and Testing	3
ICT 6606	Reliable Computing System	3
ICT 6701	Wireless Networks	3
ICT 6702	Advanced Communication Engineering	3
ICT 6703	Radio Frequency Technology	3
ICT 6704	Advanced Telecommunication Network	3
ICT 6705	Next Generation Mobile Communication	3
ICT 6706	Broadband Wireless Communications	3
ICT 6707	Smart Sensor Networking	3
ICT 6708	Advanced Computer Network	3
ICT 6709	Advanced Data Communications	3
ICT 6710	Satellite and Navigation	3
ICT 6711	Geographical Information System	3
ICT 6801	Advanced Embedded System Design	3
ICT 6802	Real Time Computing for Embedded System	3
ICT 6803	Industrial Automation and Control	3
ICT 6804	Advanced Computer Architecture	3
ICT 6805	Advancement in Microprocessor Systems	3
ICT 6900	Selected Topics in ICT	3

ICT 6101 Research Methodology 3 Credits

Definition, Objective, Motivation, Types of Research, Criteria of Good Research. Research Problem, Selection of Problem, Necessity of defining the Problems, Techniques involves in defining the problem. Meaning of Research Design, need for research Design, Features of a Good Design, Different Design Approach. Sampling Design: Census and Sample Survey, Implications and steps of a Sample Design, Criteria of Selecting a Sampling Procedure, Different Types of Sample Designs, how to Select a Random Sample, Random Sample from an infinite Universe, Complex Random Sampling Designs. Measurement in Research, Measurement Scales, Sources of Error in Measurement, Technique of Developing Measurement Tools. Collection of Primary Data, Observation Method, Interview Method, Collection of Secondary Data. Processing Operations, Problems in Processing, Elements/Types of Analysis, Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Relationship, Regression Analysis. Need for Sampling, Sampling Distributions, Central Limit Theorem, Sampling Theory, Concept of Standard Error, Estimation of Population Mean, Population Proportion, Sample Size and determination. Interpretation, Technique of Interpretation, Precautions in Interpretation, Steps in Writing Report, Types of Reports, and Precautions for Writing Research Reports.

ICT 6102 ICT Project Management 3 Credits

Introduction to Project Management: ICT Project types, Project Management Initiation, The Project Manager, The Project Organization. Project Planning, Budgeting and Cost Estimation. Scheduling and Resource Allocation: CPM Method, Resource allocation Problem, Resource loading and Resource leveling, Constrained Resource Scheduling, Multi-Project Scheduling and Resource allocation. Project Risk Management. Project Procurement Management. Project Communication and Quality Management, Project Quality Control – Monitoring and Control and Standards. Project Stakeholder Management: Stakeholder influence, PSM Process and execution. Managing Contracts.

ICT 6103 ICT Basics and Programming 3 Credits

Computer Basics: Introduction to computations; history of computing

devices; Computers; Major components of a computer; Hardware: processor, memory, I/O devices; Software: Operating system, application software; Report writing and Presentation; Basic architecture of a computer; Basic Information Technology; Number system: binary, octal, hexadecimal, binary arithmetic. Structured Programming Language: Identifier names, Variable, Type Quality, Storage Class Specification, Variable Initialization, Constants, Operators Single Character Input, Single Character Output, Entering Input Data, Writing Output Data, The Gets and Puts Function, Array, Functions, Single Dimension Array, Passing Single-Dimension Array to Function, Two-Dimensional Array, String. Object Oriented Programming Language: Philosophy of Object Oriented Programming (OOP); Advantages of OOP over structured programming; Encapsulation, classes and objects, access specifiers, static and non-static members; Constructors, Destructors and Copy Constructors.

ICT 6104 Graph Theory and Applications 3 Credits

Graphs and Subgraph: Graphs and Simple Graphs, Graph Isomorphism, The Incidence and Adjacency Matrices, Subgraphs, Vertex Degrees, Paths and Connection, Cycles, Applications – The Shortest Path Problem, Sperner's Lemma. Trees: Cut Edges and Bonds, Cut Vertices, Cayley's Formula, Spanning trees, shortest paths, distances in graphs; Hamiltonian and Eulerian graphs, Travelling Salesman problem, Chinese Postman problem; Applications - The Connector Problem. Connectivity: vertex and edge connectivity, Menger’s theorem, Blocks, Applications-Construction of Reliable Communication Networks. Euler Tours, Hamilton Cycles, Applications-The Chinese Postman Problem, The Travelling Salesman Problem. Matchings: Coverings in Bipartite Graphs Perfect Matchings, Applications - The Personnel Assignment Problem, The Optimal Assignment Problem. Vertex Colorings: Chromatic Number, Brooks' Theorem, Hajos' Conjecture, Chromatic Polynomials, Girth and Chromatic Number, Applications - A Storage Problem. Planar Graphs: Plane and Planar Graphs, Dual Graphs, Euler's Formula, Bridges, Kuratowski’s Theorem, Perfect graphs, The Five-Colour Theorem and the Four-Colour Conjecture, Nonhamiltonian Planar Graphs, Applications - A Planarity Algorithm. Networks: Flows, Cuts, The Max-Flow Min-Cut Theorem, Applications - Menger's Theorems, Feasible Flows.

ICT 6105 Advanced Algorithm and Optimization 3 Credits

Define Optimization Problems; The Simplex Algorithm; Duality; Computational Considerations for the Simplex Algorithm; The Primal-Dual Algorithm; The Primal-Dual Algorithms for Max-Flow and Shortest Path: Ford-Fulkerson and Dijkstra; Primal-Dual Algorithms for Min-Cost Flow; Algorithms and Complexity; Efficient Algorithms for the Max-Flow Problem; Algorithms for Matching; Weighted Matching; Spanning tree and Matroids; Integer Linear Programming; Evolutionary optimization algorithms; Adaptive Genetic Algorithm; Bayesian statistics as optimization technique; Artificial neural network; Optimization methods for inverse problems; A Cutting-Plane Algorithm for Integer Linear Programs; NP-Complete Problems; More About NP-Completeness; Approximation Algorithms; Unconstrained non-linear optimization problems; Constrained nonlinear optimization problems; Multi objective optimization problems; Solving optimization problems using MATLAB.

ICT 6106 Software Engineering 3 Credits

Introduction, software life-cycle models, software requirements specification, formal requirements specification and verification - axiomatic and algebraic specifications, function-oriented software design, object-oriented design, UML, design patterns, user interface design, coding and unit testing, integration and systems testing, debugging techniques, software quality - SEI CMM and ISO-9001. Software reliability and fault-tolerance, software project planning, monitoring, and control, software maintenance, computer-aided software engineering (CASE), software reuse, component-based software development, extreme programming.

ICT 6107 Software Quality Assurance 3 Credits

Definition of Software Quality, Quality Dimensions, SQ Dilemma, Achieving Software Quality. Software Defects, Defect amplification and removal, Review Metrics and their use, Informal Reviews, Formal technical reviews, Review reporting and record keeping. Elements of SQA, SQA Task, Goals and Metrics, Formal Approaches to SQA, Statistical SQA, Software Reliability, The ISO 9000 Quality Standards,

The SQA Plan. The Strategic Approach for Software Testing, Verification and Validation, Organizing for Software Testing, Criteria for Completing of Testing, Strategic Issues. Testing Strategies for Conventional Software: Unit Testing, Integration Testing, Strategies for OOS, Testing in OO context, and Integration Testing in OO context, Strategies for Web Apps., Validation Testing, Alpha and Beta Testing. System Testing: Recovery Testing, Security Testing, Stress Testing, Performance Testing, Deployment Testing, Art of Debugging. Testing Conventional Applications: White box testing, Basis Path Testing, Central Structure Testing, Black box Testing, Model Based Testing, Testing Client Server Architectures, Testing for Real Time Systems, Patterns for Software Testing. Testing Object Oriented Applications: Testing OOA and OOD Models, Object Oriented Testing Strategies, Testing methods applicable at Classes, Interclass Test case Design, Test Derived from Behavior Models. Testing Web Applications: Content Testing, User Interface Testing, Component Level Testing, Navigation Testing, Configuration Testing, Security Testing, Performance Testing.

