INSTITUTE OF INFORMATION TECHNOLOGY
JAHANGIRNAGAR UNIVERSITY

জাহাঙ্গীরনগর বিশ্ববিদ্যালয়

MASTERS IN INFORMATION AND COMMUNICATION TECHNOLOGY

FOR SESSION

2023-2024, 2024-2025,
2025-2026

OUTCOME-BASED CURRICULUM

PART A

1. Title of the Academic Program

Masters in Information and Communication Technology

2. Name of the University

Jahangirnagar University

3. Vision of the University

Promoting and advancing world-class higher education in the University.

4. Mission of the University

Mission 1	Creating skilled and trained human resources through enhancing the quality of higher education in the University, technology-based education, communication with the outside world, and expanding national and international collaboration and research activities.
Mission 2	Contributing to Vision 2041 by ensuring education with the spirit of liberation war and playing a functional role in raising the standard of higher education in Bangladesh to the international level.
Mission 3	Ensuring quality advanced higher education for all classes of citizens irrespective of religion, caste, creed, and gender.

5. Name of the Degree

Masters in Information and Communication Technology

6. Name of the Institute

Institute of Information Technology, Jahangirnagar University (IIT-JU)

7. Vision of the Program

The vision of the IIT-JU is to enlighten the graduate students through need-based academic innovation and research works and prepare them for the real-life challenges in the field of ICT.

8. Mission of the Program

The mission of IIT-JU is to create splendid graduate students by enhancing knowledge and competitiveness through excellent education, hands-on experience, state-of-the-art research and industry collaboration.

9. Description of the Program

Institute of Information Technology of Jahangirnagar University (IIT-JU) started its journey in October 2009 to create efficient ICT professionals. The total credit of Masters program named Masters in Information and Communication Technology (MICT) is 36. The curriculum has two folds, namely- Thesis and Project. The completion year of the Thesis group is 1.5 years, and the Project group requires 1 year.

The program covers various advanced topics in ICT such as computer networks, software engineering, cybersecurity, artificial intelligence, big data analytics, cloud computing, and the Internet of Things (IoT). Students will gain theoretical knowledge and practical experience with modern tools and technologies. The program includes access to well-equipped labs and research initiatives for hands-on learning and building professional networks. After completion, graduates will be prepared for various ICT roles and can pursue further studies in the field.

10. Program Educational Objective (PEOs)

PEO1	To provide a comprehensive understanding of the theoretical and practical aspects of ICT, allowing students to develop advanced skills and knowledge required to design, develop and implement innovative solutions to complex problems.
PEO2	To implement research skills, encourage lifelong learning and responsibility in graduates by providing opportunities for research, professional development, and utilizing their advanced ICT knowledge to address complex societal challenges and promote socio-economic development.
PEO3	To prepare graduates to communicate effectively, participate in multidisciplinary teams, exhibit leadership, and maintain professionalism while considering ethical and legal issues related to ICT when interacting with the stakeholders.
PEO4	To prepare graduates who can analyze, design, develop, and integrate software and hardware systems using emerging technologies, and can demonstrate critical thinking and problem-solving skills in the ICT domain integrating multidisciplinary knowledge.

11. Program Learning Outcomes (PLOs)

The main goal of the program is to assist the field of information and communication technology thrive through teaching, research, and service. The goal of graduate programs is to stay involved in this mission.

A. Fundamental Skills:

PLO1	Acquire an in-depth understanding of a specialized topic in Information and Communication Technology (ICT) and demonstrate the ability to conduct novel research and projects that contribute to the existing body of knowledge in the field.
PLO2	Demonstrate an understanding of emerging technologies in the ICT field, such as databases, networking, artificial intelligence, information security, or software engineering, big data analytics, cloud computing, and the Internet of Things (IoT), and their applications in various industries.

B. Social Skills:

PLO3	Develop effective communication ability to write and speak Information and Communication Technology (ICT) issues to both public audiences and researchers.
PLO4	Exhibit excellent leadership abilities in teamwork and in a multi-disciplinary atmosphere.

C. Thinking Skills:

PLO5	Demonstrate the ability to identify, design, and implement efficient hardware and software solutions to problems.
PLO6	Apply modern engineering ideas, processes, and technologies to solve difficult engineering challenges and tasks using engineering tools and techniques.

D. Personal Skills:

PLO7	Demonstrate an understanding of professional ethics and ethical behavior.
PLO8	Demonstrate a commitment to lifelong learning and professional development and stay up to date with emerging trends and technologies in IT Management.

12. Graduate Attributes

GA1	**Discipline specific knowledge:** Proficiency of the core concepts, theories, and principles of communication, software technology and mathematics. It enhances the specialized engineering knowledge appropriate to Information and Communication Technology.	Fundamental Domain
GA2	**Critical thinking and problem-solving:** Ability to analyze and evaluate information, make scholarly decisions, and solve complex problems using logical and evidence-based reasoning.	Thinking Domain
GA3	**Innovation and creativity:** Capacity to induce innovative ideas, exhibit creativity, and acclimate to new situations and challenges.	Thinking Domain
GA4	**Collaboration and Communication skills:** Written, visual and oral communication proficiency with the ability to effectively convey ideas and information to diverse groups.	Social Domain
GA5	**Leadership and management:** Ability to demonstrate leadership qualities, influence and motivate others, manage resources for projects or initiatives. Also appreciate diversity through communication and collaboration across cultures to effectively engage in a global context.	Personal Domain
GA6	**Ethical and professional accountability:** Understanding of ethical principles and professional standards, and the ability to apply them in ethical decision-making and professional practice.	Social Domain
GA7	**Research and investigation skills:** Competence in conducting research, gathering and evaluating data, and applying research methods to address real-world problems.	Thinking Domain
GA8	**Life-long learning:** Attitude to engage in continuous learning, adapt to changing environments, and acquire new knowledge and skills throughout their professional career. In order to escalate their performance and take proactive steps for self-improvement.	Personal Domain

13. Mapping Mission of the University with PEOs

Missions / PEOs	Mission 1	Mission 2	Mission 3
PEO1	✓		
PEO2	✓	✓	
PEO3		✓	✓
PEO4	✓		✓

14. Mapping PEO vs PLO

Program Learning Outcomes (PLOs)		Program Educational Objective (PEOs)			
		PEO1	PEO2	PEO3	PEO4
A. Fundamental Domain	PLO1	✓			✓
	PLO2	✓			
B. Social Domain	PLO3			✓	
	PLO4			✓	✓
C. Thinking Domain	PLO5	✓	✓		✓
	PLO6				✓
D. Personal Domain	PLO7		✓	✓	
	PLO8		✓		

15. Mapping Courses with PLOs

Course Code	Course title	PLOs							
		Fundamental Domain		Social Domain		Thinking Domain		Personal Domain	
		PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8
ICT 5101	Probability & Stochastic Process	✓	✓	✓		✓	✓		✓
ICT 5102	Cloud Computing	✓	✓			✓	✓		✓
ICT 5103	Internet of Things	✓	✓	✓		✓	✓		✓
ICT 5201	Advanced Machine Learning	✓	✓			✓	✓	✓	✓

ICT 5202	Cyber Security and Cryptocurrency	✓	✓		✓	✓	✓	✓	
ICT 5301	Research Methodology and Ethics	✓		✓		✓	✓	✓	✓
ICT 5401	Information Systems and Securities	✓	✓	✓	✓		✓	✓	
ICT 5402	Advanced Wireless and Cellular Communications	✓	✓			✓	✓		✓
ICT 5403	Big Data Analytics		✓			✓	✓		✓
ICT 5404	Information Retrieval	✓	✓	✓		✓	✓		
ICT 5405	Applied Cryptography	✓	✓	✓	✓		✓	✓	✓
ICT 5406	Information Theory & Coding	✓	✓	✓		✓	✓		✓
ICT 5407	Advanced Satellite Communication	✓	✓	✓	✓	✓	✓		✓
ICT 5408	High Speed Computer Networks	✓	✓	✓		✓	✓		
ICT 5409	Digital Integrated Systems Design	✓	✓	✓	✓	✓	✓		✓
ICT 5410	Project Management and Quality Assurance	✓	✓		✓	✓	✓	✓	✓
ICT 5411	Leadership and Human Resources Management	✓	✓	✓			✓		✓
ICT 5412	Geographical Information Systems	✓	✓	✓		✓	✓	✓	✓
ICT 5413	Natural Language Processing	✓	✓	✓		✓	✓		
ICT 5414	Health Informatics	✓	✓	✓	✓	✓	✓	✓	✓
ICT 5415	Management Information System		✓	✓	✓	✓		✓	✓
ICT 5416	Ethical Hacking, Network Defense and Auditing	✓	✓			✓	✓	✓	✓
ICT 5417	Digital Forensic and Disaster recovery	✓	✓			✓	✓		
ICT 5418	Cyber Crime and Cyber Terrorism	✓	✓		✓	✓		✓	✓
ICT 5419	Robotics and Industrial Automation	✓	✓			✓	✓		
ICT 5420	Digital Product Design			✓	✓	✓	✓		✓
ICT 5421	Development Operations (DevOps)	✓	✓		✓	✓	✓		✓
ICT 5422	Legal Issues in ICT	✓	✓			✓	✓	✓	

ICT 5423	Recent Trends in ICT	✓	✓	✓		✓	✓	✓	✓
ICT 5198	Research Work-I	✓	✓	✓	✓	✓	✓	✓	✓
ICT 5199	Project Work-I	✓	✓	✓	✓	✓	✓	✓	✓
ICT 5298	Research Work-II	✓	✓	✓	✓	✓	✓	✓	✓
ICT 5200	Project Work-II	✓	✓	✓	✓	✓	✓	✓	✓
ICT 5300	Research Work-III	✓	✓	✓	✓	✓	✓	✓	✓

OUTCOME-BASED CURRICULUM

PART B

16. Structure of the Curriculum

M. Sc. in Information and Communication Technology shall extend over a period of one year (two semesters) for MSc by course work and one and half years (three semesters) for MSc by research.

a) Duration of the Program	MSc by Course Work	1.0 Year (2 Semester)
	MSc by Mixed Mode	1.5 Years (3 Semester)
b) Admission Requirements	All BSc in ICT students will be eligible for admission into MSc in ICT guided as per rules of the University. Admission of students shall be guided by the Admission Ordinance and the Examination Ordinance of the University.	
c1) Graduating Credits/ Total Minimum Credit Requirement to Complete the Program	MSc by Course Work	36
	MSc by Mixed Mode	40
c2) Available Credits	MSc by Course Work	36
	MSc by Mixed Mode	40
d) Total Class Weeks in a Term	14 Weeks	
e) Minimum CGPA Requirements for Graduation	2.50	
f) Maximum Academic Years of Completion	How long a student shall be permitted to continue as a Master's Degree candidate will be decided by the rules of the University.	

Each year will be divided into two semesters and each semester will have a duration of six months. Students shall be evaluated in each semester. A semester will be segmented into Class-weeks,

Preparatory leave, and Semester-end examination. The total time distribution for completing a semester will be as follows:

Semester Duration		
SL	**Segment**	**Length**
01	Class	14 Weeks
02	Preparatory Leave	2 Weeks
03	Semester-end Examination	3 Weeks
04	Result Publishing	4 Weeks
Total		**23 Weeks**

g1) Area-wise Credit Distribution

Area	Course Type	Number of Courses	Credits	Total Credits
General Education (GED) Courses**	MSc by Mixed Mode	01	2.00	2.00
Core/ Compulsory Courses	MSc by Course Work	05	15.00	6.00
	MSc by Mixed Mode	04	12.00	12.00
Optional/Elective Courses (Theory)	MSc by Course Work	05	15.00	15.00
	MSc by Mixed Mode	02	6.00	6.00
Capstone Courses***	MSc by Course Work	02	6.00	6.00
	MSc by Mixed Mode	03	20.00	20.00
Total	MSc by Course Work	12	36.00	36.00
	MSc by Mixed Mode	10	40.00	40.00

g2) Category of Courses

Area	Course Type	Course Title Credits		Credits
General Education (GED) Courses	Theory	MSc by Mixed Mode	1. Research Methodology and Ethics	2.00
Core/ Compulsory Courses	Theory	MS**c** by Course Work	1. Probability & Stochastic Process 2. Cloud Computing 3. Internet of Things 4. Cyber Security and Cryptocurrency 5. Advanced Machine Learning	15.00
		MSc by Mixed Mode	1. Probability & Stochastic Process 2. Cloud Computing 3. Internet of Things 4. Advanced Machine Learning	12.00
Optional/Elective Courses	Theory	MSc by Course Work	Any five (05) offered courses	15.00
		MSc by Mixed Mode	Any Three (02) offered courses	6.00
Capstone Courses	Research/ Project	MSc by Course Work	Project Work-I Project Work-II	6.00
		MSc by Mixed Mode	Research Part I Research Part II Research Part III	20.00
Total	MSc by Course Work			36.00
	MSc by Mixed Mode			40.00

17. Year/Semester-wise Distribution of Courses

Semester 1							
MSc by Mixed Mode				MSc by Course Work			
Course Code	Course Title	Credit	Contact Hours/ Week	Course Code	Course Title	Credit	Contact Hours/ Week
ICT 5101	**Probability & Stochastic Process**	3	3	ICT 5101	**Probability & Stochastic Process**	3	3
ICT 5102	**Cloud Computing**	3	3	ICT 5102	**Cloud Computing**	3	3
ICT 5103	**Internet of Things**	3	3	ICT 5103	**Internet of Things**	3	3
ICT 54XX	From Option	3	3	ICT 54XX	From Option	3	3
ICT 54XX	From Option	3	3	ICT 54XX	From Option	3	3
ICT 5198	Research Work-I	3	3	ICT 5199	Project Work-I	3	3
Total		**18**		**Total**		**18**	

