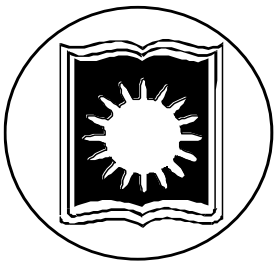
University of Rajshahi

Department of Information and Communication Engineering

Faculty of Engineering



Curriculum for M. Engineering
in
Information and Communication Engineering

Session: 2023-24

Examination

1st Semester - 2023

2nd Semester -2024

3rd Semester - 2024

Tel: +880-2588-864100
Website: www.ru.ac.bd/ice

University of Rajshahi
Department of Information and Communication Engineering

Vision

Establishment of quality academic culture in the department for the attainment of intended skills, knowledge and attitude in the field of Information and Communication Engineering (ICE) so that the graduates can cater to the current and future needs of Information and Communication Technology (ICT) oriented industry and academia leading to the socio-economic development of Bangladesh.

Mission

In order to accomplish the vision, the department will

- Establish a unique learning environment to enable the students to face the challenges in the field of Information and Communication Engineering.
- Promote the establishment of centers of excellence in appropriate technological areas to enhance the spirit of innovation and creativity among faculty members and students.
- Provide ethical and value-based education by promoting activities addressing the socio-economic needs.
- Enable students to develop skills to solve complex technological problems and provide a framework for promoting collaborative and multidisciplinary activities.

Information for Students

The M. Engg. program in Information and Communication Engineering shall have a minimum duration of three semesters of 6 months each. The duration of M. Engg. in ICE shall be of 78 weeks. A candidate for the M. Engg. Degree in ICE must complete all requirements for the degree within **three and half** academic years from the date of his/her first admission. A student shall be required to have attended at least 70% of the total number of lectures/tutorials/laboratory classes held to appear as a regular candidate at the semester final examinations.

Degree Requirements

A student must successfully complete the courses of all the semesters within **three and a half academic years** with all its pre-requisites in order to be eligible for the award of M. Engg. degree in Information and Communication Engineering. The minimum passing grade in a theoretical course will be **D** and the minimum passing grade in a **laboratory/project/field work/in-plant training**, and **viva-voce** course will be **C.** In order to qualify for M. Engg. degree in ICE, a student must **earn 40 credit points (i.e. no 'F' grade) and the CGPA** of the student must be **2.25 or highe**r.

Duration of Course and Course Structure

(i) The minimum duration of the M. Engg. program in ICE shall be three semesters of 6 months each. A candidate for the M. Engg. degree in ICE must complete all requirements for the degree within **three and half** academic years from the date of his/her first admission.

(ii) Teaching for the courses is reckoned in terms of credits within the following guidelines:

Nature of course	Contact hour (for 1 credit)
Theoretical Lecture	: 1 hour a week
Laboratory/sessional	: 2 - 3 hours a week
Project	: 2 – 3 hours a week
Field work/In-plant training	: 4 days of field work

For other fractions of credit, proportionality shall be applied.

(iii) **Course Advisor**: One of the teachers of the department shall act as Course Advisor for each of the three semesters of a batch.

(iv) **Distribution of Marks (as per course types)**

1. **Theoretical Courses:**

Continuous Assessment (**CA**)	Class Participation and Attendance	10%	30%
	Quizzes/Class Test/Assignment	20%	
Semester Final Examination			70%
		Total	**100%**

2. **Laboratory**

Continuous Assessment (**CA**)	Class Participation and Attendance	10%	40%
	Quizzes/Class Test/Assignment	30%	
Practical/Design/Assignment			60%
		Total	**100%**

3. **Project Work/Field Work/Professional Training**

Internal Examiner/Supervisor	35%
External Examiner (Any teacher from the panel of examiners other than the supervisor)	35%
Presentation and Oral Examination(will be conducted by the respective examination committee)	30%
Total	**100%**

4. **Basis for awarding marks for class participation and attendance:**

Attendance	Marks (%)
90% and above	100
85% to less than 90%	90
80% to less than 85%	80
75% to less than 80%	70
70% to less than 75%	60
65% to less than 70%	50
60% to less than 65%	40
less than 60%	0

Academic Calendar

(i) The minimum duration of the M. Engg. program in ICE shall be three semesters, duration of each semester shall be **not less than 13 teaching weeks**.

(ii) There shall be final examination at the end of each semester.

(iii) **Academic schedule** for general notification shall be published before the start of the 1st semester. The schedule may be prepared according to the following guidelines:

1st Semester (19 weeks)	**Number of weeks**
Teaching	13 (65 working days)
Preparatory Leave	2
Examination Period	2
Results Publication	2
Total:	**19**

Vacation including Inter-Semester Recess	1 week

2nd Semester (19 weeks)	**Number of weeks**
Teaching	13 (65 working days)
Preparatory Leave	2
Examination Period	2
Results Publication	2
Total:	**19**

Vacation (Summer, Ramadan, and Others) including Inter-Session Break.	13 weeks
(1st Semester+2nd Semester) Total:	**52 weeks**

3rd Semester (26 weeks)	**Number of weeks**
Teaching	13 (65 working days)
Preparatory Leave	2
Examination Period	3
Results Publication	8
Total:	**26**

(1st Semester+2nd Semester+3rd Semester) Total:	**78 weeks**

Attendance

(i) In order to be eligible for appearing at the semester final examination as a regular candidate, a student shall be required to have attended at least 70% of the total number of lectures/tutorials/laboratory classes held in the semester. The laboratory courses mean all laboratory/project/fieldwork/in-plant training or similar courses.

(ii) A student whose attendance is 60% to less than 70% in any **course** may be allowed to appear at the final examinations as an irregular student but **he/she shall not be eligible for any scholarship or stipend.**

(iii) Student having **less than 60% attendance will not be allowed to appear** at the final examinations of the semester.

(iv) The percentage of attendance of the readmitted students shall be counted from the date of the start of the semester or from his/her previous attendance of the semester.

Striking off the Names and Readmission

(i) The names of the students shall be struck off and removed from the rolls on the following grounds:
   (1) Non-payment of University fees and dues within the prescribed period,
   (2) Failing to get himself/herself promoted to the next higher semester,
   (3) Forced to discontinue **his/her** studies under disciplinary rules,
   (4) Withdrawal of names from the rolls of the University on grounds acceptable to the Vice-Chancellor of the University after having cleared all dues.

