**University of Rajshahi**

**Faculty of Engineering**

**Department of Information & Communication Engineering**

**Syllabus for Master of Philosophy(M.Phil.) and Doctor of Philosophy(Ph.D.) Degree**

**Session: 2023 -2024**

**M.Phil. Degree**

The degree of Master of Philosophy (M.Phil.) Course shall be awarded by the University of Rajshahi on the basis of (a) course work of 300 marks, (b) seminar presentation(s), (c) submission of a thesis on an approved topic, (d) an oral or both oral and practical examination, (e) at least one publication (published/accepted) in a refereed and abstracted journal.

In the first/second year of M.Phil. program, an M.Phil. degree student shall undertake three courses of total 300 marks, out of which one course is compulsory and two are optional, each of four hours duration and each carries 100 marks. Minimum passing grade point for each course is 2.25. Candidate must earn overall GPA of 2.5. If the candidate fails for the first time he/she will be allowed to sit for the examination for the last time within next six months. The courses shall be taken with prior approval of the supervisor(s) and/or chairman of the department.

Every candidate shall have to give at least two (2) seminars before the board of Examiners.

**Course duration:** The M.Phil. program shall extend over a period of not less than two (2) and ordinarily not more than five (5) academic years for the full-time researchers from the date of his/her first admission. However, for the part-time researchers, this duration shall be minimum three (03) years and maximum six (06) years. If the candidate fails to submit his/her thesis within the specified time he/she may get re-registration/re-admission for a period of two years on recommendation of his/her supervisor/principle supervisor and the relevant Committee.

**Ph.D. Degree**

The degree of Doctor of Philosophy (Ph.D.) Course shall be awarded by the University of Rajshahi on the basis of (a) course work of 300 marks, (b) seminar presentation(s), (c) submission of a thesis on an approved topic, (d) an oral or both oral and practical examination and (e) at least two publications (published/accepted) in a refereed and abstracted journal.

In the first/second year of Ph.D. program, a Ph.D. degree student shall undertake three curse works of total 300 marks, out of which one course is compulsory and two are optional, each of four hours duration and each carries 100 marks. Minimum passing grade point for each course is 2.25. Candidate must earn overall GPA of 2.5. If the candidate fails for the first time he/she will be allowed to sit for the examination for the last time within next six months. The courses shall be taken with prior approval of the supervisor(s)and/or chairman of the department.

Every candidate shall have to give at least two (2) seminars before the board of Examiners.

**Course duration:** The Ph.D. program shall extend over a period of not less than three (3) and ordinarily not more than six (6) academic years for the full-time researchers from the date of his/her first admission. However, for the part-time researchers, this duration shall be minimum five (05) years and maximum eight (08) years. If the candidate fails to submit his/her thesis within the specified time he/she may get re-registration/re-admission for a period of two years on recommendation of his/her supervisor/principle supervisor and the relevant Committee.

**Courses for M.Phil. and Ph.D.:** The examination of the M.Phil. and Ph.D. programs comprises of three courses. One course is compulsory and two are optional for all. The optional course shall be taken with the prior approval of the supervisor(s) and/or chairman of the department.

**Compulsory Course:**

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| --- | --- | --- |
| **Code** | **Course Title** | **Credit** |
| ICE 601 | Research Methodology | 4 |

**Optional Courses:**

|  |  |  |
| --- | --- | --- |
| **Code** | **Course Title** | **Credit** |
| ICE 602 | Cognitive Radio Networks | 4 |
| ICE 603 | Advanced Digital Signal Processing | 4 |
| ICE 604 | Wireless Sensor Networks | 4 |
| ICE 605 | Advanced Computer Vision | 4 |
| ICE 606 | Advanced Antenna Engineering | 4 |
| ICE 607 | Advanced Machine Learning and Deep Learning | 4 |
| ICE 608 | Electromagnetic Compatibility | 4 |

**Distribution of Marks for Theoretical Courses:**

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

**Grading System**

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| (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 | | 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 within the duration. |
| (ii) | A **Grade Point Average (GPA**) shall be computed as follows:    where, n is the number of courses offered, Ci is the number of credits allotted to a i’th course and Gi is the i’th grade point corresponding to the grade awarded for that course. |

**Duration of Course Work Examination**

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

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| Courses of 4 credits | 4 Hours |

**Course Contents:**

**ICE 601: Research Methodology**

**Overview of Research Methodology:** Concepts of research, Need for research, Types of research, Steps in conducting research.