Semester 2							
MSc by Mixed Mode				MSc by Course Work			
Course Code	Course Title	Credit	Contact Hours/ Week	Course Code	Course Title	Credit	Contact Hours/ Week
ICT 5201	**Advanced Machine Learning**	3	3	ICT 5201	**Advanced Machine Learning**	3	3
ICT 5298	Research Work-II	8	8	ICT 5202	**Cyber Security and Cryptocurrency**	3	3
Total		**11**		ICT 54XX	From Option	3	3
				ICT 54XX	From Option	3	3
				ICT 54XX	From Option	3	3
				ICT 5200	Project Work-II	3	3
				Total		**18**	

Semester 3			
MSc by Mixed Mode			
Course Code	Course Title	Credit	Contact Hours/ Week
ICT 5301	Research Methodology and Ethics	2	2
ICT 5300	Research Work-III	9	9
Total		**11**	

Optional Courses			
Course Code	**Course Title**	**Credit**	**Contact Hours/ Week**
ICT 5401	Information Systems and Securities	3.00	3.00
ICT 5402	Advanced Wireless and Cellular Communications	3.00	3.00
ICT 5403	Big Data Analytics	3.00	3.00
ICT 5404	Information Retrieval	3.00	3.00
ICT 5405	Applied Cryptography	3.00	3.00
ICT 5406	Information Theory & Coding	3.00	3.00
ICT 5407	Advanced Satellite Communication	3.00	3.00
ICT 5408	High Speed Computer Networks	3.00	3.00
ICT 5409	Digital Integrated Systems Design	3.00	3.00
ICT 5410	Project Management and Quality Assurance	3.00	3.00
ICT 5411	Leadership and Human Resources Management	3.00	3.00
ICT 5412	Geographical Information Systems	3.00	3.00
ICT 5413	Natural Language Processing	3.00	3.00
ICT 5414	Health Informatics	3.00	3.00
ICT 5415	Management Information System	3.00	3.00
ICT 5416	Ethical Hacking, Network Defense and Auditing	3.00	3.00
ICT 5417	Digital Forensic and Disaster recovery	3.00	3.00
ICT 5418	Cyber Crime and Cyber Terrorism	3.00	3.00
ICT 5419	Robotics and Industrial Automation	3.00	3.00
ICT 5420	Digital Product Design	3.00	3.00
ICT 5421	Development Operation (DevOps)	3.00	3.00
ICT 5422	Legal Issues in ICT	3.00	3.00
ICT 5423	Recent Trends in ICT	3.00	3.00

18. Course Description

Course Code: ICT 5101	Year: MSc	Term: 1st
Course Title: Probability & Stochastic Process		
Course Status: Compulsory		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course covers the fundamentals and tools for probabilistic modeling and stochastic process in a diverse range of Information and communication fields as well as signals processing.	

	Course Contents	CLOs
1	Probability: Classical, relative frequency and axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes' Theorem and independence.	1
2	Random Variables, Expectation of a Random Variable and Jointly Distributed Random Variables, Conditional Probability and Conditional Expectation, expectation. Inequalities, Characteristic function.	1,2
3	Convergence of random sequences, Types of convergences. Law of large numbers. Central limit theorem.	2
4	Discussion of the exponential distribution and the Poisson process. General definition of counting processes. Generalizations of the Poisson process.	3
5	Renewal theory and its application. Queuing theory. Reliability theory and its applications. Brownian motion and stationary processes.	5
6	Definition and classification of stochastic processes, continuous time Markov Chain, Poisson process, birth and death process, applications to queues, discrete time Markov chains.	3,4,5
7	Linear transformations of stationary processes. Doob decomposition. Stochastic Karhunen-Loeve expansions. Campbell Theorem.	5
8	Statistical signal processing. Kalman filter. Wiener filter for random sequences. Stochastic simulation.	5

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand the definition of probability and stochastic process.	1,2
	CLO2	Understand the important concept of the random variable and its manipulation	1,2
	CLO3	Apply the stochastic processes through probabilistic experiment	3,6
	CL04	Understand Markov chain and its transition matrix.	1,2

	CLO5	Apply different theories, stochastic process in Signal processing, Network Engineering, and business.	5,6,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO2	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO3	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO4	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO5	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Introduction to Probability Models by AP, - Sheldon M. Ross (2010); 10th Edition. 2. Probability and Measure by Wiley (1995) - Billingsley, P.; 3rd Edition. 3. Intuitive Probability and Random Processes using MATLAB by Kay, S; Springer (2005). 4. Introduction to Random Processes in Engineering by Balakrishnan, A. V.; Wiley (2005). 5. Probability and Measure by Billingsley, P.; 3rd Edition Wiley (1995). 6. Random Processes for Image Signal Processing by Dougherty, E. R; Wiley-IEEE Press (1998). 7. Statistical Signal Processing- D.H. Johnson. Rice University (2013)

Course Code: ICT 5102	Year: MSc	Term: 1st

Course Title: Cloud Computing

Course Status: Compulsory

Credit: 3.0

Prerequisite(s): None

Rationale	The student will learn about the cloud environment, building software systems and components that scale to millions of users in modern internet, distributed system which is the basic platform behind cloud computing, cloud concepts capabilities across the various cloud service models including Iaas,Paas,Saas, and developing cloud based software applications on top of cloud platforms.

	Course Contents	CLOs
1	Cloud Computing: At a glance (vision, challenge, reference models, deployment models, characteristics and benefits)	1
2	Historical Development of Cloud Computing (Client-Server Computing, Computing Paradigm, Distributed System, Mobile and Ubiquitous Computing, System Models for Distributed Computing, Design Challenges of Distributed Computing)	1
3	Principle of Parallel and Distributed Computing (Eras of Computing, Parallel vs. Distributed Computing, Elements of Distributed Computing, architecture of Distributed Computing, Technology concept of Distributed Computing)	1
4	Cloud Computing: in Depth (Essential Characteristics of Cloud Computing, Central Idea, SOA, SLA)	1
5	Cloud Computing Architecture & Management (Cloud Architecture, Anatomy of Cloud, Network Connectivity in Cloud, Feature of Cloud Application, Cloud Migration)	1,2
6	SOA (Components of SOA, Benefits of SOA, SOA architecture)	1,3
7	Virtualization (Characteristics of Virtualized Environment, Taxonomy of Virtualized Technique, Virtualization and Cloud Computing, Pros and Cons of Virtualization, Technology Examples)	1,3
8	Cloud Computing Requirement & Deployment Model (Industrial and End User Benefits from Cloud, Cloud Computing Service model, Cloud Computing Deployment Model)	1,2
9	Data-Intensive Computing (Introduction, Technologies for Data-Intensive Computing, MapReduce Programming)	5
10	Cloud Platforms in Industry (Amazon Web Service, Google AppEngine, Microsoft Azure)	2,4
11	Fog Computing	1
12	Cloud Applications Development	2

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	**Explain** the **core concepts** of the cloud computing paradigm: how and why this paradigm shift came about, the characteristics, advantages and challenges brought about by the various models and services in cloud computing, the core concept of distributed and parallel computing and their design	1, 2

		architecture, Challenges of building distributed system, Computing paradigm.	
	CLO2	**Apply** fundamental concepts in **cloud infrastructures** to understand the tradeoffs in power, efficiency and cost, and then study how to leverage and manage single and multiple datacenters to build and deploy cloud applications that are resilient, elastic and cost-efficient.	6
	CLO3	**Discuss system, network and storage** virtualization and outline their role in enabling the cloud computing system model, **Discuss** detail concept of **SOA**	1
	CLO4	**Illustrate** the fundamental concepts of **cloud storage** and demonstrate their use in storage systems such as Amazon S3 and HDFS.	5,6
	CLO5	**Analyze** various **cloud programming models** and **apply** them to solve problems on the cloud.	8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO2	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO3	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO4	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO5	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Rajkumar Buyya, Christian Vecchiola, S. T. Selvi -Mastering Cloud Computing, MK (Elsevier Science), 9780124095397 2. Andrew S. Tanenbaum - Distributed System: Principle and Paradigm

Course Code: ICT 5103	Year: MSc	Term: 1st

Course Title: Internet of Things

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course covers the foundations of Internet of things and protocols and introduces some of the application areas where Internet of Things can be applied. Students will also learn about the middleware for the Internet of Things.

	Course Contents	CLOs
1	**IOT:** What is the Internet of Things (IOT), Different parts or components of IOT Elements of an IOT Ecosphere, Technology. Trends of IOT and implications, Overview of Governance, Privacy and Security Issues. Architectural formation and communication models.	1
2	**RFID Technology:** Principle of RFID, Components of an RFID system, RFID Applications. **Wireless Sensor Networks**: The node, Connecting Nodes, Securing Communication. **Power line Communication technologies:** PLC technologies and standards, Architectures for home network applications, IOT using PLC technology.	2
3	**Cloud Computing:** Cloud Computing Services. Middleware and Big Data.	2
4	**HTTP:** basics of the HTTP protocol, use of HTTP in IoT applications, request/response, and event subscription communication patterns, **UPnP:** basics of the UPnP protocol, use of UPnP to discover devices in an ad hoc local area network, build devices that publish such discoverable services and events.	3
5	**CoAP:** Basic, Adding CoAP to sensor, actuator and using CoAP in controller. **MQTT protocol:** Basic, Adding MQTT support to sensor, actuator and controller.	3
6	Applications on Smart Cities, Industrial Internet of Things (IIoT), Smart Grids, Smart Homes, Smart Agriculture, Smart Health, Smart Mobility, Smart Environment	4

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Describe IoT components, architectural formation, and communication models.	1,3
	CLO2	Describe IoT technologies RFID, WSN, Cloud Computing, Big Data, Middleware.	1,3
	CLO3	Describe HTTP, UPnP, CoAP, MQTT protocols.	1,3
	CL04	Analyze IoT applications on Smart Cities, Industrial Internet of Things (IIoT), Smart Grids, Smart Homes, Smart Agriculture, Smart Health, Smart Mobility, Smart Environment, etc.	2,5,6,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO2	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture, presentation, and Group Discussion	Continuous Assessment, Assignment and Final Exam.

Learning Materials

Recommended Textbook	1. The Internet of things: connecting objects to the web / edited by Hakima Chaouchi. ISBN 978-1-84821-140-7 2. Learning Internet of Things, Peter Waher, PACKT Publishing, 2015 3. Distributed and Cloud Computing, Kai Hwang, Geoffrey C. Fox, Jack J. Dongarra, Elsevier, 2012 4. Internet of Things and Data Analytics Handbook, Hwaiyu Geng, John Wiley & Sons, 2017. 5. Principles of Internet of Things (IoT) Ecosystem: Insight Paradigm, Sheng-Lung Peng, Souvik Pal, Lianfen Huang, Springer, Intelligent Systems Reference Library, Volume 174.

Course Code: ICT 5201	Year: MSc	Term: 2nd
Course Title: Advanced Machine Learning		
Course Status: Compulsory		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course introduces some advanced machine learning concepts, learning problems and algorithms to provide understanding and simple answers to many questions arising from data explanation and generalization.	

	Course Contents	CLOs
1	**Introduction to Advanced Machine Learning:** Non-parametric Bayesian methods, PAC learning, Kernel Methods, Meta-Learning, Active Learning, Kernel Methods, Gaussian Processes	1,2
2	**Classification:** Installation, The MNIST, Measures of Performance, Confusion Matrix, Recall, Recall Tradeoff, ROC, Multi-class Classification, Training a Random Forest Classifier, Error Analysis, Multi-label Classifications, Multi-output Classification	2
3	**Deep Learning:** Deep Learning Intuition, GANs, Hyperparameter Tuning, Batch Normalization, Deep Convolutional Models, convolutional layer, Visualizing and Understanding Convolutional Networks, Deep Inside Convolutional Networks: Visualizing Image Classification Models and Saliency Maps, Understanding Neural Networks Through Deep Visualization, Learning Deep Features for Discriminative Localization	2,4
4	**Transfer Learning:** Layer kernel, feature collection methods, Deep neural data visualization, explainable layer, LIME, SHAP visualization	2,3, 5
5	**Monte Carlo Basics:** Markov Chain Monte Carlo, Advanced MCMC, MCMC Practicalities, Latent Dirichlet Allocation, State Space Models, Kernels, Gaussian Processes, Practical Gaussian Processes, Dirichlet Processes I, Dirichlet Processes II, Boltzmann Machines	4
6	**Recent trends in Machine Learning:** Advanced Neural Network, Timeseries Processing, Transformer Networks, Semantic Segmentation, Generative Models, Generative Adversarial Networks, Model Interpretation	1, 3, 5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understanding in advanced machine learning techniques.	1,2
	CLO2	Understand classification methods, performance measures, and deep learning concepts	1,2
	CLO3	Apply recent trends such as transformer networks, generative models, and model interpretation, to address modern challenges in data analysis.	5,8
	CLO4	Understand the nature of the statistical foundations of designing or adapting learning algorithms	5,6
	CLO5	Use of visualization tools and interpretability methods like LIME and SHAP to explain complex models and improve model transparency ensuring ethical and responsible deployment of machine learning solutions.	6,7

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Interactive lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO3	Interactive lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO4	Interactive lecture, problem-solving, question, and answer session	Class Test, Presentation and Final Exam
CLO5	Interactive lecture, discussion, groupwork, question, and answer session	Class Test, Presentation and Final Exam

Learning Materials

Recommended Books	1. Aurélien Géron (2019) Hands-On Machine Learning with Scikit-Learn and TensorFlow (Concepts, Tools 2. Techniques to Build Intelligent Systems), 2nd Edition, ISBN-13: 978-1492032649, O'Reilly Media 3. Ian Goodfellow, Yoshua Bengio and Aaron Courville (2016) Deep Learning, ISBN-13: 978-0262035613, MIT Press 4. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems 3rd Edition, Publisher: O'Reilly Media

Course Code: ICT 5202	Year: MSc	Term: 2nd

Course Title: Cyber Security and Cryptocurrency

Course Status: Compulsory

Credit: 3.0

Prerequisite(s): None

Rationale	This course covers a deep understanding of the security challenges and risks associated with digital currencies like Bitcoin and blockchain technology. They will also learn how to implement robust security measures to protect against cryptocurrency-related threats, ensuring safe and ethical participation in the evolving world, as well as the importance of governing principles in cyber security.