(ii) In case a student, whose name has been struck off the rolls under clause (i.1) seeks readmission **before the start of the next semester** he/she shall be readmitted on payment of all the fees and dues. But if he/she seeks readmission in any subsequent **semester**, the procedure for his/her readmission will be the same as described under **clause** (iv) below.

(iii) In case a student, whose name has been struck off the rolls under clause (i.2) seeks readmission **before the start of the next semester** he/she shall be readmitted on the approval of the relevant department on payment of all the arrear fees and dues.

(iv) A Student, whose name has been struck off the rolls by exercise of the clause (i.3), seeking readmission after expiry of the suspension period, shall submit an application to the Chairman of the Department before the commencement of the semester to which he/she seeks re-admission. The Chairman of the Department shall forward the application to the Vice-Chancellor. In case the readmission is allowed, the student will be readmitted on payment of all the fees and dues within one week from the date of permission given by the Vice-Chancellor.

(v) In case of any application for readmission is rejected, the student may appeal to the Academic Council for re-consideration. **The decision of the Academic Council shall be final.**

(vi) No student who has withdrawn his/her name under clause (i.4) shall be given readmission.

(vii) All readmission should preferably be completed before the semester starts.

(viii) The application of a student for readmission will only be considered if he/she applies within **one year** from the date he/she discontinued his/her studies in the University. **The maximum period of studies** for M. Engg. degree in ICE under **no circumstances will exceed three and half academic years.**

Grading System

(i) The letter grade system for assessing the performance of the students shall be as follows:

Numerical grade	**Letter Grade (LG)**	**Grade Point (GP)**
80% or 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	0.00

A letter grade I (incomplete) shall be awarded for courses that could not be completed in one semester, which will continue through to the next semester.

(ii) A **Semester wise Grade Point Average (SGPA**) shall be computed for each semester. The SGPA will be calculated as follows:

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

where, n is the number of courses offered during the semester, C_i is the number of credits allotted to a i'th course and G_i is the i'th grade point corresponding to the grade awarded for that course.

(iii) A Cumulative Grade Point Average (CGPA) shall also be computed at the end of second and third semester in the following way:

$$CGPA = \frac{\sum_{i=1}^{m} S_i C_i}{\sum_{i=1}^{m} C_i}$$

where, m is the total number of semesters being considered, S_i is the SGPA of a i'th semester, C_i is the total number of credits in i'th semester.

(iv) SGPA should be three digits after the period. A fourth digit after the period is not allowed at all. For instance, SGPA=3.4999 should be 3.499. However, the CGPA will be two digits after the period. In this case, if the third digit after the period is ≥ 5 then the second digit after the period will be plus 1. For instance, CGPA=3.485 will be 3.49 whereas CGPA=3.354 will be 3.35.

(v) **Earned Credit:** The courses in which a student has obtained minimum 'D' in 'Theoretical courses' and 'C' in 'laboratory/field work/in-plant training and viva voce' will be counted as credits earned by the student. Any course in which a student has earned 'F' grade in theoretical and 'F' and 'D' grades in laboratory/field work/in-plant training and viva voce will not be counted towards his/her earned credit.

Duration of Examination

Duration of **Theoretical examination of different courses** shall be as follows:

Courses of 2 credits or less than 2 credits	2 Hours
Courses of more than 2 credits	3 Hours

Conduct of Examination and Rules for Promotion

(i) The results shall be finalized at the end of the 3rd semester of the program. Individual **course** grades shall be announced within a date ordinarily not later than three weeks

after the end of the semester final examinations.

(ii) **Minimum passing grade:** The minimum passing grade in a theoretical course will be D and the minimum passing grade in a laboratory/project/field work/in-plant training and **viva-voce** course will **be C.**

(iii) **Promotion to higher semester:** A student who has a grade point average of **2.2** or higher, F grade in not more than 8 credit points and at least C grade in the laboratory/field work/in-plant training and viva voce courses of the 1st and 2nd semester shall be promoted to the 2nd and 3rd semester, respectively.

(iv) There shall be **no improvement** in laboratory/field work/in-plant training/project and viva voce courses**.** A student failing to secure a **minimum C grade** in any of these courses in any semester shall **fail the semester**.

(v) **Grade Point Improvement**:

1	A promoted student who obtains less than B grade in theoretical courses in any semester, may appear in the upcoming regular examination of that semester to improve the grade points.
2	Grade obtained by a student in the courses in which he/she appeared for improvement will be recorded for final assessment according to clause (v.1) and the grade obtain by him/her in those courses at the regular final examination shall automatically cancelled.
3	Clause (v.2) is not valid for a candidate who cannot improve his/her course grade; in that case the previous grade shall remain valid.
4	A student must clear F grade of the courses of all the semesters.

(vi) **Course Exemption:** Students who fail to be promoted to the 2nd and 3rd semester shall be exempted from taking the theoretical and laboratory courses where they obtained grades **equal to or better than B.** These grades would be counted towards calculating SGPA in the retained semesters.

(vii) **Merit Position:** The SGPA obtained by a regular student in a **semester final examination** will be considered for determining the **merit position for the award of scholarships, stipends etc.**

Class Test

For theoretical courses of **2 or less than 2 credits** there shall be at **least three** class tests and at **least four** class tests for **greater than 2 credits in a** semester.

Publication of Results

(i) A student must successfully complete the courses of all the semesters within **three and a half academic years** as outlined by the Committee of Courses with all its pre-requisites in order to be eligible for the award of M.Engg. Degree in ICE. The student must **earn 40 credit points (i.e. no 'F' grade) and the CGPA** for the student must be **2.25 or highe**r.

(ii) The final merit position will be based on CGPA.

(iii) **Dean's List:** As a recognition of excellent performance, the names of students obtaining a SGPA of 3.75 or above in two regular semesters in each academic year may be published in the Dean's List in the faculty. Students who have received **an 'F' grade** in any course during any of the two regular semesters will not be considered for Dean's List in that year.

Absence in Examination

A candidate absenting himself/herself in a **course** examination of any semester final examination in which he/she ought to have been present, will be considered **'F' grade**

in that **course**.

Eligibility for Examination

(i) A candidate may not be admitted to any semester final examination unless he/she has

1) Submitted to the Registrar/Vice-Chancellor an application in the prescribed form for appearing at the examination.
2) Paid the prescribed examination fees, and outstanding of all University and Hall dues.
3) Fulfilled the conditions for attendance in class.
4) Not barred by any disciplinary rule.

(ii) On special circumstances the Vice-Chancellor may permit a student to appear at the examination.