ICT 6201 Advanced Database Management Systems 3 Credits

Comparison between DBMS, RDBMS, Distributed and Centralized DB. Object Oriented Database; Data Model, Design, Languages; Object Relational Database: Complex data types, Querying with complex data types, Design; Distributed Database: Levels of distribution transparency, Translation of global queries to fragment queries, Optimization of access strategies, Management of distributed transactions, Concurrency control, Reliability, Administration; Parallel Database: Different types of parallelism, Design of parallel database; Multimedia Database Systems, Optimization of access strategies, Management of Multimedia Database Systems, Reliability; Database Wire-housing/Data mining: Basic Concepts and algorithms. Advanced SQL; Some applications using SQL. Integrity constraint; Relational database design; File organization and retrieval, file indexing and hashing; Transaction manager; Concurrency controller; Recovery manager; Security system; Database administration; Transaction processing: Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability and recoverability, view serializability, resolving deadlock, distributed locking. Transaction management in multi-

database system, long duration transaction, high-performance transaction system. Advanced database management systems: distributed database, parallel database, data mining and warehousing, multimedia, object-oriented, object-relational, real-time database. Semi structured data.

ICT 6202 Big Data Analysis and Design 3 Credits

Big Data Platform, Challenges of Conventional Systems, Intelligent data analysis, Nature of Data, Analytic Processes and Tools, Reporting. Mining data streams: Stream Concepts, Stream Data Model and Architecture, Stream Computing, Sampling Data in a Stream, Filtering Stream, Counting Distinct Elements in a Stream, Estimating Moments, Counting Oneness in a Window, Decaying Window, Real time Analytics Platform Applications, Real Time Sentiment Analysis, Stock Market Predictions. Hadoop: History, Hadoop Distributed File System, Components of Hadoop Analysing the Data, Scaling Out, Hadoop Streaming, Design of HDFS, Java interfaces to HDFS Basics, developing a Map Reduce Application, Map Reduce Work, Anatomy of a Map Reduce Job, Failures, Job Scheduling, Shuffle and Sort, Task execution, Map Reduce Types and Formats, Map Reduce Features. Frameworks: Applications on Big Data Using Pig and Hive, Data processing operators in Pig, Hive services, HiveQL, Querying Data in Hive, Fundamentals of HBase and Zoo Keeper, IBM Info Sphere Big Insights and Streams. Predictive Analytics, Simple linear regression, Multiple linear regressions, Interpretation of regression coefficients. Visualizations, Visual data analysis techniques, interaction techniques, Systems and applications.

ICT 6203 Advanced Information Theory and Coding 3 Credits

Fundamental Limits in Information Theory: Measure of Information, Data Compaction, Discrete Memory less Channels, Relationship among different Entropies, Mutual information, Channel Capacity, Symmetric noise structure BSC and BEC, Channel Coding Theorem, Differential Entropy and Mutual Information for Continuous Ensembles, Information Capacity Theorem, Rate Distortion Theory. Elements of Encoding: Source Coding: Instantaneous Codes, Source Coding Theorem, The Kraft Inequality and McMillan's Theorem, Average Length and Compact Codes, Shannon's Noiseless Coding Theorem, Fano Coding, Huffman Coding, Arithmetic Coding, Higher-order Modeling. Fundamentals of

Channel Coding: Code Rate, Decoding Rules, Hamming Distance, Bounds on M, Maximal Codes and Perfect Codes, Error Probabilities, Shannon's Fundamental Coding Theorem. Introduction to Algebra: Groups, Ring, Vector space and Fields, Linear Spaces, Linear Spaces over Binary Fields, Construction of Galois field GF (2m), Basic Properties of Galois Field GF (2m), Codes Derived from Hadamard Matrices. Error Correcting Codes: Linear Block Codes, Syndrome and Error detection. Cyclic Codes: Rings of Polynomials, Encoding and Decoding of Cyclic Codes and its Circuits, Goley Codes, Hamming Codes, Reed-Muller Codes. Burst Correcting Codes: Finite Fields, Irreducible Polynomials, Construction of Finite Fields, Bursts of Errors, Fire Codes, Minimum Polynomials, Bose-Chaudhuri-Hocquenghem Codes, Reed-Solomon Codes. Convolution Codes: Binary Convolution Codes, Decoding Convolution Codes, the Viterbi Algorithm, Sequential Decoding, Trellis Modulation, Turbo Codes.

ICT 6204 Information Retrieval 3 Credits

Introduction to Information retrieval: Information retrieval process, Indexing, Information retrieval model, Boolean retrieval model. Dictionary and Postings: Tokenization, Stop words, Stemming, Inverted index, Skip pointers, Phrase queries. Tolerant Retrieval: Wild card queries, Permuterm index, Bigram index, Spelling correction, Edit distance, Jaccard coefficient, Soundex. Term Weighting and Vector Space Model: Wild card queries, Permuterm index, Bigram index, Spelling correction, Edit distance, Jaccard coefficient, Soundex. Evaluation: Precision, Recall, F-measure, E-measure, Normalized recall, Evaluation problems. Latent Semantic Indexing: Eigen vectors, Singular value decomposition, Low rank approximation, Problems with Lexical Semantics. Query Expansion: Relevance feedback, Rocchio algorithm, Probabilistic relevance feedback, Query Expansion and its types, Query drift. Probabilistic Information Retrieval: Probabilistic relevance feedback, Probability ranking principle, Binary Independence Model, Bayesian network for text retrieval. XML Indexing and Search: Data vs. Text-centric XML, Text-Centric XML retrieval, Structural terms. Content Based Image Retrieval: Introduction to content Based Image retrieval, Challenges in Image retrieval, Image representation, Indexing and retrieving images, Relevance feedback.

ICT 6205 Distributed Systems 3 Credits

Introduction, Consistency - Classical synchronization + Go-style synchronization, Distributed File systems, Remote Procedure Calls, AFS, Coda, Callbacks. Time and Synchronization, Distributed Mutual Exclusion, Fault Tolerance: Detecting and Correcting Local Faults, RAID, Concurrency Control, Logging and Crash Recovery, Consistent hashing and name-by-hash, Consistent hashing and name-by-hash, Distributed File systems for MapReduce / HDFS, DNS and Content Delivery Networks, Peer-to-Peer, Virtual Machines, Byzantine Fault Tolerance, Security Protocols, Case Study - Anonymous Routing and TOR, Causally Consistent Wide-Area Replication. Distributed object systems, Retrieving and caching of distributed information, Distributed data replication and sharing, Performance Issues, Algorithms for Deadlock Detection, Concurrency Control, Networking Facilities and Resources Control and Management Methods in Network and Distributed Operating Systems, Collaborative Applications, Wide Area Network Computing, Agent Systems and Market Based Computing.