	Course Contents	CLOs
1.	**Introduction to Information Security Fundamentals:** Protecting Your Computer and its Contents. Securing Computer Networks–Basics of Networking; Compromised Computers; Secure Communications and Information Security Best Practices; Privacy Guidelines; Safe Internet Usage.	1
2.	**Ethics in Cybersecurity & Cyber Law:** Privacy; Intellectual Property; Professional Ethics; Freedom of Speech; Fair User and Ethical Hacking; Trademarks; Internet Fraud; Electronic Evidence; Cybercrimes.	1
3.	**Forensics:** Forensic Technologies; Digital Evidence Collection; Evidentiary Reporting; Network Assurance: Layered Defense; Surveillance and Reconnaissance; Outsider Thread Protection.	2
4.	**Secure Software & Browser Security:** Software Construction; Software Design and Architecture; Software Testing; Methodologies; The New Universal Client; The Web Model; Cookies and Browser Storage; HTML5 Security;	3
5.	**Business Information Continuity:** Managing a Business Information Continuity Plan; Vulnerabilities and Controls; The Law and Business Information Continuity Plan. **Information Risk Management:** Asset Evaluation and Business Impact Analysis; Risk Identification; Risk Quantification; Risk Response Development and Control; Security Policy, Compliance, and Business Continuity.	3
6.	**Cyber Incident Analysis and Response:** Incident Preparation; Incident Detection and Analysis; Containment, Eradication, and Recovery; Proactive and Post-Incident Cyber Services.	3
7.	Intro to cryptography & crypto currencies: Nakamoto consensus. Bitcoin's protocols: Block Chain, Transactions, P2P Network;	4
8.	Bitcoin applications & security: Contracts, Wallets, Usability of Bitcoin Key Management;	4
9.	Bitcoin mining: Mining, Bitcoin and the Age of Bespoke Silicon; Bitcoin mining strategy & attacks; Bitcoin community, economics & politics;	4,5
10	Extensions and altcoins: Alternative approaches to mining & consensus; Bitcoin-NG; Anonymity, traceability & mixing; Privacy-enhancing & zero-knowledge cryptocurrencies; Overview of altcoins.	4,5
11	Cryptocurrencies & the real world: Legal aspects of virtual currency, post-quantum crypto, seg wit & aggregate signatures; Smart property, data feeds, and public randomness; Applications of cryptocurrencies and blockchains in traditional finance	5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand cyber security threats, technologies, cyber law and management practices within public and private sectors.	1,2
	CLO2	Analyze digital evidence collection, and evidentiary reporting in forensic acquisition.	2,4
	CLO3	Apply approaches to secure networks, firewalls, intrusion detection systems, intrusion prevention systems and risk management, response for cyber incident.	6
	CL04	Understand the concepts of a crypto currencies, Bitcoins, Block Chain, Bitcoin mining and altcoins.	1,2
	CLO5	Analyze Bitcoin mining strategy, attacks and legal aspects of virtual currency.	5,7

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions	Class Tests, Assignments, Final Examination
CLO2	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
CLO3	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
CLO4	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
CLO5	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination

Learning Materials

Recommended Textbook	1. Cybersecurity and Cyberwar: What Everyone Needs to Know by Allan Friedman and P. W. Singer. 2. Hacking Exposed: Network Security Secrets & Solutions by Joel Scambray. 3. Cybersecurity incident management masters guide: Volume 1 - Preparation, Threat Response, & Post-Incident Activity(2020) by Colby A Clark , Ireland J Clark. 4. Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction by Narayanan, Bonneau, Felten, Miller and Goldfeder. 5. The Basics of Bitcoins and Blockchains by Antony L

Course Code: ICT 5301	Year: MSc	Term: 3rd

Course Title: Research Methodology and Ethics

Course Status: GED

Credit: 2.0

Prerequisite(s): None

Rationale	This course is designed to establish or advance the understanding of research through critical exploration of research language, ethics, and approaches. The course introduces the language of research, ethical principles and challenges, and the elements of the research process. This course also provides fundamental concepts of engineering ethics and the relationship between technology, moral and social values.

	Course Contents	CLOs
1	Nature of the research process, types of research, ethics of research: voluntary participation, anonymity and confidentiality, deceiving subjects, analysis and reporting.	1,4
2	Research proposal, planning, purposes of research: exploration, description, explanation, 'hard-data' focus, 'soft-data' focus, conceptualization; some practical considerations: time, venue, instrument to be used etc, research team, interviewers, willingness of respondents to participate.	1,2,3
3	Data collection: four levels of evaluation, levels of data collection/unit of analysis, data analysis and interpretation.	2
4	Report writing: academic writing, technical writing; feedback sessions	3
5	Introduction to morals, values and ethics, integrity, work ethic, service learning, civic virtue, respect of others.	5
6	The processes of living peacefully, caring, sharing, honesty, courage, valuing time, cooperation, commitment, empathy, Self-confidence, character, spirituality.	5,6
7	Introduction to Yoga and meditation for professional excellence and stress management.	6,7
8	Senses of "Engineering Ethics", variety of moral issues, types of inquiry, moral dilemmas, moral autonomy, Kohlberg's theory, Gilligan's theory, consensus of controversy, models of professional roles, theories about right action, self-interest, customs and religion, uses of ethical theories.	7

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate knowledge of research processes (reading, evaluating, and developing);	1
	CLO2	Identify, explain, compare, and prepare the key elements of a research proposal/report;	5
	CLO3	Define and develop a possible research interest area using specific research designs;	3,6
	CL04	Explain the rationale for research Ethics	7

	CLO5	Understand the basic perception of profession, professional ethics and various moral issues.	3,7,8
	CLO6	Understand various social issues and evaluate the effects of the use of technology on social culture, economic, legal, health welfare of the society.	3,8
	CLO7	Identify and evaluate the effects of the use of technology on environment.	3,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions	Class Test, Presentation and Final Exam
CLO2	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO3	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO4	Interactive lectures, Discussions	Class Test, Presentation and Final Exam
CLO5	Interactive lectures, Discussions	Class Test, Presentation and Final Exam
CLO6	Interactive lectures, Discussions	Class Test, Presentation and Final Exam
CLO7	Interactive lectures, Discussions	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, SAGE Publications Ltd, 3rd Edition, 2010. 2. Research Methods for Science, Michael P. Marder, Cambridge University Press, 1st Edition, 2011. 3. An Introduction to Scientific Research, E. Bright Wilson, Dover Publications; Rev Sub Edition, 1991. 4. Engineering, Ethics, and the Environment, P. Aarne Vesilind, Alastair S. Gunn, Cambridge University Press, 1998. 5. Professional Ethics and Human Values, A. Alavudeen, R. Kalil Rahman, M. Jayakumaran, Firewall Media, 2008 6. Ethics and Science: An Introduction, Adam Briggle, Carl Mitcham, Cambridge University Press, 2012

Optional / Elective Courses

Course Code: ICT 5401	Year: MSc	Term: Optional
Course Title: Information Systems and Securities		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course covers the concepts and issues related to securing information systems and the development of policies and mechanisms to implement advanced security services.	

	Course Contents	CLOs
1.	**Overview of Information System:** History of Information Systems and its Importance, Basic Concepts and Terminologies, Changing Nature of Information Systems.	1
2.	**Principles of Information Security:** Security Goals of Information- Confidentiality, Integrity Availability, Information Security Threats and Attacks, Security Services and Mechanisms, Security in Mobile and Wireless Computing, Security Challenges in Mobile Devices, Authentication Service Security, Security Implication for Organizations, Laptops Security Basic, Security Technology- Firewalls and VPNs, Intrusion Detection and Prevention Systems.	1,2
3.	**Access Control:** Types and Parts of Access Control, Threats to Access Controls, Effects of Access Control Violations. Malicious Attacks,	2
4.	**Threats and Vulnerabilities:** Classification of Threats and Assessing Damages, Security Breach, Malicious Software, Countermeasures.	2, 3
5.	**Intellectual Property Right (IPR):** Concept of Virtual Property, Trademarks, Copyrights, Patents, Data Protection Laws, Plagiarism, Software Piracy, Issues in Data and Software Privacy, Requirements of a Website, E-Marketing, E-Advertising, Online Payment Collection System, Legal,	4
6.	**Ethnical and Professional Issues in Information Security:** Legal Dimensions in Cyber World, IT Acts and Cyber Crime, IT Act, Information Assurance and E-Governance, ICT Act, ICT Policy, Trademark, Copyright and Patent Law of Bangladesh.	4
7.	**Cryptography and Steganography:** Brief History, Basic Concepts and Terminologies, Business and Security Requirement, Applications and Uses in Information System Security, Cryptographic Hash Functions, Digital Signatures and Certificate Authorities. Integrity,	5
8.	**Authentication and Key Management:** Message Integrity and Message Authentication; Passwords, Challenge-Response, Zero-Knowledge and Biometric Authentications; Symmetric and Public-key Distributions; Information Security Standards: NIST, ISO, IEC, W3C, IETF, ITU-T, ANSI	5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand the basic practice of information systems, especially in evaluation of information systems security risks across diverse settings.	1, 2
	CLO2	Analyze idea that Information Security answers are not always known, and proposed solutions could give rise to new, equally complex problems.	3
	CLO3	Discover through the language and other dimensions of the field of information security to expand knowledge, skills and their application.	3,4
	CL04	Analyze the ethical considerations in all judgments and decisions in academic and professional settings.	4
	CLO5	Evaluate software packages to explore the intricacies of cryptography, demonstrating comprehension the use of these and other tools in Information Security.	6,7

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer Session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer Session	Class Test, Presentation and Final Exam
CLO3	Lecture, discussion, question, and answer Session	Class Test, Presentation and Final Exam
CLO4	Lecture, discussion, question, and answer Session	Class Test, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer Session	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Fundamentals of Information Systems Security by David Kim, Michael G Solomon; 3rd Edition. 2. Principles of Information Security by Michael E Whitman, Herbert J Mattord; 4th Edition. 3. Cryptography and Network Security by Behrouz A Forouzan; 2nd Edition. 4. Cyber Law: The Law of the Internet by Jonathan Rosenoer. 5. Cyber Law in Bangladesh by Dr. Zulfiquar Ahmed.

Course Code: ICT 5402	Year: MSc	Term: Optional

Course Title: Advanced Wireless and Cellular Communications

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course covers advanced methods for analysis of wireless communication systems and the basic principles guiding their design.

	Course Contents	CLOs
1	**Fundamentals:** General Structure of 4G Signals; Next Generation Internet; Cloud Computing and Network Virtualization; Wireless Grids and Clouds,	1
2	**Adaptive Coding:** Adaptive and Reconfigureable Block Coding/Convolutional coding; Concatenated Codes with Interleavers; Distributed Source Coding. **Adaptive and Reconfigureable Modulation; Space time coding.**	1
3	**Multiuser Communication:** Pseudorandom Sequences; Multiuser CDMA Receivers; MMSE Linear Multiuser Detection; Single User LMMSE Receivers for Frequency Selective Fading Channels; Signal Subspace-Based Channel Estimation for CDMA Systems; Iterative Receivers for Layered Space Time Coding.	1
4	**Channel Estimation and Equalization:** LMS equalizer; Turbo Equalization; Kalman Filter Based Joint Channel Estimation and Data Detection Over Fading Channels.	2
5	**Ultra Wide Band Radio; Linear Precoding for MIMO Channels:** Space Time Precoders and Equalizers for MIMO Channels,	3
6	**Advanced Wireless Networks:** Cognitive Networks; Relay-Assisted Wireless Network. **Biologically Inspired Paradigms in Wireless Networks:** MANET; Wireless Sensor Network.	3
7	**6G Future Vision:** Requirements, Design Issues and Applications	4
8	**5G Innovation** – Using New Technical Capabilities to Explore New Use-Cases	4
9	**Enhanced Massive Machine Type Communications for 6G Era**	4

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand various techniques of cellular & wireless technologies.	1, 2
	CLO2	Apply the major wireless communication standards for Channel Estimation and Equalization.	6
	CLO3	Analyze Linear Precoding for MIMO Channels, Ultra-Wide Band Radio; Cognitive Networks; Relay-Assisted Wireless Network; MANET; Wireless Sensor Network; Biologically Inspired Paradigms in Wireless Networks.	5
	CLO4	Analyze new use cases for 5G and 6G technologies	5, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer Session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer Session	Class Test, Presentation and Final Exam
CLO3	Lecture, discussion, question, and answer Session	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Advanced Wireless Communication and Internet by Savo G. Glisi, Willy; 3rd Edition. 2. Channel Coding for Telecommunications by Martin Bossert; Willy. 3. Recent Advances in Wireless Communications and Networks by IntechOpenU, Madhow. 4. Fundamentals of Digital Communication by Cambridge University Press; 2008. 5. Digital Communications by J. G. Proakis, McGraw-Hill, 2001; 4th Edition. 6. Principles of Communication Engineering by J. M. Wozencraft and I. M. Jacobs; Wiley, 1965. 7. Digital Modulation and Coding by Stephen G. Wilson; Pearson Education (Asia) Pte. Ltd. 2003. 8. Wireless Digital Communications: Modulation and Spread Spectrum Applications by Kamilo Feher; Prentice-Hall of India, 2004.