Curriculum for M. Engg. (ICE) 2023-24

Courses offered to the M. Engg. Students of the Department of Information and Communication Engineering

Distribution of Courses

Course Type for M. Engg. (ICE)	**Credit Distribution**
Theoretical	30
Practical	4
Project	4
Board Viva-voce	2
Total credits	**40**

Credits Distribution (Semester-wise)

Semester	**Nature of Course M.Engg. (ICE)**	**Credits Distribution**
1st semester	Theoretical	10
	Practical	2
	Total	**12**
2nd semester	Theoretical	12
	Practical	2
	Total	**14**
3rd semester	Theoretical	8
	Project	4
	Board Viva-voce	2
	Total	**14**
(1st semester+2nd semester+3rd semester) Total		**40**

Course Code and Course Title for M. Engg. (ICE) 2023-24

Semester	Course Code	Course Title	Credits	Marks
1st Semester	ICE M1011	Stochastic Theory of Communication	4	100
	ICE M1012	Stochastic Theory of Communication Lab	1	25
	ICE M1021	5G Wireless Communication and Beyond	3	75
	ICE M1031	Data Mining	3	75
	ICE M1032	Data Mining Lab	1	25
1st semester Total			**12**	**300**
2nd Semester	ICE M2011	Advanced Machine Learning	3	75
	ICE M2012	Advanced Machine Learning Lab	1	25
	ICE M2021	E-Commerce	3	75
	ICE M2022	E-Commerce Lab	1	25
	ICE M2071	Multimedia Communication	3	75
	ICE M20**	Elective Course	3	75
2nd semester Total			**14**	**350**
3rd Semester	ICE M3011	Wireless Sensor Networks	4	100
	ICE M3021	Cyber Security and Digital Forensics	4	100
	ICE M3032	Project	4	100
	ICE M3030	Board Viva-voce	2	50
3rd semester Total			**14**	**350**
(1st semester+2nd semester+3rd semester) Total			**40**	**1000**

Elective Courses in 2nd Semester

Course Code	Course Title	Credits	Marks
ICE M2031	Advanced Optical Communication and Networks	3	75
ICE M2041	Mathematical Programming	3	75
ICE M2051	Computer Vision	3	75
ICE M2061	Distributed System	3	75
ICE M2081	Big Data Analytics	3	75

1st Semester

ICE M1011: Stochastic Theory of Communication
100 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
4 Credits, 4 Hours/week, Lectures: 52, Exam time: 3 hours

Prerequisite Courses	**:**	STAT 2111
Course Objectives	**:**	Stochastic processes are probabilistic system that evolve in time or space. The aim of this course is to acquire knowledge about both mathematical principals and organizational necessary to create, analyze and understand a broad range of probabilistic models. The range of application areas of the models are constantly expanding and include many applications in engineering, physics, operation research and finance.
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:** define the basic terminologies of probability and stochastic process **CLO-2:** explain random processes that are belong to discrete and continuous random processes **CLO-3:** solve different problems on random variables and stochastic processes **CLO-4:** show how a system is modeled using the random variables and processes **CLO-5:** prepare a probabilistic model of a problem with necessary mathematical backgrounds
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section A

Introduction to Probability Theory: Sample space, Events, Set operations, Axioms of probability, Conditional probabilities, Baye's formula.

Random Variables: Basic concepts, Introduction to Bernoulli, Binomial, Geometric, Poisson, Uniform, Exponential, and Normal random variables, Vector and Multiple random variables, Conditional probability and conditional expectation.

Random Process: Definition, Joint distribution of time samples, Mean, Autocorrelation and autocovariance functions, Gaussian and multiple random processes, Discrete and continuous time random processes, Stationary random processes, Continuity, Differentiation and integration of random processes, Time average of random processes and Ergodic theorems, Fourier series and Karhunen-Loeve expansion.

Section B

Markov Chains: Introduction to Markov processes, Discrete and continuous time Markov processes, Chapman-Kolmogorov equation, Classification of states, Limiting probabilities, Markov chain Monte Carlo methods, Markov decision processes, Applications of Markov chain in communication.

Introduction to Queuing Theory: Preliminaries, Little's formula, Single server queuing systems, Open and closed systems, M/M/1 queue, Multi-server systems, M/M/c, M/M/c/c and M/M/oo systems, M/G/k queuing systems, Burk's and Jackson's theorem, Applications of Queuing theory in communication.

Books Recommended:

1. Probability and Random Processes for Electrical Engineering **:**Alberto Leon-Garcia.
2. Introduction to probability Models, Ross. **:**Sheldon M.
3. Probability, Random Variables, and Stochastic Processes **:**Athanasios Papoulis.

ICE M1012: Stochastic Theory of Communication Lab
1 Credits, 25 Marks (2hours/weeks)

Lab Objectives: The objective of this laboratory course is to gain the practical experience on the theories and concepts of stochastic communication as outlined in ICE M1011 course. The students will also know the introductory concept of modeling systems.

ICE M1021: 5G Wireless Communication and Beyond
75 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
3 Credits, 3 Hours/week, Lectures: 39, Exam time: 3 hours

Prerequisite Courses	**:**	ICE 4131, ICE 4211
Course Objectives	**:**	The aim of the course is to acquire knowledge of wireless communication system and focusing on upcoming technologies like 5G mobile communication and LTE. This course also addresses the challenges and impacts of modern wireless communication system, andconcentrates on wireless network structures and planning.
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:** Identify and discuss the operational and design problems of wireless communication systems. **CLO-2:** Analyze and perform calculations of the channel coding techniques for wireless communication. **CLO-3:** Describe the operational principles of relaying, multi-hop, and cooperative communications. **CLO-4:** Identify the infrastructure of wireless network topology and cellular topology. **CLO-5:** Compare the different channel allocation techniques and network planning for CDMA system of Wireless Network. **CLO-6:** Explain the design principles and challenges of Ad-hoc Wireless Network.
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section A

An overview of LTE: Spectrum Flexibility, Multi-Antenna Enhancements, Small Cells, and Heterogeneous Deployments, WLAN Interworking, Machine-Type Communication, Latency Reduction, Device-to-Device Communication, LTE Broadcast Multicast.
5G use cases and architecture: 5G Use Cases, NGMN 5G Architecture Framework, 3GPP 5G Architecture, 5G Core Network Architecture, Radio Access Network Architecture.
Ultra-Reliable and Low-Latency Communications: URLLC Performance Requirements, Mobility, Reliability, URLLC Use Cases, URLLC Applications, UTM Architecture, 5G Performance Requirements for UTM.
NR Transmission Structure: Time-Domain Structure, Frequency-Domain Structure, Bandwidth Parts, Supplementary Uplink, Carrier Aggregation, Duplex Schemes, Antenna Ports, and Quasi-colocation.