ICT 6206 Smart Mobile Data Management 3 Credits

Mobile Location Management: Registration and Paging, Two Tier Structure, Hierarchical Scheme, Caching, Forwarding Pointers, Replication, Personal Mobility, Distributed Location Management. Distributed Systems and Algorithms, Mobile Systems and Algorithms, Structuring Distributed Algorithms, Non-coordinator Systems, Exploiting Asymmetry of Two-Tier Model, Termination Detection. Data Access Issues in Mobile Environment, Pull and Push Based Data Delivery, Dissemination in Mobile Environment, Comparison of Pull and Push Models, Classification of Data Delivery Models, Broadcast Disk, Probabilistic Model of Broadcast, Inter Mezzo, File System for Connected Clients. Context-aware Infrastructures for Smart Environment: Terminology and Historical Prospective, Designing Context-aware Applications, Formal Modeling of Contexts, System Requirements, Middleware Architectures, Smart Applications.

ICT 6301 Cloud Computing 3 Credits

Definition and evolution of Cloud Computing, Enabling Technologies, Service and Deployment Models, Popular Cloud Stacks and Use Cases, Benefits, Risks, and Challenges of Cloud Computing, Economic Models and SLAs, Topics in Cloud Security. Cloud Infrastructure: Historical Perspective of Data Centers, SaaS, PaaS and IaaS. Datacenter Components: IT Equipment and Facilities. Design Considerations: Requirements, Power, Efficiency, & Redundancy, Power Calculations, PUE and Challenges in Cloud Data Centers, Cloud Management and Cloud Software Deployment Considerations. Virtualization (CPU, Memory, I/O). Case Study: Amazon EC2, Software Defined Networks (SDN), Software Defined Storage (SDS). Introduction to Storage, Systems Cloud Storage Concepts Distributed File Systems (HDFS, Ceph FS), Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB), Cloud Object Storage (Amazon S3, OpenStack Swift, Ceph). Distributed Programming for the Cloud, Data-Parallel Analytics with Hadoop MapReduce (YARN), Iterative Data-Parallel Analytics with Apache Spark, Graph-Parallel Analytics with Graph Lab 2.0 (PowerGraph).

ICT 6302 Fog Computing 3 Credits

Fog Computing-Definition-Characteristics-Application Scenarios - Issues -Fog Computing and Internet of Things-Pros and Cons-Myths of Fog Computing -Need and Reasons for Fog Computing Fog Computing and Edge Computing-IoT, FOG, Cloud- Benefits. Working Procedure - Performance Evaluation Components- Software Systems –Architecture-Modeling and Simulation –Challenges. Fog Protocols: Fog Protocol-Fog Kit- Proximity Detection Protocols- DDS/RTPS computing protocols. Smart Management of Big Data-Smart Data-Structure of Smart Data-Smart Data Life Cycle-System Architecture-Multi-dimensional Payment Plan- -Security and Privacy Issues-Multimedia Fog Computing-Architecture-Deduplication-Hybrid Secure Deduplication- Security Challenges-Security Requirements. Wind Farm - Smart Traffic Light System, Wearable Sensing Devices, Wearable Event Device ,Wearable System, Demonstrations, Post Application Example, Event Applications Example.

ICT 6303 Internet of Everything 3 Credits

Internet in General and Internet of Things: Layers, Protocols, Packets, Services, Performance Parameters of a Packet Network as well as Applications such as Web, Peer-to-peer, Sensor networks, and Multimedia. IoT Definitions: Overview, Applications, Potential and Challenges, and Architecture. IoT Protocols: HTTP, CoAP, MQTT, AMQP, 6LoWPAN. IoT Data and the IoT Cloud Infrastructure. Performance and Security in IoT. IoT examples: Case Studies, e.g., Sensor Body-Area-Network and Control of a Smart Home.

ICT 6304 ICT Advancement towards Industrial Revolution 3 Credits

Introduction to Industry 4.0: The Various Industrial Revolutions, Digitalization and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, Comparison of Industry 4.0 Factory and Today's Factory. Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation. Road to Industry 4.0: Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Smart Manufacturing, Smart Logistics, Smart Cities. Related Disciplines, System, Technologies for enabling Industry 4.0: Cyber physical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Mobile Computing, Cyber Security. Role of data, information, knowledge and collaboration in future organizations: Resource-based view of a firm, Data as a new resource for organizations, Harnessing and sharing knowledge in organizations, Cloud Computing Basics, Cloud Computing and Industry 4.0. Business issues in Industry 4.0:Opportunities and Challenges, Future of Works and Skills for Workers in the Industry 4.0 Era, Strategies for competing in an Industry 4.0 world.

ICT 6305 Advanced Cyber Physical System 3 Credits

Introduction to Cyber-Physical Systems, CPS Principles, Models of Physical Systems, Models of Cyber Components and Interconnections, CPS Workload Modeling, Specification and Critical Properties of CPSs, Safety in CPS, Complex Systems Approaches to CPS. Discrete systems, Continuous and Hybrid Dynamics, Fractional Order Derivatives and Integrals, Information cellular processing, Control algorithms and embedded Software, Scheduling of Control Tasks Over Shared Wireless

Channels, Sensing and Fusion, Automotive Sensing and Intelligent Transportation, Wearable Sensing and Body-Area Sensor Network, Sensors and Actuators, Networked control systems, Molecular communication, Value added network, Controllability and Observability of Complex Networks. Internet of things (IoT), Internet of Service (IoS), Introduction to Industry 4.0, Big Data Issues, Hybrid systems, Real-Time Operating Systems, Holistic System Design, Controller Design and Synthesis, Multi Agent System, Real-Time Tools and Analysis, Inference Techniques, Embedded System Design, Feedback Control.

ICT 6306 Bioinformatics Computing 3 Credits

Introduction to Bioinformatics and Key Online Bioinformatics Resources (NCBI & EBI): Biology is an Information Science, History of Bioinformatics, Types of Data, Application Areas: Introduction to Upcoming Segments, NCBI & EBI resources for the molecular domain of Bioinformatics, Focus on Gen Bank, Uni Prot, Entrez and Gene Ontology. Sequence Alignment, DNA and Protein Database Searching: Homology, Sequence Similarity, Local and Global alignment, Database Searching with BLAST. Advanced Database Searching: PSI-BLAST, Profiles and HMMs, Protein structure comparisons. Structural Bioinformatics: Protein Structure Function Relationships, Protein Structure and Visualization Resources, Structural Genomics, Homology Modeling, Inferring Protein Function from Structure. Structure Based Drug Discovery and Bio-Molecular Simulations: Small Molecule Docking Methods, Protein Motion and Conformational Variants, Bioinformatics in Drug Discovery. Genome Informatics and High Throughput Sequencing Searching: Genes and Gene functions, Genome Databases, Variation in the Genome, High Throughput Sequencing, Biological Applications, Bioinformatics Analysis Methods. Proteomics and Transcriptome: Processing and Extracting Biological Information from Proteomic and Trans-criptomic Datasets, Analysis of RNA-Seq Data, Differential Expression Tests, Avoiding P-Value Misuse, Hands-on Analysis of RNA-Seq Data. Analysis of protein-Protein interactions, Pathways and Networks, Modeling and Simulation of Systems and Networks, Computational Methods of Network Modeling.