Course Code: ICT 5403	Year: MSc	Term: Optional

Course Title: Big Data Analytics

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course covers the most crucial information technologies for handling, storing, and analyzing large data. Students will learn some machine learning techniques as well as the fundamental R and Python statistical analysis tools.

	Course Contents	CLOs
1.	Basic Statistics and R.	1
2.	Relationships and Representations, Graph Databases.	1
3.	Introduction to Spark 2.0. Language processing with Spark 2.0. Introduce one of NoSQL databases for fast storage and retrieval of big volumes of textual data.	1
4.	Analysis of Streaming Data with Spark 2.0. Introduce a special messaging system (Kafka) which is a necessary buffer between actual data sources and Spark processing engine.	1
5.	Applications of Spark ML Library.	2
6.	Basic Neural Network and Tensor Flow. Learn how to use Tensor Flow both on GPU and CPU machines.	2
7.	Assessing Quality of Big Data Analysis. Learn also learn how to access precision of other large-scale calculations.	1,3
8.	Analysis of Images, OCR Applications. Learn how to use some standard API-s to perform such analysis at big data speed.	1,3
9.	Page Rank like Search systems. Searching through large volumes of textual data at very high speed is what made Google.com possible.	1,3
10.	Analysis of Streaming Data with Tensor Flow, VoltDB, Data Flow Engines and other memory databases.	1,3

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand brief idea of Statistics, R and Spark 2.0	2
	CLO2	Analyze and develop using Spark ML Library and Tensor Flow.	5,6,8
	CLO3	Evaluate quality of Big Data Analysis, Page ranking mechanism analysis	6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecturing, Discussions, Problem solving	Quiz, Class Test
CLO2	Interactive lecturing, Visualization, Discussions, Cooperative learning	Assignment, Class Test
CLO3	Presentations	Group Study , Final Project Presentations

Learning Materials

Recommended Textbook	1. Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses Authors: Michael Minelli, Michele Chambers, Ambiga Dhiraj Publisher: John Wiley & Sons, 2013 ISBN: 111814760X 2. Data Analytics and Big Data Authors: Soraya Sedkaoui Publisher: John Wiley & Sons, 2018 ISBN: 1786303264 3. Analytics in a Big Data World by Bart Baesens; Wiley. 4. Data Analytics by Dr. Anil Maheshwari; 2021 Edition. 5. Learn Analytics by Alistair Croll& Benjamin Yoskovitz; Eric Ries Series Editor.

Course Code: ICT 5404	Year:	MSc	Term: Optional
Course Title: Information Retrieval			
Course Status: Optional			
Credit: 3.0			
Prerequisite(s): None			
Rationale	The course covers a basic understanding of Information Retrieval and machine learning techniques for text classification and clustering, as well as practical knowledge on search engine systems and recommender systems for real-world scenarios.		

	Course Contents	CLOs
1.	**INTRODUCTION:** Information Retrieval – Early Developments – The IR Problem – The User's Task – Information versus Data Retrieval - The IR System – The Software Architecture of the IR System – The Retrieval and Ranking Processes - The Web – The e-Publishing Era – How the web changed Search – Practical Issues on the Web – How People Search – Search Interfaces Today – Visualization in Search Interfaces.	1
2.	**MODELING AND RETRIEVAL EVALUATION:** Basic IR Models - Boolean Model - TF-IDF (Term Frequency/Inverse Document Frequency) Weighting - Vector Model – Probabilistic Model – Latent Semantic Indexing Model – Neural Network Model – Retrieval Evaluation – Retrieval Metrics – Precision and Recall – Reference Collection – User-based Evaluation – Relevance Feedback and Query Expansion – Explicit Relevance Feedback.	2
3.	**TEXT CLASSIFICATION AND CLUSTERING:** A Characterization of Text Classification – Unsupervised Algorithms: Clustering – Naïve Text Classification – Supervised Algorithms – Decision Tree – k-NN Classifier – SVM Classifier – Feature Selection or Dimensionality Reduction – Evaluation metrics – Accuracy and Error – Organizing the classes – Indexing and Searching – Inverted Indexes – Sequential Searching – Multi-dimensional Indexing	2
4.	**WEB RETRIEVAL AND WEB CRAWLING:** The Web – Search Engine Architectures – Cluster based Architecture – Distributed Architectures – Search Engine Ranking – Link based Ranking – Simple Ranking Functions – Learning to Rank – Evaluations -- Search Engine Ranking – Search Engine User Interaction – Browsing – Applications of a Web Crawler – Taxonomy – Architecture and Implementation – Scheduling Algorithms – Evaluation.	3
5.	**RECOMMENDER SYSTEM:** Recommender Systems Functions – Data and Knowledge Sources – Recommendation Techniques – Basics of Content-based Recommender Systems – High Level Architecture – Advantages and Drawbacks of Content-based Filtering – Collaborative Filtering – Matrix factorization models – Neighborhood models.	4

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand the basic concepts and techniques in Information Retrieval and use of open search engine framework.	2,3
	CLO2	Apply IR models and appropriate method of text classification or clustering.	1,2,5
	CLO3	Design and implement innovative features in a search engine	5,6
	CLO4	Design and implement effective recommendation engines for real-world scenarios	1,2,3,5

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Ricardo Baeza-Yates and Berthier Ribeiro-Neto, —Modern Information Retrieval: The Concepts and Technology behind Search, Second Edition, ACM Press Books, 2011. 2. Ricci, F, Rokach, L. Shapira, B.Kantor, —Recommender Systems Handbook, First Edition, 2011. 3. C. Manning, P. Raghavan, and H. Schütze, —Introduction to Information Retrieval, Cambridge University Press, 2008. 4. Stefan Buettcher, Charles L. A. Clarke and Gordon V. Cormack, —Information Retrieval: Implementing and Evaluating Search Engines, The MIT Press, 2010.

Course Code: ICT 5405	Year: MSc	Term: Optional
Course Title: Applied Cryptography		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course offers a comprehensive introduction to Modern Cryptography, and, specifically, its main problems, formalisms, solutions, and open questions, with a heavy focus on application aspects, including case studies for real-life uses of Modern Cryptography solutions.	

	Course Contents	CLOs
1.	Introduction, Attacks on crypto, Crypto history, One time pad, Perfect secrecy, Stream ciphers, Semantic security	1,3
2.	Block ciphers, DES, Attacks on block ciphers, AES, Using block ciphers, EBC, CBC, CTR	1
3.	Message integrity, MAC, Collision resistance, Authenticated encryption	2
4.	Basic key exchange, Number theory review, Public key crypto intro, RSA, El Gamal	2
5.	Key management and distribution, Digital signatures, Digital certificates, PKI, Identity based encryption	2
6.	Identification and authentication, Zero knowledge protocols, Kerberos, Electronic mail security	3
7.	Web and transport level security, IP security, Wireless network security, Anonymous communication, TOR, Cryptocurrencies, Bitcoin	3
8.	Hardware–based security, Physically Unclonable Function, Trusted Platform Module, Quantum cryptography	4

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand the basic concepts underlying classical and modern cryptography, and the fundamentals.	1,2
	CLO2	Understand how security is defined and proven at the cryptographic level.	3,7
	CLO3	Understand common attacks and how to prevent them.	3,6,8
	CL04	Apply appropriate cryptographic techniques to a security engineering (and management) problem at hand.	1,2,3,4,7,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO2	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture, presentation, and Group Discussion	Continuous Assessment, Assignment and Final Exam.

Learning Materials

Recommended Textbook	1. Cryptography and Network Security: Principles and Practice (6th Edition) by William Stallings. 2. The Handbook of Applied Cryptography by Menezes, van Oorschot, and Vanstone. 3. "Introduction to modern cryptography" Jonathan Katz, Yehuda Lindell, Chapman & Hall/CRC, 2008. 4. "A Graduate Course in Applied Cryptography" Dan Boneh and Victor Shoup, 2020, http://toc.cryptobook.us/ 5. Ren J and Wu J. Survey on Anonymous Communications in Computer Networks. Computer Communications. 2010, 33(4): 420–431. 6. R. Dingledine, N. Mathewson, and P. Syverson. Tor: The second-generation onion router. In Proceedings of the 13 USENIX Security Symposium, August 2004.

Course Code: ICT 5406	Year: MSc	Term: Optional
Course Title: Information Theory and Coding		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course covers the concept of information theory and different types of coding and data encoding system.	

	Course Contents	CLOs
1.	Review of Probability theory, Introduction to Information Theory, Mutual information and Entropy.	1
2.	**Source coding:** Shannon Fano-Elias coding, Huffman coding, Arithmetic coding, LZ Code	1
3.	Image Compression, The JPEG Standard for Lossless Compression, The JPEG Standard for Lossy Compression, Video Compression Standards	2
4.	Channel capacity, Channel Coding, Information Capacity Theorem, Parallel Gaussian Channels, The Shannon Limit, Channel Capacity for MIMO Systems, Capacity Region for Multiple Access Channels.	3
5.	**Channel Coding**: Basics about the channel coding, Linear Block codes, Low Density Parity Check (LDPC) Codes , Cyclic code.	4
6.	**Bose–Chaudhuri Hocquenghem (BCH) Codes**: Introduction to BCH Codes, Primitive Elements, Minimal Polynomials, Decoding of BCH Codes **Reed-Solomon** (RS) Codes: Implementation of Reed-Solomon Encoders and Decoders Performance of RS Codes Over Real Channels. **STBC:** Anatomy of Space-Time Block Code, Space-Time Code Design Criteria.Convolutional Codes.	5

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understanding the concept of information and source coding theorem.	1
	CLO2	Apply the knowledge of source coding application like image compression.	2
	CLO3	Analyze channel capacity mathematically and the capacity of a given channel.	2,6
	CL04	Understand the basics of error control coding.	1,2
	CLO5	Create different types of coding based on conventional coding	3,5,6,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions	Class Tests, Assignments, Final Examination
CLO2	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
CLO3	Interactive lecturing, Discussions, Class works	Class Tests, Assignments, Final Examination
CLO4	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
CLO5	Interactive lecturing, Discussions, Class works	Class Tests, Assignments, Final Examination

Learning Materials

Recommended Textbook	1. Ranjan Bose, Information Theory, Coding and Cryptography, Publication,2005 2. Elements of Information Theory by Thomas M. Cover, Joy A. Thomas, 2nd Edition 3. Coding and information theory by R. W. Hamming, Prentice Hall Inc.; 1980. 4. Essentials of Error-Control Coding by Jorge Castiñeira Moreira, Patrick Guy Farrell, ISBN: 978-0-470-02920-6 5. Error control coding by Costello.

Course Code: ICT 5407	Year: MSc	Term: Optional

Course Title: Advanced Satellite Communication

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course covers the history, launchers, orbits, frequencies, networks, equipment, bandwidth, applications, markets, regulations, and industry structure with solid understanding of how the satcom market is structured and the capabilities of the technology that makes it all possible.