Section B

Software-Defined Networking: Evolving Network Requirements, SDN Architecture, Characteristics of Software-Defined Networking, SDN Data Plane, OpenFlow.

Network Functions Virtualization: Motivation for NFV, Virtual Machines and Containers, NFV Concepts, NFV Principles, NFV Benefits and Requirements, NFV Reference Architecture, NFV Infrastructure, Virtualized Network Functions.
Machine Type Communications: The Internet of Things, Components of IoT-Enabled Things, IoT and Cloud Context, Relationship Between MTC and the IoT, Smart Agriculture, Smart Cities.
6G and Onward: 6G system architecture, Air interface, New spectrum, Artificial intelligence/machine learning, Advanced beamforming with very large scale antenna (VLSA), Coexistence of variable radio access technologies, Network dimensions, Potential technologies, 6G application.

Reference books:
1. 5G Wireless: A Comprehensive Introduction by William Stallings
2. A Network Architect's Guide to 5G by Syed Farrukh Hassan, Alexander Orel
Kashif Islam
3. 5G Mobile and Wireless Communications Technology by AFIF OSSEIRAN, JOSE F . MONSERRAT, PATRICK MARSCH
4. 5G NR THE NEXT GENERATION WIRELESS ACCESS TECHNOLOGY by ERIK DAHLMAN, STEFAN PARKVALL, JOHAN SKOLD

ICE M1031: Data Mining
75 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
3 Credits, 3 Hours/week, Lectures: 39, Exam time: 3 hours

Prerequisite Courses	**:**	ICE4111, ICE4141
Course Objectives	**:**	The main objective of the course is to gather knowledge on data scope, data processing, data visualization. This also provides fundamental idea about data warehouse, k-Nearest Neighbor, Bayesian classifier about on analysis of large data sets which is very important for data mining analysis.
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:** Define Multidimensional data analysis, Graph mining. **CLO-2:** Illustrate advanced knowledge of data mining concepts and techniques. **CLO-3:** Classify of different data-mining techniques: frequent pattern mining, prediction, decision tree and outlier analysis **CLO-4:** Apply the techniques of classification, association finding, feature selection and visualization on real world data **CLO-5:** Demonstrate knowledge of the ethical considerations involved in data mining. **CLO-6:** Discover whether a real world problem has a data mining solution **CLO-7:** Evaluate different models used for OLAP and data preprocessing
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section A

Data Warehouse: Definition, The compelling need for data warehouse, Data warehouse architecture, 2-tiere, 3-tiere data warehouse, OLAP and Multidimensional data analysis.
Data Mining: Introduction, scope, Types of data, Data processing, Measures of Similarity and dissimilarity, Summary statistics, Data visualization.

Classification: Basic concepts, Decision tree, Attribute Selection measure, Nearest-neighbor classifiers, Bayesian classifier, Naïve Bayes Classifier, Rule-based classifier, Classification by back propagation, ANN, SVM. Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods.

Section B

Cluster Analysis: Introduction, Types of clusters, Partitioning Methods, Hierarchical Methods, Density based Methods, Grid-Based and Model-Based Methods, Clustering high dimensional data.

Association Analysis: Basic concept, Frequently item-set generation: The Apriori principles, Candidate Generation, Support Count; Rule generation, Mining various kinds of association rules, Correlation analysis.

Books Recommended:

1. Data Mining Concepts and Techniques **:** Jiawei Han and Micheline Kamber
2. Introduction to Data Mining **:** Pang-Ning Tan,Michael Steinbach,Vipin Kumar

ICE M1032: Data Mining Lab
1 Credit, 25 Marks (2 hours/week)

Lab Objectives: Data mining tools allow predecting future trends and behaviors, knowledge-driven decisions.The data mining laboratory course is designed to exercise the data mining techniques such as classification, clustering, pattern mining etc with varied datasets and dynamic parameters.At the end of the data mining lab, student have a clear concept what they are studying in their theory classes.

2nd Semester

ICE M2011: Advanced Machine Learning
75 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
3 Credits, 3 Hours/week, Lectures: 39, Exam time: 3 hours

Prerequisite Courses	**:**	ICE 4111
Course Objectives	**:**	This course is designed to provide a broad understanding of machine. Both supervised and unsupervised learning will be explored with learning theory. Recent applications of machine

		learning are also included in the course that contains investigating existing algorithms and developing new algorithms to meet the applications.
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:** Define the basic terminologies of machine learning and deep learning. **CLO-2:** Explain a wide variety of machine learning algorithms. **CLO-3:** Solve problems applying variety of learning algorithms on data **CLO-4:** Design and implement variety of machine learning algorithms in a variety of real-world application.
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section A

Introduction to Machine Learning: Introduction to machine learning (ML), Resurgence of ML, Relation with AI, Applications of machine learning, Mathematical fundamentals of Matrices, Numerical methods, Random variables, Linear algebra, Differential calculus.

Learning Models: Supervised learning, classification problem, Regression problem, Unsupervised learning, Semi-supervised learning and Reinforcement learning.
Regression: Introduction, Regression model, Problem formulization, Linear regression, Normal and Gradient descent method, Logistic regression, Sigmoid and cost function, Gradient descent.

Classification and Random Forest: Decision boundary, Skewed class, Naïve Bayes' algorithm, Decision tree, Information gain, Gini impurity criterion, Random forest, Data bagging, Feature bagging, Cross validation, Prediction, Proximities, Outliers, Prototypes.

Section B

Testing Algorithms and Networks: Test set, Outfit, Underfit, Finding number of degrees and lambda, Increasing data count, High bias and variance case, Derived data, Test data.
Neural Networks (NN): Regression extension for NN, NN as oversimplified brain, Visualizing NN equation, Matrix formulization of NN, NN representation, Training the NN, Vectorization.

Deep Learning: Introduction, Recurrent neural network (RNN), Representation of RNN, Vanishing gradients, LSTM, GRU, Self-organizing maps. Evaluation metrics: Confusion Matrix, Precision, Recall, F1 Score, Classification Accuracy.
Reinforcement Learning (RL): Introduction, Components of RL, Agents, Environment, Environment state transitions and actions, Agents behavior, Value function, RL algorithms, Monte Carlo learning, Q-learning, Monte Carlo tree search.