ICT 6307 Biomedical Image Processing 3 Credits

Fundamentals of Digital Image Processing; Image Transformation; Image

Enhancement; Image Reconstruction; Image Registration; Image Segmentation; Feature Extraction. Fundamentals of Producing a Medical Image- X-Ray, MRI and CT-SCAN; Image Collection Techniques; Image Reconstruction Algorithms; Detailed Examination of the Main Areas of Medical Imaging and Clinical Application of each Area.

ICT 6401 Intrusion Management and Ethical Hacking 3 Credits

Introduction to Hacking Concepts, Types of Hacking, Phases of Hacking, Definition of Hacking, Necessity of Ethical Hacking, Scope and Limitations of Ethical Hacking, Information Security Controls, Information Assurance, Threat Modeling, Enterprise Information Security Architecture, Network Security Zoning, Types of Security Policies, Vulnerability Assessment, Types of Vulnerability Assessment, Network Vulnerability Assessment Methodology, Vulnerability Research Websites, Penetration Testing, Comparing Security Audit, Vulnerability Assessment, and Penetration Testing, Blue Teaming/Red Teaming, Hacking Phases, Scan for Vulnerability, Vulnerability Scanning and Tool, Network Vulnerability Scanners, Vulnerability Scanning Tools for Mobile, Network Discovery Tool, Network Topology Mapper and Network View, Network Discovery Tools for Mobile, Gaining Access, Maintaining Access, Clearing Tracks, Information at Hand Before System Hacking Stage, System Hacking: Goals, CEH Hacking Methodology, CEH System Hacking Steps, Cracking Passwords, Password Cracking, Types of Password Attacks, Non-Electronic Attacks, Active Online Attack, Dictionary, Brute Forcing and Rule-based Attack, Password Guessing, Default Passwords, Active Online Attack, Trojan/Spyware/Keylogger, Active Online Attack Using USB Drive, Hash Injection Attack, Passive Online Attack, Wire Sniffing, Man-in-the-Middle and Replay Attack, Offline Attack, Rainbow Attacks, Tools to Create Rainbow Tables: rtgen and Winrtgen, Distributed Network Attack. Denial of Service: Attacks, Preventing DoS/DDoS; Buffer Overflow: Introduction, Testing Vulnerability, Countermeasures.

ICT 6402 Applied Cryptography 3 Credits

Introduction, Crypto History Attacks on Crypto, One-time Pad, Perfect

Secrecy. Stream Ciphers, Semantic Security Block Ciphers, DES. Attacks on Block Ciphers, AES using Block Ciphers, EBC. Using block ciphers, CBC, CTR Message integrity, Collision Resistance, Authenticated Encryption, Deterministic Encryption. Basic Key Exchange, Number Theory Review, Public Key Crypto Introduction. Public Key Crypto: RSA, El Gamal. Digital Signatures. Key Management and Distribution, Digital Certificates PKI, Identity based Encryption. Identification and Authentication, Zero Knowledge Protocols, Kerberos Electronic Mail Security, PGP. Web and Transport Level Security, SSH, TLS/SSL IP Security, Wireless Network Security. Anonymous Communication, ToR Crypto-currencies, Bitcoin. Hardware–based security, Side Channel Attacks Physically Unclonable Function, Trusted Platform Module. Quantum Safe Cryptography Cloud Security.

ICT 6403 Internet and Cyber security 3 Credits

Internet Architecture, Working procedure of Internet, TCP/IP Vulnerabilities, Attacks, and Countermeasures, Physical Layer, Jamming Attacks, Secured Web Programming, Data Link Layer: ARP Protocol and Cache Poisoning, Network Layer: IP Protocols, Packet Sniffering, IP Spoofing, IP Fragmentation Attacks, ICMP Protocol and ICMP Misbehaviors, IP Routing Protocol Attacks, Transport Layer: TCP Session Hijacking, Reset and SYN Flooding Attacks, DoS and DDoS Attacks, DNS Protocol and Attacks, BGP Protocol and Attacks. IP Tunneling and SSH Tunneling, Virtual Private Networks, Firewalls, Bypassing Firewalls, Transport Layer Security (TLS/SSL), TLS Programming, Secured Socket Programming, Java Script Security, Cross Site Forgery. Introduction to Cyber Security, Interrelated Components of the Computing Environment, Models of Cyber Security (the CIA triad, the Star Model), Cyber Vulnerabilities and consequences, Cyber Threats-Types of Attacker, Cyber-Attack, Methods, Classification of Cyber-Attack and Vectors, Risks of Conducting a Cyber-Attack. Cybercrime, Cyber Harassment, Cyber Warfare, Cyber Surveillance, Difficulties in Cyber Security, State of Security today. Principles of Risk, Types of Risk, Risk Strategies, Risk Management Framework, Disaster Recovery Plan and Procedures, Challenges of Disaster Recovery Plan, Traditional Disaster Recovery. National ICT Act & Policy, National Information Security Policy Guideline, Government and Private Sector Role's in Securing Cyberspace.

ICT 6501 Computational Linguistics 3 Credits

Introduction and Overview: Computational Linguistics, Hands-on Demonstrations, Ambiguity and Uncertainty in Language, The Turing Test; Regular Expressions: Chomsky Hierarchy, Regular Languages, and their Limitations, Finite-state Automata, Practical Regular Expressions for Finding and Counting Language Phenomena. Context Free Grammars: Constituency, CFG Definition, Use and Limitations. Chomsky Normal Form. Syntactic Processing: Grammars and Parsing, Augmented grammars, Grammars for Natural Language, Top-down Parsing, Bottom-up Parsing, and the Problems with each, Ambiguity Resolution; The Desirability of Combining Evidence from both Directions. Semantic Interpretation: Semantics and Logical Form, Linking Syntax and Semantics, Scoping; Context and World Knowledge: Knowledge Representation and Reasoning, Local Discourse Context and Reference, using World Knowledge, Conversational Agent.

ICT 6502 Statistical Machine Translation 3 Credits

Difference between Statistical and Structured Natural Language Processing (NLP), Basic Statistics and Statistical Model, Linguistics Essentials, Corpus-based NLP; Statistical Machine Translation, Models and Techniques: Collocations, Statistical Inference, Word Sense Disambiguation, Lexical Acquisition, Markov Models; Grammar: Part-of-Speech Tagging, Probabilistic Context Free Grammars, Probabilistic Parsing; Applications and Techniques: Statistical Alignment, Clustering, Information Retrieval, Text Categorization.

ICT 6503 Advanced Artificial Intelligence 3 Credits

Introduction to AI; Advanced search techniques in AI: Heuristic search, Local search, Adversarial search; Genetic and evolutionary algorithm, Knowledge-based system design: Propositional logic, First-order logic, Planning logic, Modeling constraint satisfaction and optimization problems in MiniZinc; Advanced plan generating systems: Automated classical planning, Partial-order planning (POP), SAT Planning, Hierarchical task network (HTN) planning; Bayesian network and probabilistic reasoning: Uncertain reasoning, Probabilistic reasoning,

Bayesian Network, Dynamic Bayesian Network; Introduction to deep learning: Supervised, unsupervised, and reinforcement learning, Neural Network; Deep belief network, Deep neural network, deep learning for natural language processing and computer vision, and other applications; Introduction to Robotics and Robot programming.