**Literature Review:** Introduction of literature review, Need for literature review, Technique of literature review.

**Identifying Research Problem:** Problem formulation, Necessity and criteria for selecting a problem, Identifying variables, Evaluating problems, Functions of a hypothesis.

**Writing Research Proposal:** Necessity of writing research proposal, Technique for writing good research proposal.

**Conducting the Research:** Research activities, Preparations before conducting the research.

**Writing Research Reports and Thesis:** Necessity of writing papers and reports, Writing a research report, Writing a technical paper, Contents of a thesis

**Books Recommended:**

1. **Dipankar Deb, Rajeeb Dey, Valentina E. Balas: Engineering ResearchMethodology: A Practical Insight for Researchers**
2. **Catherine Dawson : Practical Research Methods, USB**

***Publishers & Distributors***

1. **C.R.Kothari : Research Methodology- Methods and Techniques, *Wiley Eastern Limited***
2. **Ranjit Kumar : Research Methodology-A Step-by-Step Guide for Beginners,*Pearson Education***
3. **M.Zainul Abedin : A Handbook of Research, *Book Syndicate, Dhaka,Chittagong***

**ICE 602: Cognitive Radio Networks**

**Cognitive Radio Communications:** Cognitive Radios and Dynamic Spectrum Access, Capability of Cognitive Radios, Spectrum Sharing Models of DSA, Opportunistic Spectrum Access, Dynamic Spectrum Access in Open Spectrum, Fundamental Limits of Cognitive Radios.

**Cognitive Radio**: Cognitive Radio Networks Architecture-network architecture, Terminal Architecture of CRN- cognitive radio device architecture, Scaling Laws of Ad-hoc and Cognitive Radio Networks.

**Spectrum Sensing:** Spectrum Sensing to Detect Specific Primary System- conventional spectrum sensing, cooperative spectrum sensing, Spectrum Sensing for Cognitive OFDMA Systems, Spectrum Sensing for Cognitive Multi-Radio Networks.

**Medium Access Control:** MAC for Cognitive Radios, Multichannel MAC- general description of multichannel MAC, collision avoidance/resolution, access negotiation, Carrier Sense Multiple Access with AMC, CSMA with Spatial-Reuse Transmissions.

**Network Layer Design:** Routing in Mobile Ad-hoc Networks- features of routing in CRN, dynamic source routing in MANET, ad-hoc on-demand distance vector (AODV), Routing in Cognitive Radio Networks.

**Spectrum Management of Cognitive Radio Networks:** Spectrum Sharing, Spectrum Pricing, Mobility Management of Heterogeneous Wireless Networks.

**Cognitive Interference Channel:** Simultaneous transmission of primary and secondary users, Interference mitigation using precoding techniques such as zero-forcing, Enhancing capacity using selective and phase-align precoding.

**Books Recommended:**

1. Cognitive Radio Networks: Kwang-Cheng Chen and Ramjee Prasad
2. Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems: : Hüseyin Arslan
3. Cognitive Radio Networks : Yang Xiao and Fei Hu
4. Cognitive Wireless Communication: Ekram Hossain, and Vijay Bhargava
5. Cognitive Radio MobileAd Hoc Networks: F. Richard Yu

**ICE 603: Advanced Digital Signal Processing**

**Introduction:**Basics of signal and information, Need for signal processing, Methods of signal processing, Sampling and ADC, Application of DSP.

**Probability Models:** Random and stochastic processes, probabilistic models, stationary and non-stationary random processes, expected value of a random process, classes of random processes.

**Wiener Filters**: Least Square Error Estimation, Formation of the wiener filter, interpretation, formulation, applications, Wiener filter for prediction.