Text Books:

1. An Introduction to Machine Learning : GopinathRebala, Ajay Ravi and Sanjay Churiwala

Reference Books:

2. Introduction to Machine Learning : EthemAlpaydin

ICE M2012: Advanced Machine Learning Lab
1 Credit, 25 Marks (2 hours/week)

Lab Objectives: The objective of this laboratory course is togain the practical experience on how to make use of data sets in implementing the machine learning algorithms. The students will also know how to implement the machine learning concepts and algorithms in any machine learning application.

ICE M2021: E-Commerce
75 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
3 Credits, 3 Hours/week, Lectures: 39, Exam time: 3 hours

Prerequisite Courses	**:**	ICE4221, ICE4141
Course Objectives	**:**	The aim of this course is to present and discuss concepts and challenges of e-commerce and e-business, including a balanced coverage of both the technical and the management (operational, tactical and strategic) aspects of successful e-business. It covers business strategies, and technologies involved in the design and deployment of e-commerce business on the internet and World Wide Web.
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:** State the basic concepts of e-commerce and e-business, including presentation and discussion of the strategies and technologies involved. **CLO-2:** Discuss and explain theoretical and practical issues of conducting e-commerce over the internet and the Web. **CLO-3:** Choosing modern computing infrastructures from the perspective of the internet and organizations. **CLO-4:** Analyzed the relative existing technology and future growth of e-commerce according to organization goal. **CLO-5:** Design and develop the Web for prospective e-commerce business
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section A

E-commerce and Internet: Definition of E-Commerce, Myths of E-commerce, Advantages and limitations of Ecommerce, Value chain in E-commerce, Integrating E-commerce, Recommendation system for ecommerce, The making of WWW, Web Fundamentals.

Internet Architecture and Website Hosting: Definition of Network, Network Hardware and Design Consideration, Intranet and Extranet, Types of client-server Architecture, ISP Structure and Services, Choosing an ISP, Domain Name Registration.

Website Building and Evaluation: Website Building Life Cycle, Constructing Website, Design Criteria, Site Evaluation Criteria, Cookies, Site Content and Traffic Management.

Section B

Internet Marketing: Internet marketing technique, Advantage and disadvantage of internet marketing, E-cycle of internet marketing, Market presence, Online advertising for attracting customer, Tracking customer, M-commerce, T-commerce. Customer relation management and E-value, Real world cash, E-money, Cyber cash, NetBill, SET, Cryopto-currency, Debit card, Credit card, Smart card

B2B E-commerce and Web Portal: Definition of Web portal and Web Service, Evaluation of Web portal, Categories and Characteristics of Web portal, Enterprise Portal Technology, B2B Models, B2B Tools-EDI, Legal Issue.

Security: Security in Cyberspace, Virus, Security Protection and Recovery, How to Secure your System, Role of Biometrics, Encryption and DecryptionTechnique, Digital Certificate and Signature, Internet Security Protocols.

Books Recommended:

1. Electronic Commerce **:** Elias M. Awad
2. Managing Your E-Commerce Business **:**. Kienan.
3. E-Security & You **:** Sudeep Oberoi
4. Web Advertising and Marketing **:**. Kueglar.
5. Developing E-Commerce Sites **:**Sharma
6. E-Commerce: Strategy, Technologies and Applications **:**Whiteley.

ICE M2022: E-Commerce Lab
1 Credit, 25 Marks (2 hours/week)

Lab Objectives: The objectives of the laboratory are to provide virtual B2B, B2C commerce environment for the students to cultivate the knowledge. This provides the basic concepts of Internet type marketing and Web service protocol. This also provides basic concepts of Cyber and Internet security protocols, knowledge about Payment systems and User experience.

ICE M2071: Multimedia Communication
75 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
3 Credits, 3 Hours/week, Lectures: 39, Exam time: 3 hours

Prerequisite Courses	**:**	ICE 4231
Course Objectives	**:**	The objective of this course is to provide fundamental knowledge on the principles of the multimedia communications systems and application. In addition, it is also cover the topics of different media digitization principles, analyzing of the multimedia streaming, performing and establishing multimedia, communication terminals and presentation of multimedia communications.
Course Learning	**:**	**After successfully complete this course, students will be able to:**

Outcomes (CLOs)		**CLO-1:** Describe the basic concept of multimedia contents, their representation and digitization principles **CLO-2:** Explain different types of compression techniques, coding, decoding, standardization and communication mechanism of multimedia contents **CLO-3:** Interpret the multimedia database and distributed multimedia systems. **CLO-4:** Describe the multimedia communication protocols such as RTP, RTCP and signaling protocols such as SIP, RTSP. **CLO-5:** Discuss the basic concept of networked multimedia concepts and real-time multimedia streaming techniques and their protocols **CLO-6:** Describe the concept of audio/video packet in the network, video transport across generic network and internet access networks and interpret the multimedia across wireless
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section A

Multimedia Communication: Multimedia Communication model, Elements of Multimedia Systems, User and Network requirements, Multimedia Terminals, Audio-Visual Integration, Application of Multimedia communication Networks.

Media Digitization: Digitization principles: Text, Image, Audio, Video, Digital media and Signal Processing Elements.

Text and Image Compression: Compression principles, Text compression, Limpel-Ziv-Welsh Coding, Image coding, Image Compression and Format, Digitized Documents and Pictures, JPEG Multimedia System Design.

Multimedia Processing and Communication Standards: Audio Fundamentals, Transform coding, Subband coding, Audio compression: Differential Pulse Code modulation, Adaptive Differential PCM, Adaptive predictive coding, Linear predictive coding, MPEG Audio Coder, Analog and Digital Video Formats, Video Compression Principles, H.261, H.263, MPEG standards.

Section B

Signaling Protocols for Multimedia: Protocols for multimedia communication: RTP, Signaling protocols: SIP, Enhanced QoS: RSVP, DiffServ, IntServ, Real-time multimedia streaming techniques: RTSP.

Network for Multimedia: QoS issues in networked Multimedia, Network Traffic, Network queue management, Scheduling.

Multimedia Communication Across Networks: Multimedia across ATM networks, Multimedia across IP networks and DSLs, Streaming Media with TCP and UDP, Internet access networks.

Multimedia Synchronization: Basic synchronization concepts and methods, Synchronization Quality of Service (QoS) Parameters, Multimedia synchronization reference model, Synchronized Multimedia Integration Language (SMIL).