ICT 6504 Machine Learning 3 Credits

Introduction; Applications; Maximum likelihood; Regularizers, basis functions and cross-validation; Supervised learning: Optimisation, Logistic regression, Perceptron, Exponential family, Generative learning algorithms, Gaussian discriminant analysis, Naive Bayes, Support vector machines, Model selection and feature selection, Ensemble methods (Bagging, boosting), Evaluating and debugging learning algorithms; Learning theory: Bias/variance tradeoff, Union and Chernoff/Hoeffding bounds, VC dimension, Worst case (online) learning; Unsupervised learning: Clustering. K-means, EM. Mixture of Gaussians, Factor analysis, PCA (Principal components analysis), ICA (Independent components analysis); Reinforcement learning and control: MDPs. Bellman equations, Value iteration and policy iteration; Linear quadratic regulation (LQR), LQG, Q-learning. Value function approximation, Policy search. Reinforce. POMDPs; Back-propagation and layer-wise design of neural nets; Deep neural network; Convolutional neural networks; Recurrent neural networks and LSTMs; Deep Reinforcement learning with direct policy search; Neuro-dynamic programming.

ICT 6505 Automated Planning 3 Credits

Forms of planning; Domain-Independent planning; Conceptual, restricted, and extended models for planning; Representations (Set-Theoretic, Classical, and State-Variable) for planning; Complexity of classical planning; State-Space planning and the STRIPS algorithm; Plan-Space planning; Planning-Graph techniques (e.g., the Graph plan planner); Propositional satisfiability techniques; Constraint satisfaction techniques; Heuristics for state-space and plan-space planning; Control rules in planning; Hierarchical Task Network (HTN) planning; Situation Calculus and Dynamic Logic in deductive planning; Numeric Planning; Temporal planning; Planning and resource scheduling; Planning under uncertainty

(based on Markov Decision processes, model checking, and Neo-Classical techniques).

ICT 6506 Neuro-Fuzzy Systems 3 Credits

Overview of Artificial Neural Networks; Artificial Neuron Models, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architecture, Classification of ANN; Simple neural networks; Multi-layer neural networks: Multilayer Perceptions (MLP), Logistic Activation Function, Backpropagation Algorithm; Neural Network Applications; Overview of Fuzzy System; Crisp sets to Fuzzy Sets; Operations on Fuzzy Sets, Fuzzy Arithmetic, Fuzzy Relations.

ICT 6601 Speech Processing 3 Credits

Basic Concepts: Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds; Acoustic Phonetics – Acoustics of Speech Production; Review of Digital Signal Processing Concepts; Short-Time Fourier Transform, Filter-Bank and LPC Methods. Speech Analysis: Features, Feature Extraction and Pattern Comparison Techniques: Speech Distortion Measures – Mathematical and Perceptual – Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths. Speech Modeling: Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issues. Speech Recognition: Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary Continuous Speech Recognition System – Acoustics and Language models – Context Dependent Sub-word Units; Applications and Present Status. Speech Synthesis: Text-to-Speech Synthesis: Concatenative and Waveform Synthesis Methods, Sub-word units for TTS, Intelligibility and Naturalness – Role of Prosody, Applications and Present Status.

ICT 6602 Antennas and Propagation 3 Credits

Basic Antenna Parameters - Patterns, Beam Area, Radiation Intensity,

Beam Efficiency, Directivity-Gain-Resolution, Antenna Apertures, Effective Height. Thin Linear Wire Antennas: Radiation from Small Electric Dipole, Quarter wave Monopole and Half wave Dipole – Current Distributions, Field Components, Radiated Power, Radiation Resistance, Beam-widths, Directivity, Effective Area and Effective Height. Antennas of Different Lengths, Illustrative Problems. Loop Antennas - Introduction, Small Loop, Comparison of Far Fields of Small Loop and Short Dipole, Radiation Resistances and Directivities of Small and Large Loops. Helical Antennas - Helical geometry, Helix Modes, Practical Design Considerations for Monofilar Helical Antenna in Axial and Normal Modes. Horn Antennas - Types, Fermat's Principle, Optimum Horns, Design Considerations of Pyramidal Horns, Illustrative Problems. Microstrip Antennas - Introduction, Features, Advantages and Limitations, Rectangular Patch Antennas - Geometry and Parameters, Characteristics of Microstrip Antennas. Impact of Different Parameters on Characteristics, Reflector Antennas - Introduction, Flar Sheet and Corner Reflectors, Paraboloidal Reflectors - Geometry, Pattern Characteristics, Feed Methods, Reflector Types - Related Features, Illustrative Problems. Lens Antennas - Introduction, Geometry of Non-metallic Dielectric Lenses, Zoning, Tolerances, Applications. Antenna Measurements: Introduction, Concepts - Reciprocity, Near and Far Fields, Coordinate System, Sources of Errors. Patterns to be Measured, Pattern Measurement Arrangement, Directivity Measurement, Gain Measurements (by Comparison, Absolute and 3-Antenna Methods). Introduction, Definitions, Categorizations and General Classifications, Different Modes of Wave Propagation, Ray/Mode Concepts, Ground Wave Propagation (Quantitative Treatment) - Introduction, Plane Earth Reflections, Space and Surface Waves, Wave Tilt, Curved Earth Reflections, Space Wave Propagation - Introduction, Field Strength Variation with Distance and Height, Effect of Earth's Curvature, Absorption, Super retraction, M-Curves and Duct Propagation, Scattering Phenomena, Tropospheric Propagation. Sky Wave Propagation - Introduction, Structure of Ionosphere, Refraction and Reflection of Sky Waves by Ionosphere, Ray Path, Critical Frequency, MUF, LUF, OF, Virtual Height and Skip Distance, Relation between MUF and skip Distance, Multi-hop Propagation.

ICT 6603 Radar Engineering 3 Credits

Introduction to Radar: Historical background, radar terminology, radar band designations, Radar block diagram, radar equation: detection of signals in noise and signal-to-noise ratio, Probabilities of detection & False alarm, integration of radar pulses, radar cross section, distributed targets, Transmitted power, pulse-repetition frequency, antenna parameters & system losses, introduction to radar clutter. Radar Types: Pulse radars and CW radars, Advantages of coherent radar, Doppler radar and MTI: Doppler effect, delay-line cancellers, blind speeds, staggered PRFs, Digital filter bank, Moving Target Detector, limitations of MTI, tracking with radar, monopulse tracking, conical scan, limitation to tracking accuracy. Radar Signals & Clutter: Basic radar measurement, theoretical accuracy of radar measurements, Range and velocity ambiguities, the ambiguity diagram, pulse compression-principles, the matched filter, chirp waveforms, Waveform design: nonlinear FM, phase codes, waveform generation and compression Descriptions of land & sea clutter, statistical models for surface clutter, detection of targets in clutter. Module –IV: Devices and Radar Systems: 8L Radar transmitter: Solid-state RF power source, Magnetron, other RF power sources, Radar receiver: Super heterodyne receiver, receiver noise figure, duplexers & diplexers, Receiver protectors, Applications: Electronic Warfare: ESM, ECM, ECCM; super resolution, IFM, types of jammers, Stealth and counter-stealth: stealth techniques for aircraft and other target types, low frequency and UWB radar.