	Course Contents	CLOs
1.	**Introduction**. History of satellite communications. The first satellite. How many satellites are there now? Today's satellite market. The Global VSAT Forum.	1
2.	**Applications**. Direct-To-Home (DTH) Television. Broadcast program distribution. Internet backhaul. Voice and data trunking. Mobile base station backhaul. Enterprise VSAT. Consumer broadband. Rural telephony. Satellite radio (DARS). Mobile satellite services (MSS). Mobile VSAT services. Transportable VSATs. Energy (oil and gas). Navigation. Tracking. Military. E-government. Other VSAT applications. Disaster preparedness. Earth observation.	1
3.	**Wireless concepts**. How wireless links work. Repeaters and base stations. Antennas are important. Coverage area.	2
4.	**Orbits and launches**. Gravity controls orbits. Ballistics experimenter. Orbit experimenter. Satellites in orbit (animated). Satellites viewed from the ground (animated). The great LEO vs. GEO debate. GEO satellite positions. Orbit slots. Co-location. Launch vehicles. Getting to orbit. Multiple payloads.	2
5.	**Spacecraft technology**. What is a satellite? How big is a satellite? What a satellite needs to function. Payloads. Transponders. Station keeping and lifetime. High throughput satellites (HTS).	2
6.	**Satellite links**. Link budgets and why they control the business model. What dish size is necessary? Spot beams. EIRP and G/T. Footprints and spot beams. Contours. Polarization. Pol frequency re-use. Circular polarization. Frequency bands. Rain fading and availability.	2
7.	**Network technologies**. Direct broadcast television. Program distribution. Point-to-point links. Star VSAT networks. Time Division Multiplexing (TDM). Time Division Multiple Access (TDMA). Mesh networks. One hop or two? Interoperability. Hybrid networks. Satellite radio (SDARS). GPS - how it works. LEO satellites for mobile service. GEO satellites for mobile service.	3
8.	**Ground equipment for GEO satcom**. Antennas for VSATs and large earth stations. RF electronics. Modems. VSAT electronics. Interoperability issues. Large antennas. High-power RF amplifiers. Up-down-converters. LNBs and LNAs. Modems. VSAT antennas. Receive only antennas. IRDs. VSAT indoor units. Video encoders.	3
9.	**Satellite Industry Structure**. Market chains for the VSAT market. Market chains for the DTH market. Market chains for the GMPCS market. Horizontal markets. Launch industry: major players in the industry; launch costs; insurance; launch market size; future trends. The spacecraft industry: satellite costs, major industry players, market size and trends. Satellite operators: the major global, regional, and DTH GEO satellite operators; satellite radio (DARS) operators; mobile satellite service operators. Service providers and integrators. Ground equipment market segments, sizes, and trends.	4
10.	**Regulatory issues**. How is satcom regulated? Frequency bands and regions. Slot allocation and coordination. Open skies. Earth station licenses. License fees.	4

	Regulated performance specifications. Type approvals and homologation. CE marking. Satellite operator verification and type approvals. Band sharing with fixed communications. Band sharing with mobile communications. Network licenses and restrictions. Local regulations. Radiation safety regulations.	

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand basics of satellite communication and applications of VSAT.	2,3
	CLO2	Understand satellite, wireless satellite links concepts and different types of satellite.	1,5
	CLO3	Apply communication theory, modulation techniques, multiple access technologies, error correction codes, telephone traffic analysis related to satellite communication.	3,5,6
	CL04	Analyze future trends of Satellite industry and regulatory issues.	4,6,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions	Class Tests, Assignments, Final Examination
CLO2	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
CLO3	Interactive lecturing, Discussions, Class works	Class Tests, Assignments, Final Examination
CLO4	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination

Learning Materials

Recommended Textbook	1. Satellite Communication Systems by M. Richharia, McGraw-Hill, 1999, ISBN: 0071342087; 2nd Edition. 2. Satellite Communications by Pelton, Joseph N., Springer. 3. Advanced Satellite Communications by William Andrew; 1st Edition. 4. Satellite Communications by Dennis Roddy; 4th Edition. 5. Modern Wireless Communications by Haykin, Moher; Pearson.

Course Code: ICT 5408	Year: MSc	Term: Optional

Course Title: High Speed Computer Networks

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course covers in-depth knowledge in various architecture, protocols and applications of major high-speed networking technologies, enabling students to apply these techniques to support real-time traffic and congestion.

	Course Contents	CLOs
1.	Introduction: A Brief Networking History, The Need for Speed and Quality of Service, Advanced TCP/IP and ATM Networks.	1
2.	Protocols and Network Fundamentals: Protocols and TCP/IP Suite: The Need for a Protocol Architecture, The TCP/IP Protocol Architecture, The OSI Protocol Architecture, Internetworking,	1
3.	Data Networks: Packet-Switching Networks, Frame Relay Networks, Congestion in Data Networks and Internets.	1
4.	High Speed Networks: Asynchronous Transfer Mode, ATM Protocol Architecture, ATM Logical Connections, ATM Cells, ATM Service Categories, ATM Adaptation Layer,	1
5.	High-Speed LANs: Fast Ethernet and Gigabit Ethernet, ATM LANs. Performance Modeling and Estimation: Overview of Probability and Stochastic Processes: Probability, Random Variables, Stochastic Processes, Queuing Analysis, Self-similar Traffic.	1,2
6.	End-System Traffic Management: Link-level Flow and Error Control: The Need for Flow and Error Control, Link Control Mechanisms, ARQ Performance,	2
7.	Transport-level Traffic Control: Transmission Control Protocol (TCP), TCP Congestion Control, Performance of TCP over ATM, Real-time Transport Protocol.	3
8.	Network-Traffic Management: Internetwork traffic management: The Internet Protocol (IP), IPv6, Integrated Services Architecture (ISA), Queuing Discipline, Random Early Detection.	3
9.	Internet Routing: Overview of graph theory and least-cost path: Elementary Concepts of Graph Theory, Shortest Path Length Determination, Routing Protocols: Internetwork Routing Principles,	3

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand architecture, protocols, and applications of major highspeed networking technologies.	1,2
	CLO2	Analyze performance modelling and error control mechanism.	2,5
	CL03	Apply the techniques involved to support real-time traffic and congestion control as well as graph theory and routing principles.	2,3,5,6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions	Class Tests, Assignments, Final Examination
CLO2	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
CLO3	Interactive lecturing, Discussions, Class works	Class Tests, Assignments, Final Examination

Learning Materials

Recommended Textbook	1. High-Speed Networks: TCP/IP and ATM Design Principles by William Stallings. 2. High-Speed Networks and Internet: performance and quality of service by William Stallings. 3. Architecture and Protocols for High Speed Networks by Otto Spaniol. 4. Traffic Management for High-Speed Networks by H. T. Kung.

Course Code: ICT 5409	Year: MSc	Term: Optional
Course Title: Digital Integrated Systems Design		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course covers the analysis and design of MOS digital integrated circuit families and their applications in modern electronic systems.	

	Course Contents	CLOs
1.	**MOS technology and device fabrication overview:** Review of MOSFET transistor device, static and dynamic behavior via analysis and SPICE circuit models and simulations, Review of the CMOS inverter, Designing Combinational Logic Gates, with Layout Design Rules and CMOS Layout Techniques, Scaling and submicron technology issues.	1
2.	**Designing Sequential Logic Circuits:** Timing Metrics for Sequential Circuits, Classification of Memory Elements, Static Latches and Registers, Dynamic Latches and Registers, Pulse Registers, Sense-Amplifier Based Registers, Pipelining: An Approach to Optimize Sequential Circuits, Non-Bistable Sequential Circuits, Implementation.	1,2
3.	**Strategies for Digital ICs:** From Custom to Semicustom and Structured-Array Design Approaches, Custom Circuit Design, Cell-Based Design Methodology, Array-Based Implementation Approaches. **Coping with Interconnect:** Capacitive Parasitic, Resistive Parasitic, Inductive Parasitic, Advanced Interconnect Techniques, Introduction to Networks-on-a-Chip (NoC).	2,3
4.	**Timing Issues in Digital Circuits:** Timing Classification of Digital Systems, Synchronous Design-An In-Depth Perspective, Self-Timed Circuit Design, Synchronizers and Arbiters, Clock Synthesis and Synchronization Using a Phased-Locked Loop (PLL).	3
5.	**Designing Arithmetic Building Blocks:** Datapaths in Digital Processor Architectures, The Adder, The Multiplier, The Shifter, Other Arithmetic Operators, Power and Speed Trade-Offs in Datapath Structures.	4
6.	**Designing Memory and Array Structures:** The Memory Core, Memory Peripheral Circuitry, Memory Reliability and Yield, Power Dissipation in Memories, Case Studies in Memory Design.	4

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Analyze functionality of digital circuits including combinational, sequential, and memory.	1,2
	CLO2	Characterize speed, energy consumption, and robustness of combinational, sequential, and memory circuits.	3, 5
	CLO3	Design combinational, sequential, and memory circuits to meet specified functionality, speed, energy, and robustness targets.	4, 6
	CL04	Apply simulation of digital circuits and write reports conforming to technical writing standards.	6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions	Class Tests, Assignments, Final Examination
CLO2	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
CLO3	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
CLO4	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination

Learning Materials

Recommended Textbook	1. Digital Integrated Circuits: A Design Perspective. 2nd ed. Prentice Hall, 2002 by Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic. 2. Modern VLSI Design: Systems on Silicon by W. Wolf, Prentice; 2nd Edition, 1998. 3. Synthesis and Optimization of Digital Circuits by G.De Micheli, McGraw-Hill; 1994 Edition. 4. Logic Synthesis and Verification Algorithms by G. Hachtel and F. Somenzi, Kluwer; 1998 Edition.

Course Code: ICT 5410	Year: MSc	Term: Optional

Course Title: Project Management and Quality Assurance

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	The main objective of this course is to allow students to review project management and fundamentals, justify and select projects, and understand the stakeholder influence. This course helps to learn about planning, project launch, execution and quality maintenance to effectively manage multiple projects in a business environment.

	Course Contents	CLOs
1	**Project Planning:** Overview, Capital expenditure, Phases of capital budgeting, Project development cycle, 7-s of project management, Requirements of a project manager, Forms of project organization.	1
2	**Project Analysis**: Market Analysis, Technical Analysis, Financial Analysis, Risk Analysis, Social cost Benefit Analysis.	2, 4
3	**Project Control:** Control Systems, Control of major constraints, Project management software & information systems, Performance of Evaluation, Abaudonment Analysis, Behavioral issues in Project Management.	3
4	**Quality Management:** Quality systems, ISO 9000 series, ISI, Benchmarking, Quality Function development (QFD), Total Productive Maintenance (TPM).	3, 4
5	**Concept Sampling:** Sampling designs and schemes, Errors in sampling, Simple random sample, stratified random sample, Cluster sample, Sample size destination, Estimating population mean, Estimating population proportion.	2, 5

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Identify the fundamental differences between quality assurance and testing	1, 5
	CLO2	Explain the fundamental concepts of software testing.	1, 2
	CLO3	Design test processes and project management tools	4, 5
	CLO4	Recognize different types of test levels and run one needed	5, 7
	CLO5	Apply Static testing and Dynamic testing on projects	6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam

	Learning Materials
Recommended Textbook	1. Projects preparation, Apprisal, Budgeting & Implementation – Prasanna Chandra – Tata McGraw Hill 2. Projects – Planning, Analysis, Selection, Implementation & Review – Prasanna Chandra – Tata McGraw Hill 3. Project Management – Harvey Maylor – Pearson Education 4. Total Quality Management – Dale H. Besterfield – Pearson Education 5. Quality control and Improvement – Amitava Mitra – Pearson Education 6. Quality assurance and TQM – Jain & Chitale – Khanna Publishers

Course Code: ICT 5411	Year: MSc	Term: Optional
Course Title: Leadership and Human Resources Management		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	The course content assists students in learning more about human resources and their relevance, as well as how they function. This curriculum covers a broad range of topics for the student to understand the material and achieve a high score to advance in their career.	

	Course Contents	CLOs
1	**Introduction of Human Resource Management:** Nature, Definition and Challenges, External and Organizational Environments, Job Analysis and Design, Human Resource Planning, Recruiting Employees, Selecting Employees Orientation and Employees Training.	1
2	**Management and Organizational Development:** The Organizational Reward System, Career Development, Employee Safety and Health, International Human Resource Management.	1, 2
3	**Leadership and Management Development:** Human Resource Management Practice in Context, Coaching and Mentoring, Leading Organizational Design and Development, Research Methods and Research Based Output.	2, 3
4	**Global Business Strategy:** Innovation Management in a Digital Age, Success Through Business Ethics, Leading, & Developing People, Strategic Human Resource Management, Coaching, Mentoring & Development, Relations, Organizational Development, Responsibility of Directors, Business Project, Professional Development	1, 4
5	**Organization Development:** Theoretical and Historical Base, The OD Process, Implications of OD in Globalized, Environment, OD in the Philippines, Future Challenges in OD, Global Expansion of Organizational, Infrastructure: Framework and Systems, OD and Organization Culture, Theoretical Bases of organization, Development, Managing the OD process, Organizational culture and change, Organization development and other Ethical Branding.	3, 4, 5
6	**Partnering for and Embracing Change:** Emotional Intelligence, The importance of EI for leaders, The impact of EQ versus IQ, Measuring EQ, The Model of EQ, The IQ Communication Style, The EQ Communication Style, Bridging the GAP between IQ and EQ, Hiring, Emotional Intelligence as HR Leverage.	4, 5

			Mapping with PLOs
Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		
	CLO1	Understand managerial roles in human resource affairs	1
	CLO2	Understand HRM approaches to staffing, performance, compensation, and strategic issues	2
	CLO3	Develop a clear understanding of the specific functions and activities of HRM by analyzing real life business problems/issues	1,8
	CLO4	Provide knowledge of contemporary issues	3
	CLO5	Apply practical techniques associated with effective practice of HRM	6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Fundamentals of Human Resource Management 8th Edition; by Raymond Noe and John Hollen Beck 2020 2. Human Resource Management 10th Edition; Raymond Noe; John Hollen Beck; Barry Gerhart and Patrick Wright 2017 3. Human Resource Selection; Robert Gatewood 2016

Course Code: ICT 5412	Year: MSc	Term: Optional

Course Title: Geographical Information Systems

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	Students will learn how to compile, analyze, and present geospatial data while emphasizing the value of visual communication. Students will learn these basic geospatial concepts using industry standard GIS technology.