Books Recommended:

1. Multimedia Communication Systems Techniques, Standards and Networks Multimedia **:**K. R. Rao, Zoran S. Boojkovic, Dragorad A. Milovanovic.
2. Multimedia Communications Applications, Networks, Protocols and Standards **:**Fred Halsall.
3. Multimedia Communications **:**Jerry D. Gibson.
4. Multimedia System Design **:**Andleigh, Thakrar.
5. Multimedia Information Networking **:**Sharda
6. Multimedia: Making It work **:**Vaughan

3rd semester

ICE M3011: Wireless Sensor Networks
100 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
4 Credits, 4 Hours/week, Lectures: 52, Exam time: 3 hours

Prerequisite Courses	**:**	ICE 4131, ICE 4211
Course Objectives	**:**	The objective of this course is to introduce the fundamental principles and concepts related to the wireless sensor nodes and sensor networks. Students will learn how to design and use sensor nodes in wireless communication systems to formulate energy efficient wireless sensor networks in a particular aspect. The goals of this course are to provide a comprehensive theory of wireless sensor network technology, sensor node architecture and protocol stacks
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:** Describe the background of Wireless Sensor Network (WSN) technology and its applications. **CLO-2:** Interpret sensor node architecture and its design principles **CLO-3:** Explain the wireless channel, Physical layer standards for WSNs **CLO-4:** Discuss the fundamentals of MAC protocols for WSNs **CLO-5:** Identify the different error control techniques for WSNs **CLO-6:** Analyze the topology control aspects such as topology management in flat and hierarchical WSNs **CLO-7:** Explain network layer issues of WSN with emphasis on routing techniques **CLO-8:** Discuss the concepts of time synchronization and localization methods in WSNs **CLO-9:** Explain transport layer aspects of WSNs such as reliable data delivery, congestion control and rate control issues.
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section-A

Introduction: Background of wireless sensor network (WSN) technology, applications of WSN, sensor node architecture, WSN architecture and protocol stack, design principles of WSN.

Physical Layer and Medium Access Control (MAC) aspects: Wireless channel, PHY layer standards, IEEE 802.15.4, fundamentals of MAC protocols, low duty cycle schemes, contention-based schemes, schedule-based schemes.

Link Layer Aspects: Error control, ARQ technique, FEC technique, hybrid technique, framing, naming and addressing issues.

Section-B

Topology Control and Network Layer Aspects: Topology control in flat networks, hierarchical networks, Challenges for routing, data-centric and flat-architectural protocols, hierarchical protocols, geographic routing.

Time Synchronization and Localization: Challenges for time synchronization, time synchronization techniques in WSN, challenges in localization, ranging techniques, range-based localization protocols, range-free localization protocols.

Transport Layer Aspects: Challenges for transport layer, reliable data transport, single packet delivery, block delivery, congestion control and rate control in WSN.

Books Recommended:

1. Protocols and Architectures for Wireless Sensor Networks, **:**Holger Karl and Andreas Willig, John Willey and Sons Ltd.
2. Wireless Sensor Networks, **:**Ian F. Akyildiz and Mehmet Can Vuran, John Willey and Sons Ltd.
3. Wireless Sensor Networks Technology, Protocols and Applications **:** Kazem Sohraby, Daniel Minoli, and Taieb Znati, John Willey and Sons Ltd.

ICEM3021: Cyber Security and Digital Forensics
100 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
4 Credits, 4 Hours/week, Lectures: 52, Exam time: 3 hours

Prerequisite Courses	**:**	ICE 4221
Course Objectives	**:**	The aim of the course is to acquire knowledge of wireless communication system and focusing on upcoming technologies like 5G mobile communication and LTE. This course also addresses the challenges and impacts of modern wireless communication system, andconcentrates on wireless network structures and planning.
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:** Identify key concepts and terminology in cybersecurity and digital forensic. **CLO-2:**Apply various types of cybersecurity functions for information risk assessment and security management. **CLO-3:** explain the role of digital forensics in digital world. **CLO-4:**outline a range of techniques and tools of digital forensic.
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section – A

Fundamentals of Cybersecurity: Definition of cyberspace and cybersecurity, cybersecurity objectives, cybersecurity dilemmas, the standard of good practice for information security, The

effective Cybersecurity management process. security governance principles and desired outcomes, security governance components, approach, and evaluation.

Information Risk Assessment and Security Management: Risk assessment concept, Asset, threat, control, and vulnerability identification. Risk assessment approaches, Likelihood assessment, Impact assessment. Risk determination, evaluation, and treatment. The security management function, security policies, Acceptable use policies.

Managing the Cybersecurity Function: People management, Information management, Physical asset management, System access, System management., Supply chain management and cloud security. Technical security management. Local Environment Management.

Security Assessment: Security audit and alarms model, data to collect for auditing, Internal and external audit, security audit controls. Security performance measurement. Security monitoring and reporting. Information Risk Reporting, Information security compliance monitoring.

Section – B

Introduction to Digital Forensic: Definition of Computer Forensics, Evolution of computer forensics, objectives and role of computer forensics; use and benefits of computer forensics.

Digital Evidence: Characteristics of digital evidence, stages in digital evidence investigation process, Locard's principle, best evidence rules. issues facing computer forensics-technical issues, legal issues, and administrative issues; types of investigation-criminal forensics, intelligence gathering, Electronic discovery, intrusion investigation.

Techniques and Tool Kit of Digital Forensics: Cross-drive analysis, live analysis, volatile data, recovery of deleted files, stochastic forensics, steganography. First responder toolkit, some common mistakes first responder should avoid, operating systems-parrot OS, CAINE OS, forensic tools, Analysis tools, Imaging tools, documentation, Digital Forensics Investigation Checklists.

Digital Forensic Hacks: Discovering Digital Traces on Different Linux Distributions, Searching Files, File Carving, Data Recovery in NTFS, RAM Imaging, Remote Imaging, PDF Malware Analysis, Word Document Artifacts, Internet and Email Artifacts.