ICT 6604 Advanced Digital Signal Processing 3 Credits

Discrete Random Signal Processing: Discrete Random Processes-Ensemble averages, stationary processes, Autocorrelation and Auto covariance matrices. Parseval's Theorem, Sum Decomposition Theorem. Wiener-Khintchine Relation- Power Spectral Density- Periodogram Spectral Factorization, Filtering random processes. Low Pass Filtering of White Noise. Parameter estimation: Bias and consistency. Spectrum Estimation: Estimation of spectra from finite duration signals, Non-Parametric Methods-Correlation Method, Periodogram Estimator, Performance Analysis of Estimators- Unbiased, Consistent Estimators-Modified Periodogram, Bartlett and Welch methods, Blackman & Tukey Method. Parametric Methods - AR, MA, and ARMA model based spectral

estimation. Parameter Estimation -Yule-Walker equations, Solutions using Durbin's algorithm. Linear Estimation and Prediction: Linear prediction-Forward and Backward Predictions, Solutions of the Normal Equations-Levinson-Durbin Algorithms. Least mean squared error criterion -Wiener filter for filtering and prediction, FIR Wiener filter and Wiener IIR filters, Discrete Kalman filter. Adaptive Filters and Multirate DSP: FIR adaptive filters -adaptive filter based on steepest descent method- Widrow-H off LMS adaptive algorithm, Normalized LMS. Adaptive channel equalization-Adaptive echo cancellation-Adaptive noise cancellation-Adaptive recursive filters (IIR). RLS adaptive filters-Exponentially weighted RLS-sliding window RLS. Polyphase filter structures, timevariant structures. Multistage implementation of multirate system. Application to sub bandcoding - Wavelet transform and filter bank implementation of wavelet expansion of signals. Digital Signal Processors and its Applications: General purpose Digital Signal Processors.

ICT 6605 Advanced VLSI Design and Testing 3 Credits

Overview of VLSI technology; Review of CMOS logic circuits; Scaling and Interconnect Issues; Deep submicron design issues; Advanced clocking strategies; Clock distribution trees; High speed switching circuits; Low power design; Memory circuit design trends, Performance optimization; SOI technology and circuits; VLSI circuit in signal processing, VLSI circuit in wireless communication; Introduction to ASIC design. Overview of VLSI circuit; Faults in VLSI circuit; Fault modeling; Fault simulation: Serial, parallel and deductive fault simulation; Testing stuck faults and bridging faults; Test algorithms; Automatic test equipment, Functional testing; Design For Testability: controllability and observability, scan techniques, Built in self-Test; Compression techniques; Testing of digital core; Memory Testing; Testing of analog and mixed signal core; Iddq Testing, Production Testing; Test effectiveness: coverage, yield and defect levels; System level test and diagnosis; MCM and core based testing.

ICT 6606 Reliable Computing System 3 Credits

Fault classification and measures of fault tolerance. Hardware fault tolerance: basic terminology and structure of hardware fault tolerance.

Information redundancies for detection and correction of faults. Software fault tolerance and check pointing. Defect tolerance in VLSI circuits. Simulation techniques of fault tolerance. Fault injection techniques. Case studies of modern fault tolerant processors. Multi-core processing and fault tolerance back-up. Error and Exception Handling.

ICT 6701 Wireless Networks 3 Credits

Overview of Wireless Communication Networking and Mobile Computing: Historical perspectives, first and second generation cellular systems, land mobile vs. satellite vs. indoor wireless systems, adaptation and mobility in wireless information systems, challenges of mobile computing, mathematical preliminaries. Wireless Channel Modeling: Path-loss and shadow fading models, Rayleigh and Ricean fading, coherence time, coherence bandwidth, frequency flat and selective fading. Modulation, Coding, Diversity Techniques: Digital modulation and coding techniques for wireless communication systems, spread-spectrum modulation, diversity combining techniques. Cellular Concept: Frequency reuse/cellular/microcellular concepts including sectorization and cell splitting, trunking efficiency, Erlang capacity. Multiple Access Techniques: TDMA, FDMA, CDMA, ALOHA, Slotted-ALOHA, CSMA/CA, MACA, reservation protocols, PRMA, capture effects. Wireless Networking Standards: 3G Systems, Wireless LAN standards (IEEE 802.11), WMAN standards (IEEE 802.16), WPAN standards (IEEE 802.15).

ICT 6702 Advanced Communication Engineering 3 Credits

Communication Engineering Preliminaries, traffic sources, resources, operational modes and traffic, unit of traffic, inter-arrival time and call holding time, traffic variation and busy hours; Random variables: Random variables, probability distribution function, probability density function, moments, Bernoulli random variable, uniform discrete random variable, Binomial distribution, Poisson distribution, negative exponential distribution, quality of service circuit switching voice networks, packet switched networks, probabilities of traffic systems; Models for circuit switched networks: Kendall notation, Erlang's loss formula (M/M/n/n) and examples, marginal utility, Wilkinson's model, equivalent random

method and examples, overflow routing in circuit switched networks; Models for packet switched networks: M/M/1, M/G/1, M/G/1 priority queues, Erlang's delay formula (M/M/n), System simulation: random number and random variable generation, event-by-event simulation method, sampling theory.

ICT 6703 Radio Frequency Technology 3 Credits

Networks And Matrices: Scattering and chain scattering matrices, Generalized scattering matrix, Analysis of two port networks, Interconnection of networks. Positive real concepts, scattering matrix, representation of microwave components (directional coupler, circulators, hybrids and isolators). High Frequency Circuit Design: Tuned Circuits, Filter design- Butterworth filter, Chebyshev filter, impedance matching. High frequency amplifier, BJT and FET amplifier, Broadband Amplifiers RF Oscillators, Colpitts, Hartley Oscillators, PLL. High Frequency Integrated Circuits. Microwave Amplifier Design: Types of amplifiers, Power gain equations. Introduction to narrow band amplifiers basic concepts, Maximum gain design, Low noise design. High power design, Negative resistance, reflection amplifiers – various kinds – stability considerations, Microwave transistor amplifier design – input and output matching networks – constant noise figure circuits. Microwave Transistor Oscillator Design: One port and two port negative resistance oscillators. Oscillator configurations, Oscillator design using large signal measurements, Introduction to Microwave CAD packages, Microwave integrated circuits, MIC design for lumped elements. RF And Microwave Antennas: Radiation from surface current and line current distribution, Basic Antenna parameters, Feeding structure-Patch Antenna, Ring Antenna, Micro strip dipole, Micro strip arrays, Traveling wave Antenna, Antenna System for Mobile Radio-Antenna Measurements and Instrumentation. Propagation characteristics of RF and Microwave signals, Introduction to EBG structures.

ICT 6704 Advanced Telecommunication Network 3 Credits

Role of Telecommunications in Developing Countries, Telecom Organizations and Standardization: Administrative Organizations: ITU, National PTTs, Private Telephone Companies; Standardization Bodies:

ITU-T, ITU-R, etc. Public Switched Telephone Network : Network Topology: International, National and Local Networks, Architecture of the Analog PSTN; Switching Hierarchy; Trunk Networks; Junction Networks; Local Distribution Networks; Local Loop and 2W/4W Circuits; Architecture of the Digital PSTN; DSL; Signaling; Dialing; Tone Dialing; DTMF; Telephone Terminals Common Channel Signaling; Telephone Numbering in PSTN; Signals Carried Over the Network: Types of Information and Their Requirements; Simplex, Half-Duplex, and Full-Duplex Communications; Frequency and Bandwidth; Analog and Digital Signals and Systems; Frequency Division Multiplexing ; Time Division Multiplexing ; Pulse Code Modulation; Speech Coding; Power Levels of Signals; Decibel; Gain and Loss. Transmission Media and Systems: Transmission Media: Copper Pairs; Optical Fibers; Radio Waves; Overview on Transmission Systems; Microwave Radio Relay Lines; Satellite Communications Networks; Optical Fiber Communication Networks; Mobile Communication Systems; Wireless Local Loop Systems.