**Adaptive Filters:**RLS filters,Kalman filters, Sample adaptive filters, forward and backward error filters, lattice filters, LMS filters.

**Linear Prediction Models:**Linear prediction coding, forward and backward linear predictors, lattice forward and backward predictors, short-term and long term predictors, signal restoration using linear prediction model.

**Bayesian Estimation:** Bayesian estimation theory, Bayesian estimation, Bayesian classification.

**Hidden Markov Models:**Hidden Markov Models, Training Hidden Markov Models, HMM based wiener filter.

**Power Spectrum Estimation:**Estimation of spectra, Parametric methods for power spectrum estimation, Nonparametric methods for power spectrum estimation, Minimum Variance Spectral Estimation.

**Books Recommended:**

**1. Saeed V. Vaseghi : Advanced Digital Signal Processing and Noise Reduction,**

***John Wiley and Sons Ltd*.**

**2. John G.Prokis : Algorithms for Statistical Signal Processing , *Eduction Asia***

**ICE 604: Wireless Sensor Networks**

**Introduction:**Information theoretic Bounds on sensor network performance: Sensor Network models, Digital architectures, The price of Digital architectures, Bound of digital architecture.

**Information Processing in WSNs:** Communication Complexity Model, Computing functions over wireless Networks-Spatial Reuse and block computation, Wireless Networks with Noisy Communications: reliable computation in a collected Broadcast network, toward an Information theoretic Formulation.

**The Sensing Capacity:**Large scale Detection Applications, Sensor Network as an encoder, Information Theory context, Sensor networks with arbitrary connection, random coding and methods of types. Sensing capacity theorem, Illustration of sensing capacity bound.

**Detection in WSNs:** Centralized detection, the classical decentralized detection framework, Decentralized detection in WSNs-sensor nodes, network architecture, data processing, Wireless Sensor Networks-Detection under capacity constraint, wireless channel considerations, Attenuation and fading, New Paradigms-constructive interference, Message passing, cross layer consideration, Energy saving via censoring and sleeping.

**Distributed Learning in WSNs:** Classical learning-the supervised learning model, Kernel Methods and the principle of Empirical Risk Minimization, other learning algorithms. Distributed learning in WSNs-A general model for distributed learning, Distributed learning in WSNs with a Fusion Center-clustering approach, statistical limits of Distributed learning, Distributed learning in Ad-hoc WSNs with In-network processing.

**Laws of Sensor Network Lifetime and its applications:** Law of Network lifetime and General Design principles-Network characteristics and lifetime definition, Law of lifetime, A general design principle for lifetime maximization. Fundamental performance limits, Dynamic protocols for Lifetime maximization.

**Books Recommended:**

1. **Wireless Sensor Networks Signal Processing and Communications Perspectives—John Wiley & Sons Ltd.**
2. **Problem solving for Wireless Sensor Networks—Springer-Verlag London Limited.**
3. **Building Wireless Sensor Networks by R Faludi—O’Reily Media , Inc.**
4. **Wireless Sensor Network Design by Anna Hac---John Wily & Sons, Ltd.**

**ICE 605: Advanced Computer Vision**

**Introduction:**AI, Computer vision, Sensing, Seeing, and Perceiving. Role of vision.

**Image Formation Models:** Monocular imaging system, Orthographic and Perspective Projection, Camera model and Camera calibration, Binocular imaging systems.

**Image Processing and Feature Extraction:** Binary Image Analysis and Segmentation, Edgedetection, corner detection, Line and Curve Detection, SIFT operator, Image-based modeling and rendering.

**Motion Analysis:** Regularization theory, Motion detection and optical flow, Structure from motion, Motion estimation.

**Shape Representation and Segmentation:** Deformable curves and surfaces, Snakes and active contours, Level set representations, Fourier and wavelet descriptors, Medial representations, Multiresolution analysis.

**Object recognition:** Hough transforms and other simple object recognition methods, Shape correspondence and shape matching, Principal component analysis, Shape priors for recognition.