Text Books:

1. William Stallings **:** Effective Cybersecurity
2. J. Pande & A. Prasad **:** Digital Forensics
3. Lucas Mahler **:**The Digital Forensic Handbook

Reference Books:

4. Eoghan Casey :Handbook of Digital Forensics and Investigation

ICE M2031: Advanced Optical Communication and Networks
75 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
3 Credits, 3 Hours/week, Lectures: 39, Exam time: 3 hours

Prerequisite Courses	**:**	ICE 3241
Course Objectives	**:**	The objective of the course is to provide to provide students with the design and operating principles of modern optical communication systems and networks. The first part of the course focuses on optical communication system and its key components. It also explains different channel impairments and optical link budget. Learning different modulation schemes and detections for optical link is also one of the objectives of the course. Next part of the course deals with different types of basic optical network architecture and networking elements. Different types of optical switching are also presented in this section. Additionally, the course aim to describe different types of optical access networks and next generation future optical networks.
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:** Define and describe general optical communication system and key components in optical communication link. **CLO-2:** Explain signal propagation principle in optical fiber. **CLO-3:** Illustrate different types of optical access network as well as control and management of those networks. **CLO-4:** Demonstrate different optical networking elements. **CLO-5:** Design different types of optical network architecture with different types of switching techniques.
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section A

Introduction: Historical Perspective, General Optical Communication system.
Key Optical Components: Optical fibers, light sources (Optical transmitter), optical filters and multiplexers, optical modulators, photodiodes (Optical receivers).

Signal Propagation in Optical Fiber: optical fiber losses, waveguide theory of optical fiber, nonlinear schrodinger equation for multichannel transmission, Optical channel noise.
Channel Impairment: nonlinear effects to system performance, link power budget.

Modulation Schemes: ASK, FSK, PSK, QAM, DPSK, QDPSK, OFDM for optical communication, direct and coherent detection of optical signal.

Section B

Evolution of Optical network: Wavelength division multiplexing (WDM) Optical Network.
Optical Networking Elements: optical line terminal (OLT), optical network unit (ONU) wavelength converters, optical cross connects, optical add-drop multiplexers, arrayed waveguide gratings (AWG), wavelength routers.

Wide Area Optical Network (WDM-WAN): routing and wavelength assignment, Network Architecture, optical packet switching and optical burst switching, optical Metro Network, Optical core network.

Optical Access Network: PON, FTTH, FTTB, FTTC networks, IP over WDM, Optical CDMA networks, Control and Management of optical network, Optical submarine networks, next generation future optical networks.

Books Recommended:

1. Advanced Optical Communication Systems and Networks Advanced **:**. Milorad Cvijetic and Ivan B. Djordjevic, Artech Publisher, University of Arizona
2. Optical Fiber Communication, Principle and Practice **:** John Senior, Prentice Hall Publisher.
3. Fiber Optic Communication System **:** Govind P Agarwal.
4. WDM Technologies, Optical Networks, **:** Achyut Dutta and Masahiko Fujiwara
5. Optical Switching and Networking Handbook **:**Regis J. and Bates.
6. Optical Switching Networks **:**Martin Maier

ICE M2041: Mathematical Programming
75 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
3 Credits, 3 Hours/week, Lectures: 39, Exam time: 3 hours

Prerequisite Courses	**:**	MATH 1111
Course Objectives	**:**	The aim of this course is to give the concepts of mathematical programming, with an emphasis on techniques for the solution and analysis of deterministic linear models. The primary types of models to be addressed will be linear programming and integer linear programming. However, the course will touch on more complex models, such as nonlinear programming problems. The main emphasis will be on solution techniques and on analysis of the underlying mathematical structure of these models.
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:** Define the basic terminologies of mathematical programming including of linear and integer programming **CLO-2:** Describe mathematical programming problem solution techniques **CLO-3:** Apply linear and integer programming to solve problems **CLO-4:** Show how a mathematical programming problem is constructed **CLO-5:** Formulate real world problem to mathematical programming problem and solve the problem **CLO-6:** Assess critically the utility of a number of mathematical programming techniques
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section A

Mathematical Programming- An Overview: An Introduction to Management Science and Operation Research, Model Specification, Mathematical Formulation of Problems, General and Scientific Solution Method for Operation Research, Geometrical Preview.

Linear Programming- Simplex Method: Introduction, Fundamental Properties of Solutions, The Computational Procedure, Use of Artificial Variables, Solution of Simultaneous Linear Equations, Applications of Simplex Method.

Duality in Linear Programming: Introduction, General Primal-Dual Problem, Formulating a Dual Problem, Primal-Dual Pair in Matrix Form, Duality Theorems, Duality and Simplex Method, Economic Interpretation of Duality.

Section B

Integer Programming: Introduction, Gomory's All I.P.P Method, Fractional Cut Method, Branch-and-bound Method, Applications of Integer Programming.

Advanced Linear Programming: Introduction, Revised Simplex Method, Bounded Variables, Parametric Linear Programming, Linear Fractional Programming.

Nonlinear Programming: Introduction, Formulating a NLPP, General Nonlinear Programming Problem, Constrained Optimization with Equality Constraints and Inequality Constraints, Saddle Point Problems, Saddle Point and NLPP.

Books Recommended:

1. Operation Research : Kanti Swarup, P. K. Gupta and Man Mohon.
2. Applied Mathematical Programming : S. Bradley, A. Hax and T. Magnanti.
3. Non-linear Programming, Theory and Algorithms : Mokhtar S. Bazaraa, Hanif. D. Sherali and C. M. Shetty
4. Operation Research and Introduction : H. A. Taha.

ICE M2051: Computer Vision
75 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
3 Credits, 3 Hours/week, Lectures: 39, Exam time: 3 hours

Prerequisite Courses	**:**	ICE 3131, CSE1291
Course Objectives	**:**	Computer Vision plays very important roles in fields such as Machine and Robot Intelligence. It provides the means for the machine or robot to interact intelligently with the outside world through visual perception. The objective of this course is to prepare students for working in such intelligent automation fields.
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:** Describe history and application of computer vision. **CLO-2:** Explain image formation and transformation technique. **CLO-3:** Explain the camera calibration and homography techniques in computer vision. **CLO-4:** Describe and compare techniques for extracting and representing features of an object **CLO-5:** Apply image segmentation algorithm to segment an object within an image. **CLO-6:** Describe the roles of machine learning in computer vision, including probabilistic inference, discriminative and generative methods. **CLO-7:** Analyze motion of an object using different techniques of motion analysis.
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section A

Introduction: Introduction to computer vision, imaging basics.
Digital Image Formation and Low-level Processing: Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc.

Depth Estimation and Multi-camera Views: Perspective, Binocular Stereopsis: Camera and Epipolar Geometry; Homography, Rectification, RANSAC, 3-D reconstruction framework; Auto-calibration.

Feature Extraction: Edges - Canny edge detection, thresholding and linking, edge thinning, Second-order approaches to edge detection; Line detectors, Corners - Harris and Hessian Affine, Orientation of Histogram, SIFT, SURF, HOG, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters.

Section B

Image Segmentation: Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, Texture Segmentation.