ICT 6705 Next Generation Mobile Communication 3 Credits

Introduction to Personal Communications Services (PCS): PCS Architecture, Mobility management, Networks signaling. Global System for Mobile Communication (GSM) system overview: GSM Architecture, Mobility management, Network signaling, Performance Analysis: Admission control and handoffs. 2.5/3G Mobile Wireless systems: packet switched Data Introduction, 3G CDMA cellular standards, Wideband Code Division Multiple Access (W-CDMA), and CDMA 2000, Quality of services in 3G. 2.5/3G TDMA: General Packet Radio Services (GRPS) and EDGE. Access Scheduling techniques in cellular systems: Slotted Aloha access, integrated access: voice and data, scheduling in packet based cellular systems. Mobile Data Communication: WLANs (Wireless LANs) IEEE 802.11 standard, Mobile IP. Wireless Application Protocol (WAP): The Mobile Internet standard, WAP Gateway and Protocols, wireless mark up Languages (WML).Wireless Local Loop (WLL): Introduction to WLL Architecture, wireless Local Loop Technologies. Global Mobile Satellite Systems; case studies of the IRIDIUM and GLOBALSTAR systems.

ICT 6706 Broadband and Wireless Communications 3 Credits

Overview of broadband wireless communications, WiMAX Genesis and framework 9 802.16 standard, WiMAX forum, Other 802.16 standards, Protocol layer topologies - Layers of WiMAX, CS, MAC CPS, Security layer, Physical layer, Reference model, topology. Unit No. II: Frequency utilization and system profiles 9 Cellular concept, Licensed and unlicensed frequencies, Fixed WiMAX system profiles, Mobile WiMAX profiles. Unit No. III: WiMAX physical layer 9 OFDM Transmissions, SOFDMA, subcarrier permutation, 802.16 transmission chains, Channel coding, Turbo coding, Burst profile. Unit No. IV: WiMAX MAC and QoS 9 CS layer, MAC function and frames, Multiple access and burst profile, Uplink bandwidth allocation and request mechanisms, Network entry and QoS management. Unit No. V: Radio engineering considerations 9 Radio resource management, Advance antenna technology in WiMAX, MBS. WiMAX architecture, Mobility handover and power save modes, Security.

ICT 6707 Smart Sensor Networking 3 Credits

Introduction to sensor technology, Sensor systems; Smart sensors basics; Smart sensors: Characteristics; Smart sensors architectures; Smart sensors buses and interfaces; Smart sensors software; Data acquisition methods for smart sensors; Virtual sensor systems; Smart sensors for electrical and non-electrical variables; Sensor networks architectures: Single node architecture; Multi node architectures; Design principles; Energy efficient topologies; Wired sensor networks and wireless sensor networks; Applications; Communication protocols: Physical layer; MAC protocols; Link layer protocols; Localization and positioning; Routing protocols; Transport layer; Data gathering and processing: Protocols for gather information; Data processing techniques; Energy management: Energy consumption of sensor nodes; energy harvesting; Techniques for reducing consumption and communication energy; Energy aware routing; Security, reliability and fault-tolerance: Security and privacy protection; Reliability support; Fault-tolerance; Sensor networks standards; platforms and tools: IEEE 802.15.4, IEEE 802.15.6 and IEEE 802.11; Berkeley motes; Sensor Operating Systems.

ICT 6708 Advanced Computer Network 3 Credits

Design and implementation of computer communication networks and their end-to-end protocols. layered network architectures, applications, transport and routing, routing protocols, IP version 6, mobile IP, multicasting, session initiation protocol, quality of service, network security, network management, and TCP/IP in wireless networks. Data center architectures; Data center network protocols, Data center workloads and performance, Data center network virtualization End host architectures; Server and network virtualization, Software defined networking, Wireless sensor networks; IoT networks, Network verification, Machine learning for networks. Networks Layer: Packetizing, Routing and Forwarding, Packet Switching, Network Layer Performance, IPv4 Address, Address Space, Classful Addressing, Classless Addressing, Dynamic Host Configuration Protocol (DHCP), Network Address Translation (NAT), Forwarding of IP Packets, Forwarding based on Destination Address, Forwarding based on Label, Routing as Packet Switches. Unicast Routing : Introduction, Routing Algorithms-Distance Vector Routing, Link State Routing, Path Vector Routing, Unicast Routing Protocols- Routing Information Protocol (RIP), Open Short Path First Version.

ICT 6709 Advanced Data Communications 3 Credits

Data Communications, Networks and Network Types, Internet History, Standards and Administration, Protocol Layering, TCP/IP protocol suite, OSI Model. Digital Data Transmission, DTE-DCE interface. Data Link Layer: Introduction, Data Link Layer, Nodes and Links, Services, Categories of Links, sub layers, Link Layer Addressing, Address Resolution Protocol. Error Detection and Correction: Types of Errors, Redundancy, detection versus correction, Coding Block Coding: Error Detection, Vertical redundancy cheeks, longitudinal redundancy cheeks, Error Correction, Error correction single bit, Hamming code. Cyclic Codes: Cyclic Redundancy Check, Polynomials, Cyclic Code Encoder Using Polynomials, Cyclic Code Analysis, Advantage of Cyclic Codes, Checksum Data Link Control: DLC Services, Data Link Layer Protocols, HDLC, Point to Point Protocol. Switching: Introduction to Switching, Circuit Switched Networks, Packet Switching, Structure of switch Multiplexing: Multiplexing, Frequency Division Multiplexing, Time Division Multiplexing. Connecting devices: Passive Hubs,

Repeaters, Active Hubs, Bridges, Two Layer Switches, Routers, Three Layer Switches, Gateway, Backbone Networks. Wired LANS: Ethernet Protocol, Standard Ethernet, Fast Ethernet, Gigabit Ethernet, 10 Giga bit Ethernet. Media Access Control (MAC) Sub Layer Random Access, ALOHA, Carrier Sense Multiple Access (CSMA), Carrier Sense Multiple Access with Collision Detection (CSMA/CD), Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), Controlled Access-Reservation, Polling- Token Passing, Channelization – Frequency Division Multiple Access (FDMA), Time – Division Multiple Access (TDMA), Code Division Multiple Access (CDMA). Spectrum Spreading: Spread Spectrum-Frequency Hopping Spread Spectrum and Direct Sequence Spread Spectrum.

ICT 6710 Satellite and Navigation 3 Credits

Orbits & Launching Methods: Kepler laws, Orbital elements, Orbital perturbations, Apogee perigee heights, Inclines orbits, Sun synchronous orbits, Geo stationary orbits, Limits of visibility, Sun transit outage, polar Mount antenna, Antenna Look angles, launching orbits, Low earth orbits, medium orbits, constellation. Space Link: EIRP, transmission losses, power budget equation, system Noise carrier to Noise ration, Uplink and downlink equations, Input and Output back Off, TWTA, Inter modulation Noise, C/No, G/T measurement. Space & Earth Segment: Space segment, space subsystems payload, Bus, power supply, attitude control, station keeping, thermal control, TT & C Subsystem, Transponders, Antenna subsystem, Earth segment, cassegrain antenna, Noise temperature, Low Noise Amplifiers, Earth station subsystems, TVRO. Single channel per carrier. MCPC, Combanded FDM/FM/FDMA, Time division multiplexing, T1 carrier, Time Division multiple Access, Frame Burst structure, Frame efficiency, frame Acquisition and synchronization, SS TDMA, SPADE, Spread spectrum, direct sequence, CDMA. Satellite Services: INTELSAT, INSAT Series, VSAT, Weather forecasting, Remote sensing, LANDSAT, Satellite Navigation, Mobile satellite Service, Direct to Home. **Bangabandhu Satellite-1**: Evaluation History, Spacecraft Properties, Orbital Position, Transponders, Platform.