	Course Contents	CLOs
1	**Introduction to GIS:** Spatial Thinking, Geographic Concepts, Geographic Information Systems for Today and Beyond, Map Anatomy, Maps and Map Types, Map Scale, Coordinate Systems, and Map Projection, Map Abstraction**.**	1
2	**Data Models for GIS:** Data and Information, Data about Data, Finding Data, Raster Data Models, Vector Data Models, Satellite Imagery and Aerial Photography.	2
3	**Geospatial Data Management:** Geographic Data Acquisition, Geospatial Database Management, File Formats, Data Quality, Data Characteristics and Visualization, Descriptions and Summaries, Searches and Queries, Data Classification.	3
4	**Geospatial Analysis:** Single Layer Vector Operations Analysis, Multiple Layer Vector Operations Analysis, Raster Data, Basic Geoprocessing with Raster, Scale of Analysis, Surface Analysis, Spatial Interpolation, Surface Analysis: Terrain Mapping**.**	3, 4
5	**Geographic Data Analysis:** Watershed Analysis. Terrain Analysis, Network Analysis Spatial Interpolation, Geosocial Data Mining, Explore Patterns.	4

			Mapping with PLOs
Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		
	CLO1	Demonstrate in-depth understanding of GIS fundamentals	1,2
	CLO2	Apply various geospatial analysis techniques to solve real-world problems.	5,6
	CLO3	Analyze geospatial data using various software tools and programming languages.	1,5
	CLO4	Evaluate the quality and characteristics of geospatial data and apply appropriate visualization techniques to communicate results effectively.	3,7,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam

Learning Materials	
Recommended Textbook	1. Chang, Kang-tsung, 2019. Introduction to Geographic Information Systems, McGraw Hill Higher Education, 9th Edition, ISBN10: 1259929647, ISBN13: 9781259929649 or more recent edition. 2. Lo, C.P. and Yeung, Albert K.W., 2002. Concepts and Techniques of Geographic Information Systems, Prentice Hall, New Jersey, ISBN 0-13-080427-4; 2nd Edition, 2007 3. Tor Bernhardsen, 2002. Geographic Information Systems - an Introduction, 3rd Edition, John Wiley & Sons, Inc. ISBN 0-471-41968-0 4. Christopher Jones, 1997. Geographical Information Systems and Computer Cartography, Longman, ISBN 0 582 04439 1

Course Code: ICT 5413	Year: MSc	Term: Optional
Course Title: Natural Language Processing		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	Students who complete this course will gain a foundational understanding in natural language processing methods and strategies. They will also learn how to evaluate the strengths and weaknesses of various NLP technologies and frameworks as they gain practical experience in the NLP toolkits available	

	Course Contents	CLOs
1	**Introduction:** What is natural language processing, regular expressions and automata CFGs for English, NLTK, Python 3 and the Jupyter Notebook, Introduction to HPC.	1
2	**Morphology:** APIs, Social Media, Web Scraping, Building your Corpus, FSTs, Phonetics, Phonology and text-to-speech, N-grams and machine learning.	2
3	**Pre-processing:** Word pronunciation and spelling, Automatic speech recognition, Word classes and POS tagging, Tokenization, N-grams and Scriptio continua, Stemming and Lemmatization, Synsets and Hypernyms, Tokenizing Corpus.	2, 3
4	**Parsing and Syntax:** Basic parsing with CFGs, Parsing problems and some solutions, Probabilistic and lexicalized parsing	2, 4
5	**Semantic Analysis:** Meaning representations and semantic analysis, Lexical semantics, Word sense disambiguation OS Tagging and Stopwords, Text “Features” and TF-IDF Classification, The “Words” in a “Text”, Named Entity Recognition (NER).	3, 4
6	**Advanced Structure and Application**: Document Clustering and Word Vectors, Advanced Vector Analysis, Robust semantics and information retrieval, Hidden Markov and maximum entropy models. Hidden Markov and maximum entropy models.	3, 5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand the basic terminology used in natural language processing	2
	CLO2	Understand how to construct regular expressions and automata for any natural language processing model	1, 2,5
	CLO3	Apply lexical analysis of a natural language by parsing parts-of-speech tag generation for a natural language	1,6
	CLO4	Analyzing semantics of any natural language text and applying coherence and discourse analysis	1, 5
	CLO5	Design text to speech, speech to text machine translation, text summarization, etc. applications	1,2,3,5,6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Daniel Jurafsky, James H. Martin,"Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition", Prentice Hall, 1st edition, 2000. 2. Christopher D. Manning, Hinrich Schtze,"Foundations of Statistical Natural Language Processing", The MIT Press; 1st edition, 1999. 3. Natural Language Understanding James F. Allen, by Pearson

Course Code: ICT 5414	Year: MSc	Term: Optional

Course Title: Health Informatics

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course focuses on the application of informatics skills and knowledge to health-related problems. Application activities will include simple data analysis and visualization of clinical data, answering clinical questions using information retrieval methods, and doing simple association analysis of gene variants and disease.

	Course Contents	CLOs
1	**Health Informatics Resources:** Introduction, Future Trends, Converting data to information to knowledge, Clinical Data warehouse, Terminology of data analytics, Challenges, Application of analytics.	1
2	**Electronic Health Records:** Knowledge environment of health informatics, from cells and genes to people to health systems, Demonstration of the electronic health record (EHR) and its derivatives, functions for which it is used, including clinical, decision support and re-use of clinical data.	2, 3
3	**Bioinformatics:** Genomic primer, Importance of Bioinformatics, Genomics, Genomic information integrated with EHRS, Find and apply informatics in genomics and other aspects of molecular biology.	3
4	**Ethical Issues in Health Informatics:** Informatics ethics, Ethical challenges for the use of data and information in health-related areas, Ethics, laws and culture, Codes of individual countries, Pertinent ethical principles, Transferring ethical responsibilities.	3, 4
5	**Quality Improvement strategies:** Improvement strategies, Dashboards, Quality Improvement concerns, Limitations, Virtualization.	5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Apply basic knowledge to the research and practice of health informatics.	1, 4
	CLO2	Demonstrate basic skills and knowledge in health informatics for application in future health-related careers.	1, 2, 8
	CLO3	Identify genomic variants associated with a disease phenotype and communicate this association.	3, 5
	CLO4	Perform visualization and simple analysis of a data set to assess difficulty of predicting cardiovascular risk in a synthetic patient dataset.	1, 6
	CLO5	Analyze ethical and diversity issues in health inform.	7

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Hoyt, RE and Yoshihashi, A, Eds. (2014). Health Informatics: Practical Guide for Healthcare and Information Technology Professionals, Sixth Edition. Pensacola, FL, Lulu.com. 2. Health Informatics: An Interprofessional Approach 2nd Edition by Ramona Nelson, Nancy Staggers, Publisher: Elsevier 3. Innovation with Information Technologies in Healthcare (Health Informatics) by Lyle Berkowitz and Chris McCarthy

Course Code: ICT 5415	Year: MSc	Term: Optional
Course Title: Management Information System		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide students with a basic understanding of how Information Systems are used in organizations for meeting strategic and operational goals. To that end, students will acquire skills using current end-user software for communication, data transformation, collaboration, and problem- solving.	

	Course Contents	CLOs
1	**Introduction:** Purpose of Information Systems, Data vs. Information vs. Knowledge, The Components of Information Systems, Information Technology for Strategic Advantage in the Marketplace, Information Technologies, Hardware, End User and Enterprise Computing, Application Software: End User Applications.	1
2	**Database Security:** Data Communication and Internet Technology, The Wired and Wireless Networked Enterprise, Telecommunications Network Alternatives, Security Issues, Ethical Concerns, Technical Foundations of Database Management, Components of a Database Application System, Managing Data Resources and Warehouses.	2
3	**Planning Information Systems:** Systems Development Life Cycle, Rapid Application Development, Object Oriented Systems Development, Security and Systems Development, Building Information Systems, Value of systems and managing change, Modeling and Designing Systems, Structured and object-oriented methodologies.	2, 3
4	**E-Commerce and Supply Chain Systems Organizations:** Information Systems within Organizations, Categories of Information Systems, Survey of Functional Systems, Competitive Strategy and Value Chains, Business Process Design, Doing Business on the WWW, Web Technologies, Supply Chain Management, Inter-Organizational Information Systems, Ethics of Supply Chain Information Sharing.	4
5	**Business Intelligence and Knowledge Management:** Developing Business/IT Solutions, Data Warehouses and Data Marts, Data Mining, Knowledge Management, Information Systems Management, Planning the Use of IT, Managing the Computing Infrastructure, Enterprise Applications, Outsourcing, User Rights and Responsibilities.	4, 5
6	**Information Security:** Security Threats, The Security Program, Senior Managements Role, Risk Management, Data Safeguards, Human Safeguards, Disaster Preparedness, Managing Global Information Technology.	1, 5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping With PLOs**
	CLO1	Explain how computers process data into useful information and knowledge managing principles of management information system.	3, 8
	CLO2	Demonstrate the use of common application software including Word, PowerPoint, Access, Excel, and Project to support business processes.	2, 8
	CLO3	Identify and describe the principles of a relational database management system.	3, 5
	CLO4	Identify and describe the principal technologies and standards for networking communication and Internet access and how they support communication and e-business.	2, 3, 5
	CLO5	Analyze the relationship among ethical and social issues that are raised by information systems for safeguarding information resource.	3, 4, 7

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam

	Learning Materials
Recommended Textbook	1. Process, Systems, and Information, David M. Kroenke, ISBN: 0-13-278347-9 2. MIS Cases Decision Making with Application Software, 4th Edition, Lisa Miller, ISBN-10 0-13-238105-2 3. Management Information Systems, Effy OZ, Thomson Leaning/Vikas Publications 4. Management Information Systems, James A. O'Brein, Tata McGraw-Hill

Course Code: ICT 5416	Year: MSc	Term: Optional

Course Title: Ethical Hacking, Network Defense and Auditing

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course prepares to assess and then correct the vulnerabilities present within information systems. Learn about tools and penetration testing methodologies used by ethical hackers. Discover who and what an ethical hacker is and how important they are in protecting corporate and government data from cyber-attacks. Methods and tools used in attacks and their countermeasures, as well as available security resources and attack types are investigated.

	Course Contents	CLOs
1	Introduction: Information Security fundamentals, Ethical Hacking fundamentals, Role of Network Security.	1
2	Ethical Hacking: Hacking Techniques, Tools and Incident Handling Penetration Planning, Ethical Hacking and Network Defense.	1,4
3	Attack Techniques and Testing: Vulnerability Analysis, External and Internal Network Penetration Testing, Information System Incident Handling and Response.	2,3
4	Network Level Attacks and Countermeasures: Web Application, Database Penetration Testing, Penetration Testing Report Writing.	4
5	Attack Control and Auditing Process: Internal Controls, Performing an IS Audit, Control Self-Assessment, The Evolving IS Audit Process, Corporate Governance, IT Governance (ITG)	5

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand the fundamentals of ethical hacking, network security and importance of Auditing	1,2
	CLO2	Identify different attacks, attackers and security threats and vulnerabilities present in the computer system.	5
	CLO3	Examine how social engineering can be done by attacker to gain access of useful & sensitive information about the confidential data.	1,5
	CL04	Analyze cryptography techniques, Testing and basics of web application attacks	2,6
	CLO5	Design basic security architectures through selection and integration of relevant security components, domain of ethical hacking and ethical responsibilities.	6,7,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Case Study and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Project, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Project, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Beginners Guide To Ethical Hacking And Cyber Security Paperback – August 6, 2020, Author. Abhinav Ojha 2. Hacking: A Beginners' Guide to Computer Hacking, Basic Security, And Penetration Testing, Author: John Slavio 3. Hacking: The Art Of Exploitation, Author: Jon Erickson

Course Code: ICT 5417	Year: MSc	Term: Optional

Course Title: Digital Forensic and Disaster recovery

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course addresses the collection and analysis of the digital footprint left by humans and computers in a way that is reproducible by third-parties and suitable for presentation to. Topics include the rules of evidence, preservation of data, network forensics, live forensics, anti-forensics as well as forensics for non-standard devices such as mobile/smart phones, cloud computing. Emphasizes the need for disaster recovery plan, what it should cover, and how organizations can back up their electronic data to avoid irreparable loss.

	Course Contents	CLOs
1	**Introduction:** Introduction to Digital Forensics, Computer Forensics, System Analysis, Terms, History.	1
2	**Digital Vulnerability & Attacks:** Evolution of Computer Virus Technology, Functions, Types, Computer Virus Remediation Process & Resources, Differentiating Victims & Perpetrators in Digital Crimes, Cybersecurity Vulnerabilities.	2
3	**Forensic Investigation:** Digital Forensics Investigation Handling Evidence in Digital Forensics., Digital Forensics & the Expert Witness, Scrambling, Hiding & Recovering Data.	1,3
4	**Digital Forensics in Operating System and Email:** Digital Forensics & Email, Operating Systems & Digital Forensics.	4,5
5	**Disaster Recovery:** Integration of Advanced Technology, Incidence Response & Future Trends in Digital Forensics.	5

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Define digital forensics and basic principles of the science and laws regarding digital forensics.	1,2
	CLO2	Understand computer crimes, methods for investigating computer crimes and the establishment of forensics labs.	1,2
	CLO3	Analyze the collection of digital data, seize and protect digital evidence, methods for hiding, scrambling, and recovering data	5
	CL04	Evaluate E-mail's functions, and how to investigate and trace E-mail. Also operating system-specific forensics: Windows, Linux, and Macintosh.	5
	CLO5	Investigate mobile forensics, and the types of evidence available from phones/devices, and describe analysis of data on networks, including packet, traffic, router, and firewalls.	5,6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Case study and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test, Project and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Project, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Security, Privacy, and Digital Forensics in the Cloud, Author. Lei Chen, Hassan Takabi, Nhien-An Le-Khac, WILEY publishers 2. Advancements in Cybercrime Investigation and Digital Forensics, Editors: A. Harisha, Amarnath Mishra, PhD, Chandra Singh 3. Computer Forensics: Computer Crime Scene Investigation, Author. John R. Vacca, John Vacca 4. Digital Forensics and Incident Response: A practical guide to deploying digital forensic techniques in response to cyber security incidents, Author. Gerard Johansen

Course Code: ICT 5418	Year: MSc	Term: Optional

Course Title: Cyber Crime and Cyber Terrorism

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course will explore some of the biggest global threats to our society today while scrutinizing how technology and the online world are disrupting the way crimes are committed and society's responses to them. This will provide you with an in-depth understanding of cybercrime, terrorism theory, strategy and tactics, and professional security management.