Recognition: Object detection, Face recognition, Instance recognition, Category recognition, Context and scene understanding, Recognition databases and test sets.

Motion Analysis: Background Subtraction and Modeling, Optical Flow, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.

Books Recommended:

1. Computer Vision: Algorithms and Applications **:**Richard Szeliski, Springer-Verlag London Limited, 2011
2. Computer Vision: A Modern Approach **:**D. A. Forsyth, J. Ponce, Pearson Education, 2003
3. Multiple View Geometry in Computer Vision **:** Richard Hartley and Andrew Zisserman, 2nd Edition, Cambridge University Press, March 2004.
4. Introduction to Statistical Pattern Recognition **:** K. Fukunaga, Second Edition, Academic Press Morgan Kaufmann, 1990.
5. Digital Image Processing **:**R..C. Gonzalez and R.E. Woods, Addison- Wesley, 1992
6. Data Mining Concepts and Techniques **:**Jiawei Han and Micheline Kamber.

ICE M2061: Distributed Systems
75 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
3 Credits, 3 Hours/week, Lectures: 39, Exam time: 3 hours

Prerequisite Courses	**:**	STAT 1211, STAT 211
Course Objectives	**:**	A distributed systems combines the computational power of multiple computers to solve problems. This course is designed to provide a comprehensive understanding of how to design system models, algorithms and protocols that allow computers to communicate and coordinate their actions to solve the problems.
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:** Define the basic terminologies and core concepts of distributed systems. **CLO-2:** Explain the design and development of distributed systems. **CLO-3:** Use algorithms to solve problems of distributed systems. **CLO-4:** Design and testing of software for distributes systems.
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section A

Introduction: Multiprocessor vs. networked systems, types of distributes system, centralized vs. distributes architecture, self-management in distributed system.

Processes: Threads, Virtualization, Client-server computing, Code migration.
Communication and Naming: Remote procedure call, Message-oriented and steam-oriented communication, Flat, structure and attribute-based naming.

Synchronization: Clock synchronization, Logical clock, vector synchronization, Mutual exclusion, election algorithms.

Section B

Fault Tolerance: Basic concepts, Process resilience, Reliable client-server and group communication, Distributed commit, Recovery.
Security: Introduction, Digital certificate, Cryptography, Authentication, Message integrity and confidentiality, Secure group communication, Kerberos, Firewalls, Denial of service, Security management.

Distributed Object-Based Systems: Architecture,Processes, Communication, Synchronization, Consistency and Replication, Faulttolerance, Security.

Distributed File Systems: Architecture,Processes, Communication, Naming, Synchronization, Consistency and Replication, Faulttolerance, Security.

Books Recommended:

1. Distributed Systems Principles and Paradigm **:** Andrew S. Tanenbaum, Martem Van Steen.

2. Distributed Systems: Concepts and Design **:** George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair

ICE M2081: Big Data Analytics
75 Marks [70% Exam, 20% Quizzes/Class Tests, 10% Attendance]
3 Credits, 3 Hours/week, Lectures: 39, Exam time: 3 hours

Prerequisite Courses	**:**	STAT 2111, ICE4111, ICE4141
Course Objectives	**:**	The objective of this course is to introduce the concepts, tools and technologies of Big Data Analytics. Students will be able to understand the processing and management of Big Data in Cloud environments. This course will also provide the insight on using Apache Hadoop tools for Big Data Analytics. In addition, the students will be familiar with machine learning algorithms for Big Data Analytics and Big Data visualization techniques.
Course Learning Outcomes (CLOs)	**:**	**After successfully complete this course, students will be able to:** **CLO-1:**Understand the basic concepts of Big Data. **CLO-2:**Identify the requirements for Big Data storage. **CLO-3:**Analyze the methods for Big Data processing and management. **CLO-4:**Apply the concepts of Big Data in Cloud environments. **CLO-5:**Understand the concepts of Big Data Analytics. **CLO-6:**Utilizethe Apache Hadoop tools for Big Data Analytics. **CLO-7:** Develop machine learning algorithms for Big Data Analytics. **CLO-8:**Perform different types of visualization for Big Data.
Assessment Methods	**:**	Total mark of the course is distributed as: 70% Examination, 20% Quizzes/Class Tests, and 10% Attendance. Students should be asked to answer SIX questions out of EIGHT taking not more than THREE from each section.

Course Contents

Section A

Introduction to Big Data: Understanding Big Data, Evolution of Big Data, 3Vs of Big Data, Sources of Big Data, Different types of Data, Big Data infrastructure, Big Data life cycle, Big Data technologies, Applications and Use cases.

Big Data Storage: Cluster computing, Distribution models, Distributed file system, Relational and non-relational databases, NoSQL database, CAP theorem, ACID, BASE, Schemaless databases, Migration from RDBMS to NoSQL.

Big Data Processing and Management: Data processing, Shared-Everything and shared-nothing architecture, Batch processing, Real-time data processing, Parallel computing, Distributed computing, Big Data virtualization.

Big Data in Cloud Computing: Cloud computing types, Cloud services, Cloud storage, Cloud architecture, Big Data processing and management in Cloud computing.

Section B

Hadoop Tools and Technologies: Apache Hadoop, Hadoop storage, Hadoop computation, Hadoop 2.0, HBASE, Apache Cassandra, SQOOP, Flume, Apache Avro, Pig, Mahout, Oozie, Hive, Hive architecture, Hadoop distributions.

Big Data Analytics: Terminology and understanding of Big Data Analytics, Data analytics life cycle, Big Data Analytics techniques, Semantic analysis, Visual analysis, Big Data business intelligence, Big Data Analytics real-time processing, Enterprise data warehouse.

Big Data Analytics with Machine Learning: Introduction to machine learning, Machine learning use cases, Types of machine learning, Applications of machine learning in Big Data analytics.

Big Data Visualization: Big Data and conventional data visualization techniques, Tableau, Different types of charts in Tableau, Tableau use cases, Use of R in Big Data visualization, Basic graphs in R.

Books Recommended:

1. Big Data – Concepts, Technology and Architecture (Wiley) **:**BalamuruganBalusamy, NandhiniAbirami. R, SeifedineKadry and Amir H. Gandomi.
2. Data Analytics with Hadoop: An Introduction for Data Scientists (O'Reilly) **:**Benjamin Bengfort and Jenny Kim
3. Big Data Analytics with R (Packt) **:**Simon Walkowiak
4. Big Data Analytics for Cloud, IoT and Cognitive Learning (Wiley) **:** Kai Hwang and Min Chen