ICT 6711 Geographical Information System 3 Credits

Remote Sensing (RS) Technologies: Basic Technology Requirement, Aerial Photography, Satellite Image, Microwave Remote Sensing, Electro-optical Remote Sensing, Wireless Sensor Network Based Remote Sensing. Introduction to Geographical Information Systems (GIS) and Remote Sensing (RS) Concepts; Basic Principles and Techniques used in GIS and RS; Practice Applications and their Evolutions using GIS and RS; Global Positioning System (GPS). Fundamentals of GIS, Basic Hardware, Software and Data Requirements for GIS; Evolution of GIS Technology, Key Areas of Application of GIS; Spatial Data and Modeling & Analysis, Issues in the Management of GIS, Organizational Role of GIS, and Emerging trends in GIS Development and Future Usage.

ICT 6801 Advanced Embedded System Design 3 Credits

Typical embedded system: Core of the embedded system, Memory, Sensors and Actuators, Commutation interface, Embedded firmware, Other system components. Characteristics and quality attribution of Embedded Systems. Hardware software co-design and program modeling: Fundamental issues in hardware software co-design, Computational models in embedded design, Introduction to Unified modelling language, Hardware software trade-off. Embedded firmware design and development: Embedded firmware design approaches, Embedded firmware development language. Realtime operating system (RTOS) based embedded system design: Operating system basics, Types of OS, Tasks, Process and threads, Multiprocessing and multitasking, Task scheduling, Threads, Processing and scheduling: Putting them altogether, Task communication, task synchronization, Device drivers, How to choose an RTOS. The embedded system development environment: The Integrated development environment (IDE), Types of files generated on cross compilation, Disassembler / Decompilers, Emulators and debugging, Target hardware debugging, Boundary scan. Trends in the embedded industry: Processor trends in embedded system, Embedded OS trends, development language trends, Open standards, Frameworks and alliances, Bottlenecks.

ICT 6802 Real Time Computing for Embedded System 3 Credits

Definition of real-time, temporal and event determinism, design principles

and practice; Architecture review and interfacing, interrupts, traps and events, response times and latency, real-time clocks; Operating systems: Structure of an RTOS, nucleus, servers, schedulers and dispatchers; Synchronization and communication: priority and distribution queues, system Modeling, static scheduling, priority drive scheduling; Real-time communication, device drivers, operating systems; Languages in real-time, concurrency issues, Real-time programming.

ICT 6803 Industrial Automation and Control 3 Credits

Industrial Automation and Control, Architecture of Industrial Automation Systems, Sensors and measurement systems, Temperature measurement, Pressure and Force measurements, Displacement and speed measurement, Flow measurement techniques, Measurement of level, humidity, pH etc, Signal Conditioning and Processing, Estimation of errors and Calibration, Introduction to Process Control, PID Control, Controller Tuning, Implementation of PID Controllers, Special Control Structures: Feedforward and Ratio Control, Special Control Structures : Predictive Control, Control of Systems with Inverse Response, Special Control Structures: Cascade Control, Overriding Control, Selective Control, Split Range Control, Sequence Control, PLCs and Relay Ladder Logic, Sequence Control: Scan Cycle, RLL Syntax, Sequence Control: Structured Design Approach, Sequence Control: Advanced RLL Programming, Sequence Control: Hardware Environment, Control of Machine tools: CNC Machines, Control of Machine Tools: Analysis of a control loop, Actuators: Flow Control Valves, Hydraulic Actuator Systems: Components and Symbols, Hydraulic Actuator Systems: Pumps and Motors, Proportional and Servo Valves, Pneumatic Control Systems: System Components, Controllers and Integrated Control Systems, Electric Drives: Energy Saving with Adjustable Speed Drives, Step motors: Principles, Construction and Drives, DC Motor Drives: DC-DC Converters, Adjustable Speed Drives, Induction Motor Drives: Characteristics, Adjustable Speed Drives, Synchronous Motor Drives: Motor Principles, Adjustable Speed and Servo Drives, Networking of Sensors, Actuators and Controllers: The Field bus, The Field bus Communication Protocol, Introduction to Production Control Systems.

ICT 6804 Advanced Computer Architecture 3 Credits

Course Introduction, Introduction to Computer Architecture, Instruction set architecture, Evolution of architectures, RISC architecture (Single cycle, multi-cycle, and pipelined architectures), Pipeline hazards, Memory system, Cache architecture, Beyond Pipeline, Superscalar architecture, Superscalar architecture: An overview, Instruction flow optimization: Handling branches, Branch predictors – 1, Branch predictors – 2, Advanced optimization in instruction flow, register flow techniques: Register renaming and out of order execution, Out of order execution, Advanced data flow techniques: Instruction reuse and value prediction, Memory data flow, Advanced memory data flow architectures, Limits of superscalar architectures, Beyond ILP, Multi-threading, Simultaneous multithreaded (SMT) architectures, SMT architecture: Choices, SMT performance on various designs, SMT architecture: OS impact and adaptive architectures, VLIW architectures, Multi-scalar architecture, Multi-core Architectures, Multi-core Interconnect – NOC, Network-on-Chip, Cache Coherence, Cache Consistency model, Dynamic Core architectures, GP-GPU Architecture, CPU-GPU Integration.

ICT 6805 Advancement in Microprocessor Systems 3 Credits

Introduction: Need of advance microprocessors, Difference between RISC and CISC, RISC Design philosophy, ARM Design Philosophy, History of ARM microprocessor, ARM processor family, Development of ARM architecture. The ARM Architecture and Programmers Model : The Acorn RISC Machine, ARM Core data flow model, Architectural inheritance, The ARM7TDMI programmer's model: General purpose registers, CPSR, SPSR, ARM memory map, data format, load and store architecture, Core extensions, Architecture revisions, ARM development tools. ARM Instruction set: Data processing instructions, Arithmetic and logical instructions, Rotate and barrel shifter, Branch instructions, Load and store instructions, Software interrupt instructions, Program status register instructions, Conditional execution, Multiple register load and store instructions, Stack instructions, Thumb instruction set, advantage of thumb instructions, Assembler rules and directives, Assembly language programs for shifting of data, factorial calculation, swapping register contents, moving values between integer and floating point registers. Programming for ARM: Overview of C compiler and optimization, Basic C data types, C Looping structures, Register allocations, function calls,

pointer aliasing, structure arrangement, bitfields, unaligned data and Endianness, Division, floating point, Inline functions and inline assembly, Portability issues. C programs for General purpose I/O, general purpose timer, PWM Modulator, UART, I2C Interface, SPI Interface, ADC, DAC.Memory management units: Moving from memory protection unit (MPU) to memory management unit (MMU), Working of virtual memory, Multitasking, Memory organization in virtual memory system, Page tables, Translation look aside buffer, Caches and write buffer, Fast context switch extension. Advanced Topics: Advanced Microprocessor Bus Architecture (AMBA) Bus System, User peripherals, Exception handling in ARM, ARM optimization techniques.

ICT 6900 Selected Topics in ICT 3 Credits