	Course Contents	CLOs
1	**Introduction:** Cybercrime and cybersecurity fundamentals, Terrorism and counter terrorism, Classifications of Cybercrimes, Legal perspectives	1
2	**Real World Practices for Cyber Security:** Cyber Offenses, Malware Analysis, Cyber Security Analysis, Social Engineering, Cyberstalking.	2,3
3	**Cybercrime Media:** Mobile & Wireless Devices, Tools & Methods used in Cybercrimes, Phishing & Identity Theft, Cybercrimes & Cybersecurity – The Legal Framework	3
4	**Computer Forensics:** Forensics of Handheld Devices, Forensics data, Security management and organizations,	3, 4
5	**Cybersecurity:** Organizational Implications, Security risk and resilience, Cybercrime & Cyberterrorism, Cybercrime Illustrations & Case Studies	5

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand the fundamentals of Cybercrimes and it's Legal perspectives	1,2
	CLO2	Examine a range of topics including the online environment and how its infrastructure is exposed to and counters attacks.	2
	CLO3	Analyze the threat posed by both cybercrime and terrorism to the commercial sector caused by different media and the risks faced by the professional security sector.	5
	CL04	Evaluate the role of the professional security manager and security function in combatting these.	7,8
	CLO5	Develop Organizational Implications to mitigate Cyber Crime	4

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Case study and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test, Project and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Project, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Cybercrime and Cyber Warfare, Author. Igor Bernik 2. Cyber Crime and Forensic Computing Modern Principles, Practices, and Algorithms, Edited by: Gulshan Shrivastava , Deepak Gupta and Kavita Sharma 3. Cyber Crime and Cyber Terrorism (What's New in Criminal Justice) 4th Edition, Author. Robert Taylor, Eric Fritsch, John Liederbach, Michael Saylor, William Tafoya 4. Cyber Crime and Cyber Terrorism Investigator's Handbook, author. Babak Akhgar, Andrew Staniforth, Francesca Bosco

Course Code: ICT 5419	Year: MSc	Term: Optional

Course Title: Robotics and Industrial Automation

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course will provide students with the necessary knowledge and abilities to create, execute, and sustain automated systems, hence improving efficiency, productivity, and safety in industrial operations. Through the study of this subject, students can remain at the cutting edge of technological progress, equipping themselves for professions in areas where automation and robotics play a crucial role in maintaining competitiveness and driving innovation.

	Course Contents	CLOs
1	**Introduction:** Definitions, Types of Robots, Application of Robots, Representing Position and Orientation, Representing Pose in 2-Dimensions, Representing Pose in 3-Dimensions, Representing Orientation in 3-Dimensions, Combining Translation and Orientation.	1
2	**Time and Motion:** Trajectories, Smooth One-Dimensional Trajectories, Multi-Dimensional Case, Multi-Segment Trajectories, Interpolation of Orientation in 3D, Cartesian Motion, Time Varying Coordinate Frames, Rotating Coordinate Frame, Incremental Motion, Inertial Navigation Systems. Mobile Robot Vehicles, Mobility, Car-like Mobile Robots, moving to a Point, Following a Line, Following a Path, Moving to a Pose.	1,3
3	**Navigation:** Reactive Navigation, Braitenberg Vehicles, Simple Automata, Map-Based Planning, Distance Transform, D*, Voronoi Roadmap Method, Probabilistic Roadmap Method, Localization, Dead Reckoning, Modeling the Vehicle, Estimating Pose, Using a Map, Creating a Map, Localization and Mapping, Monte-Carlo Localization.	3
4	**Robot Arm Kinematics:** Describing a Robot Arm, Forward Kinematics, A 2-Link Robot, A 6- Axis Robot, Inverse Kinematics, Closed-Form Solution, Numerical Solution, Under-Actuated Manipulator, Redundant Manipulator, Trajectories, Joint-Space Motion, Cartesian Motion, Motion through a Singularity.	1,2
5	**Getting Started with ROS:** Installing ROS, Understanding the ROS Filesystem level, Packages, Stacks, Messages, Services, Understanding the ROS Computation Graph level, Nodes, Topics, Services, Messages, Bags, Master, Parameter Server, Creating workspace, Creating & Building an ROS package, Creating & Building the node, Visualization of images, Working with stereo vision, 3D visualization, Visualizing data on a 3D world using rviz.	4
6	**Robot Programming:** Using Sensors and Actuators with ROS, SCORBOT structure, joint movements, work envelop, motors, encoders, microswitch, transmission, gripper, SCORBOT programming, IS-14533 : 2005 Manipulating industrial robots - Performance criteria related test methods, Mobile Robot Programming, Industrial Robot Programming.	5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Explain 3D translation and orientation representation & Illustrate the robot arm kinematics and use of Robot Operating System usage.	1,2
	CLO2	Design / Simulate a robot which meets kinematic requirements.	5
	CLO3	Apply localization and mapping aspects of mobile robotics.	6
	CL04	To understand ROS applications.	1,2
	CLO5	To understand robot programming	1,6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Case Study and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Project, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Project, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Robotics, Vision and Control: Fundamental Algorithms in MATLAB® - Peter Corke, Springer Tracts in Advanced Robotics, Volume 73, 2011 2. Learning ROS for Robotics Programming - Aaron Martinez & Enrique Fernández, Packt Publishing, September 2013 3. Industrial Robotics-Groover, Weiss, Nagel, McGraw Hill International, 2nd edition, 2012

Course Code: ICT 5420	Year: MSc	Term: Optional

Course Title: Digital Product Design

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course will provide business thinking and strategy frameworks into the design of digital products that are sustainable and offer value. Through projects and assignments, students explore business and strategy concepts such as business models, value proposition and competitive analysis, and articulate how these approaches can inform the research, planning, ideation and prototyping phases of product development. Students demonstrate the business case for digital products and leverage strategic principles to generate innovative ideas for further exploration.

	Course Contents	CLOs
1	Innovation: Strategy development, SWOT analysis (Strengths, Weaknesses, Opportunities, and threats), Disruptive innovation	1,3
2	Value Proposition: Assessing value, Visualizing value proposition	2,4
3	Business Model Design: Business thinking, Visualizing business models	2
4	Sustainable Design: Extending value, Value chain	5
5	Information Design: Ethnographic approaches, Mapping, sorting, Dealing with data	5
6	**Interface Design:** Visual design, Typography. **Strategic Design**: User experience, Dashboard design	5

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Assess strategy development based on a competitive analysis.	5
	CLO2	Apply business thinking strategies to the design of digital products to ensure sustainable value for the user.	6
	CLO3	Utilize strategy frameworks in the design of digital products to ensure stakeholder needs are met.	8
	CL04	Prepare an innovation proposal for a digital product	6
	CLO5	Create a digital product design that incorporates a value proposition based on stakeholder needs.	3,4

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Case Study and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Project, Presentation and Final Exam

CLO5	Lecture, discussion, question, and answer session	Class Test, Project, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Value Proposition Design: How To Create Products and Services Customers Want, Osterwalder, A., Pigneur, Y., Bernarda, G., & Smith, A., Hoboken, New Jersey: John Wiley and Sons, Inc., 1st ed., 2014 2. UX strategy: How to Devise Innovative Digital Products that People Want, Levy, J., O'Reilly Media, Inc., 1st ed., 2015 3. Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, Osterwalder, A., Pigneur, Y., Hoboken, N.J: Wiley, First ed., 2010 4. Product Design Process: The manual for Digital Product Design and Product Management: Franco, Tiago, Costa, Beatriz, Grilo, Maria: 9789871973644 5. Product and Process Design - Jan Harmsen, André B. de Haan, Pieter L. J. Swinkels

Course Code: ICT 5421	Year: MSc	Term: Optional

Course Title: Development Operations (DevOps)

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course will provide knowledge to bridge the gap between software development and IT operations, gaining skills in automating processes, continuous integration and delivery, and collaboration to streamline software development and deployment pipelines. This knowledge empowers students to enhance software quality, increase deployment speed, and effectively manage infrastructure, aligning them with the evolving practices in the software development industry.

	Course Contents	CLOs
1	Introduction, What is DevOps?, How Was DevOps Derived?, DevOps Roots and Origin, Why Is DevOps Required?, Who Is a DevOps Engineer? What Is the Job Description for the DevOps Engineer?	1
2	The DevOps Lifecycle and Workflow: What Is the Lifecycle of DevOps?,	2, 3
3	DevOps Practices: Delivery, Support Practices, Architecture and Risk Mitigation, DevOps Improvement, DevOps Metric Practices, DevOps Business Drivers, DevOps Culture,	1, 3
4	DevOps Tools: System Monitoring Tools, Network Tools, Log Monitoring, Deployment and Configuration Tools,	4
5	Adopting DevOps: Brief on adaptation, Reasons for Adopting DevOps Culture, DevOps Adoption Hurdles, Signs That an Organization Is Not Ready for DevOps, Steps to DevOps Success,	4
6	Docker Overview, Building Container Images, Storing & Distributing Images, Managaing Containers, Launching Multiple Containers using Docker Compose, Using Docker Machine, Vagrant and Multipass, Moving from Linux to Windows Containers, Clustering with Docker Swarm, Portainer - A GUI for Docker, Running Docker in Public Clouds, Clustering with Docker & Kubernetes, Discovering more Kubernetes options, Running Kubernetes in Public Clouds, Securing your Docker Environment, Docker Workflows, Next Steps with Docker	4
7	Signs of Dysfunctional Processes in DevOps, The Future of DevOps	5

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Gain proficiency with DevOps tools and practices, enabling automation in software testing, integration, and deployment workflows.	1,2
	CLO2	Develop collaboration skills to cultivate a shared culture and communication between software development, QA, and IT operations teams.	4

	CLO3	Acquire expertise in implementing infrastructure as code, continuous monitoring, and proactive security measures within the DevOps lifecycle.	4,8
	CL04	Master Docker for containerization, learning to create, deploy, and manage containers for application development, ensuring consistent environments from development to production.	2,5
	CLO5	Analyze emerging trends and technologies to predict future developments in DevOps, and prepare strategies for adopting innovations that can lead to improved software delivery and operations.	5,6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Case Study and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Project, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Project, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. DevOps: The Ultimate Beginners Guide to Learn DevOps Step-by-Step, Mark Reed, Publishing Factory, 2020 2. Red Team Development and Operations: A practical guide, James Tubberville, Independently published, Joe Vest, 2020 3. Project Management Handbook Simplified Agile, Scrum and DevOps for Beginners, Jack C. Stanley and Erik D. Gross, The Tech Academy, 2020 4. Mastering Docker: Enhance your containerization and DevOps skills to deliver production-ready applications, Russ McKendrick, Packt Publishing, 2020.

Course Code: ICT 5422	Year: MSc	Term: Optional

Course Title: Legal Issues in ICT

Course Status: Optional

Credit: 3.0

Prerequisite(s): None

Rationale	This course equips students with the knowledge and critical thinking skills needed to address legal challenges, safeguard digital assets, and make informed ethical decisions while working in the field of information and communication technology.

	Course Contents	CLOs
1	Introduction to ethical theories and principles, Ethics and critical reasoning in computer science, Privacy, personal information, and trust, Software piracy, Music and video piracy, Misuse of software, Viruses and hacking,	1,2
2	Computer communication and freedom of expression, Security and encryption, Content control and censorship, Computer crime, Ethical hacking, Professional issues and decision making, Intellectual property and licensing,	2
3	ACM Code of Ethics and Professional Conduct Software Engineering, Code of Ethics and Professional Practice as recommended by the ACM/IEEE-CS Joint Task Force.	2
4	Law: National ICT Act, National ICT Policy, National e-services rules, National Information security policy guideline, National Copyright, patent, trademark related laws, Laws on document & records retention.	3,4
5	UN conventions/Laws related to internet or cyber security, Rights to know, Freedom of Information, cybersecurity from a global perspective: cyberterrorism, cybercrime, and cyberwarfare;	4,5
6	The international legal environment; nation- and region-specific norms regarding privacy and intellectual property; international standard setting; effects on trade (including offshore outsourcing); and opportunities for international cooperation.	5

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Develop a comprehensive understanding of ethical theories and principles	1
	CLO2	Apply knowledge in privacy, personal information, trust, and intellectual property matters in the field of ICT.	5
	CLO3	Identify, prevent, and respond to security threats	5,6
	CL04	Utilize foundation for legal compliance and ethical decision-making in the field.	6,7
	CLO5	Understand the global perspective of cyber threats and their impact on international relations, trade, and cooperation	1,2

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy

CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Case Study and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. A Text on Cyber Law in Bangladesh by Dr. Zulfiquar Ahmed 2. S. Kundra, Media Laws and Indian Constitution (Anmol Publications Pvt. Ltd, 2012). 3. Durga Das Bhagabati Prosad sarati, Vep P. Basu, Law of the Press (Wadhwa & Co. 2002). 4. Mr Anupa P Kumar, Cyber Law (Create Space Independent Publishing Platform, 2009). 5. Justice Yatindra Singh, Cyber Laws (Universal Law Publishing Co. ltd., 2nd ed., 2005) 6. M.K. Saxena, Information Technology Law: Concepts, Evolution and Enactments (Mangal Deep Publications, 2004).

Course Code: ICT 5423	Year: MSc	Term: Optional
Course Title: Recent Trends in ICT		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course focuses on the new trends and disruptive technologies in IT. The course objective is to teach students about the current trends in various computer science and information technology fields. Emphasis will be given to the way technologies create a competitive edge and generate business value.	

	Course Contents	CLOs
1	**Introduction:** Information Technology Fundamentals, Enterprise Hardware & Software, Virtualization, Evolution of IT, Information Technology Leadership & Systems.	1
2	**Cloud Computing:** What does "X as a Service" mean (X=Platform, Infrastructure or Software), Service Models & Business Benefits, Scalability, Reliability & Security, Development frameworks (e.g. AWS, Azure, AppEngine)	2
3	**Data Science & Analytics:** Trends in data science for marketing, data analytics, evolution of marketing and data science, data visualization, data visualization in information design, the tools and software used in data visualization, importance of data visualization.	3
4	**Artificial Intelligence:** History of artificial intelligence, how expert systems and artificial intelligence are used to solve complex problems, Machine learning models, Deep neural nets.	4
5	**Big Data & Cyber Security:** Big Data technologies, Smart Healthcare systems, Big data analytics. Big data computing platforms, Big data insights and adoption, Large-scale data system, anomaly detection, Data streaming and big data.	2, 5
6	**Internet of Things:** The "Post-PC" Era, IoT applications 5G Network, Blockchain Technology, different forms and types of digital and virtual currencies, the creation of cryptocurrency and the uses of blockchain technologies, Ethical, Economical & Social Impact of Current Technology Trends	4, 5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Identify the skills and knowledge of today's IT leaders and describe the role IT leaders play in modern organizations.	1, 5
	CLO2	Improve data management and security with respect to data visualization techniques	2, 7
	CLO3	Evaluate current trends and practices across different industries employing artificial intelligence and machine learning	3, 5
	CLO4	Define Internet of Things (IoT) and to identify current and future trends in IoT.	1, 6
	CLO5	Design trends associated with blockchain technology and evaluate the future impact of blockchain on data security.	6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO2	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO3	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO4	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam
CLO5	Lecture, discussion, question, and answer session	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. Textbook of Emerging Trends in Information Technology Paperback – 1 January 2011 by Ravi P Patki, Publisher: Techtree Educations 2. Introduction to Information Systems: People, Technology and Processes, 4th edition 3. Published by Pearson (July 6th 2020) - Copyright © 2021, Patricia Wallace Johns Hopkins University

Ordinance for M.Sc. in ICT

Program Overview:

The Master of Science (M. Sc.) program in Information and Communication Technology is designed to span a specific duration, as outlined below:

For MSc by Coursework:

- The program shall be completed within one year, consisting of two semesters.
- Each academic year will be divided into two semesters, with each semester lasting for six months.
- A semester will be organized into Class-weeks, Preparatory leave, and Semester-end examination periods.

For MSc by Mixed Mode:

- The program is designed to be completed within one and a half years, spanning three semesters.
- Each academic year for the mixed mode will also be divided into three semesters, each lasting six months.
- Each semester will consist of Class-weeks, Preparatory leave, and Semester-end examination segments.

A semester will be segmented into Class-weeks, Preparatory leave, and Semester-end examination. The total time distribution for completing a semester will be as follows:

Table: Timeline

Sl.	Segment	Length
1.	Class	14 Weeks
2.	Preparatory leave	2 Weeks
3.	Semester-end examination	3 Weeks
4.	Result Publishing	4 Weeks

Eligibility and Admission

Direct Admission: Regular students of BSc in ICT from the Institute of Information Technology, Jahangirnagar University will be granted direct admission to the Masters in ICT Program.

Application for Graduates from Government Approved Universities:

- Graduates from programs such as CSE, Software Engineering, IT, ICT, ICE, or equivalents from any recognized university are eligible to apply for the Masters in ICT program at IIT.
- The application process for admission to the Master's program will be announced through standard channels of advertisement.
- As part of the selection process, candidates may be required to undergo an oral and/or written test, which will be conducted by a Selection Committee.
- The minimum CGPA of the applicant shall be 3.00 on the scale of 4.00.
- The formation of the Selection Committee shall be determined by the Academic Council of the University.
- A maximum of 20% of total seats shall be available for applicants within this category.

Admission for Graduates from Foreign Universities:

- Graduates from foreign universities in the fields mentioned above are eligible to submit applications for the master's program.
- A written/oral test will be organized by the Selection Committee to assess their qualifications.
- The minimum CGPA of the applicant shall be determined by the Academic Committee of IIT.

Tuition & Other Fees:

Tuition fees and the mode of payment for MSc in ICT program shall be guided as per rules of the university.

Course Offer and Instruction:

The courses to be offered in a particular semester are announced and published in the Registration Package along with the tentative semester schedule before the end of the previous semester. The courses to be offered in any semester will be decided by the Academic Committee. Each course is conducted by a course teacher who is responsible for maintaining the expected standard of the course and for the assessment of the student's performance. One of the course teachers or any other member of the teaching staff of the Institute will be designated as course coordinator for each semester. He/she has the full responsibility for coordinating the work of the other members of the Institute involved in that semesterCourse Pattern and Credit Structure:

Course Designation and Numbering System:

A course will be represented by course number, course title, credit hours and contact hours per week (See below). Each course is designated by a three two letter code identifying the M. Sc. program offered followed by a four-digit number having the following interpretation: The first and second digits correspond to the year and the semester in which the course is normally taken by the students. The third digit is reserved for maintaining continuity. The following example illustrates a course representation system:

Table: Course Code, Title, Credit hrs

Course Code	Course Title	Credit Hrs	Class Hr/ Week
ICT 5101	Probability & Stochastic Process	3	3

Assignment of Credits:

Courses of study for the M.Sc. in Information & Communication Technology are defined as per rules of the University.

Degree Requirement for MS in ICT by Coursework (Project Group):

To obtain the degree of Master of Science by Coursework, a student has to:

i. Obtain successful grades for a minimum of 30 credits from the coursework.
ii. Complete and successfully defend a project work of 6 (six) credits.
iii. Bear a minimum CGPA of 2.5.

Degree Requirements for Mixed Mode program (Thesis Group):

To obtain the degree of Master of Science by Mixed Mode, a student has to:

i. Obtain successful grades for a minimum of 20 credits from coursework (graded)
ii. Complete and successfully defend his/her 20 credits research work (satisfactory)
iii. Bear a minimum CGPA of 2.5 (from course work).

Minimum requirement for Thesis/Project group

The minimum requirement for thesis or project students will be set by the Academic committee of IIT.

Thesis/Project Evaluation:

During the initial semester, students from both the thesis and project groups will undergo a proposal defense. The proposal defense is valued at a total of 100 marks. The assessment of these 100 marks will be divided into two components: the Examination Committee will assess and allocate 40 marks, while the Supervisor will evaluate the project, contributing to a total of 60 marks.

Project Evaluation:

In the second semester, each student will submit a project report. There will be a project Examination committee consisting of three internal members and an external member. A project will be evaluated out of 100 marks (Project defense 60 marks and project report 40 marks).

Steps of Project Evaluation:

Project Defense:

- The student is required to submit the project report, signed by their respective supervisor, to the Examination Committee.
- The project report's similarity index (excluding bibliography) must not exceed 20%.
- The Examination Committee will assess the project, assigning up to 40 marks.
- Marks awarded by the Examination Committee will be forwarded to the Chairman of the Examination Committee and the Examiner Controller of Jahangirnagar University.
- The Examination Committee reserves the right to reject the project with appropriate justification.

Project Report Evaluation:

- Accepted project reports will be sent for evaluation by two examiners, including one external/internal member and the project's supervisor.
- Each examiner will independently assess the project report, contributing up to 60 marks.
- The marks awarded by the examiners will be submitted to the Chairman of the Examination Committee.
- The final mark will be determined as the average of the two marks.
- Any examiner may reject a report by providing comprehensive comments.
- In the event of a rejected report, the Examination Committee will make the ultimate decision.
- Furthermore, the assessment will consider the similarity report of the project in making the final determination.

Thesis Evaluation:

Thesis Evaluation Committee:

- Each student will have a dedicated thesis evaluation committee, comprised of one internal member, the supervisor, and an external expert.
- Thesis evaluation will be based on a total of 300 marks, distributed as follows:
    - Thesis Defense (Committee): 60 marks
    - Thesis Report: 180 marks
    - Supervisor Evaluation: 60 marks

Steps for Thesis Evaluation:

Pre-defense:

- Each student must present their research work and findings, signed by their respective supervisor, to the thesis defense committee.
- The committee will assess the thesis as one of the following: Accepted, accepted with corrections, or rejected.

Thesis Progress Defense:

- Students will present their research work and findings, as endorsed by their respective supervisor, to the examination committee.
- The committee will evaluate the thesis and provide detailed comments to the students.

Final Defense:

- Each student is required to submit their accepted or corrected work, signed by the supervisor, to the examination committee within a specified deadline.
- The dedicated thesis evaluation committee will conduct the final defense and assess it out of 60 marks.
- The supervisor will also evaluate the thesis, contributing 60 marks.
- The thesis evaluation committee holds the authority to reject a thesis with proper justification.
- Please note that the student (as a first author) must have a publication from the research to be eligible for the final defense.

Thesis Blind Review:

- Two external experts will independently evaluate the final thesis, providing marks out of 180, which also consider the quality and number of publications.
- The final mark is determined by averaging the marks from the two external experts.
- Any examiner may recommend rejecting the thesis by offering proper comments.
- The examination committee will make the ultimate decision considering the rejection report.
- If the total marks for the thesis (out of 300) equal or exceed 60%, the thesis will be graded as satisfactory. Marks below 60% will result in rejection and require resubmission.

Assessment of courses:

For assessment, 100 marks shall be assigned to each three-credit hours course. Assessment of a student in a course shall be based on marks obtained in the final examination and class assessments.

Table 3: Theoretical Course

Class/Continuous Assessment	40%
Final examination	60%
Total	100%

Class Assessment/Continuous Assessment and Submission of Assessment:

Class assessment/continuous assessment will consist of class attendance, written class tests, quizzes, presentation, project works, case studies, assignments, term papers and discussion sessions. For assessment of class test in theoretical courses there shall be a minimum of three tutorial tests (declared/undeclared) for each three-credit hours course. For assessment of class test in practical courses there shall be a minimum of three declared written tutorial tests for each three-credit hours course. The distribution of marks for each theoretical course shall be as follows:

Table 4: Assessment

Theoretical Courses	**Marks (%)**
Class participation / Attendance	10%
Assignments	10%
Tutorial tests/Class tests	20%
Semester-end Examination	60%
Total	100%

Examinations:

Final examinations for each semester will be conducted as per the Examination Ordinance for semester system in the university and controlled by the Office of the Controller of Examination.

Grading System:

The Universal Grading System introduced by the University Grant Commission (UGC) of Bangladesh, will be followed which are given below. The total numerical marks obtained by a student in each course will be converted into Letter Grade (LG) and Grade Point (GP). According to the Grade Point, the GPA (Grade Point Average) and CGPA (Cumulative Grade Point Average) will be calculated. The conversion of Letter Grade and Grade Point will be as follows:

Numerical Grade	Letter Grade	Grade Points
80% and above	A+	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00
Incomplete	I	
Satisfactory or Unsatisfactory	**S or U**	**≥60%**

Earned Credits:

- The grades of the courses in which a student has obtained minimum qualifying pass grade, shall only be counted as credits earned by him/her. Other grades shall not be counted for Grade Point Average (GPA) calculation.
- If a student obtains an F grade in any course in any semester, he/she shall have to repeat the course(s), whenever offered within his/her total duration of academic years. In that case his/her earned credit shall not be more than B+.
- If a student obtains I(incomplete) grade in one or more courses in any semester, he/she shall have to repeat the course(s), whenever offered within his total duration of academic years.

Performance Evaluation:

The performance of a student will be evaluated in terms of two indices: (i) semester grade point average (GPA) and (ii) Cumulative Grade Point Average (CGPA) which is the grade point average for all the semester completed. Students will be making normal progress toward a degree if their Cumulative Grade Point Average (CGPA) for all work attempted is 2.50 or higher. Students who regularly maintain a GPA of 2.50 in each semester or better are making good progress toward the degrees and are in good standing with the University.

2023-2024, 2024-2025, 2025-2026

For Session

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