**Books Recommended:**

1. **Computer Vision - A modern approach, by D. Forsyth and J. Ponce, Prentice Hall.**
2. **Introductory Techniques for 3D Computer Vision, by E. Trucco and A. Verri, Publisher: Prentice Hall.**
3. **Multiple View Geometry in Computer Vision, by Richard Hartley, Andrew Zisserman, Cambridge**

**University Press.**

**ICE 606: Advanced Antenna Engineering**

**Introduction**: Antenna basic, Radiation mechanism, Fundamental Parameters of Antenna, Antenna Theorems, Types of Antennas: Linear Wire Antennas, Loop Antennas, Antenna Arrays, Microstrip and Smart Antennas.

**Smart Antenna for IoT application**: A Via-Based Rectangular Patch Antenna for Narrow Band IoT Applications, A Square Slotted Dual Bandwidth Rectangular Patterned Antenna for IoT Applications, A Wideband Microstrip Patch Antenna for NBIOT Applications, Design of a Practical Miniaturized Antenna to Support IoT Applications.

**Antenna for Advanced Wireless Communication**: Performance metrics for MIMO antenna system; Antenna design for USB Dongles, Mobile Phone, wireless access point and 5G communication system.

**Terahertz Antenna**: Antennas for Terahertz (THz) band, Characteristics of THz Antenna, Antenna design for THz application, Quasi-optical coupling for THz radiation.

**Antenna for Medical Application**: Overview, Waveguide- and Radiation-Type Antennas, Implantable Antennas (Radiators) for Localized Cancer Treatment, Antenna for medical imaging, Heating and Biotelemetry.

**Artificial Intelligence based Antenna Design**: Linear SVM, Linear Gaussian Process, Kernels for signal and array processing, Basic concept of machine learning and deep learning for antenna design, Beam forming.

**Books Recommended:**

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| 1. Electromagnetic Waves and Antenna | Sophocles J. Orfanidis |
| 2. Antenna Engineering Handbook | John L. Volakis |
| 3. Machine Learning Application in Electromagnetics and Antenna Array Processing | M. Martinez-Ramoh, Arjur Gupta, JL Rojo-Alvarez, C. Christodoulou |
| 4. Antenna Design for Narrowband IoT | B. Pattanaik, M. Saravanan, U. Saravanakumar, G. Babu |

**ICE 607: Advanced Machine Learning and Deep Learning**

**Introduction:** Perspectives and Issues in deep learning framework, introduction to Deep Learning, review of fundamental learning techniques.

**Feedforward Neural Network:** Artificial Neural Network, activation function, multi-layer neural network, Bayesian Learning, Decision Surfaces, Linear Classifiers, Linear Machines with Hinge Loss.

**Training Neural Network:** Risk minimization, loss function, back propagation, regularization, model selection, and optimization.

**Deep Learning:** Deep Feed Forward network, regularizations, training deep models, dropouts, Convolutional Neural Network, Recurrent Neural Network, Deep Belief Network, Optimization Techniques, Gradient Descent, Batch Optimization, Unsupervised Learning with Deep Network, Auto encoders.

**Advanced Topics on Deep Learning:** Convolutional Neural Network, Building blocks of CNN, Transfer Learning

Revisiting Gradient Descent, Momentum Optimizer, Effective training in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization, Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN, Classical Supervised Tasks with Deep Learning, Image Denoising, Semanticd Segmentation, Object Detection, LSTM Networks, Generative Modeling with DL, Variational Autoencoder, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer.

**Books Recommended:**

1. Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016..

2. Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006.

**ICE 608: Electromagnetic Compatibility**

**Introduction**: Definition of Electromagnetic Compatibility (EMC), History of EMC, Aspects of EMC, Decibels and Common EMC Units.

**EMC Requirements for Electronic Systems:** Typical Product Emissions, Measurement of Emissions for Verification of Compliance, Radiated Susceptibility (Immunity), Conducted Susceptibility (Immunity), Requirements for Commercial Vehicles.

**Conducted Emissions, Radiated Emissions and Susceptibility:** Measurement of Conducted Emissions, Power Supply Filters, Power Supply and Filter Placement, Conducted Susceptibility, Simple Emission Models for Wires and PCB Lands, Simple Susceptibility Models for Wires and PCB Lands.

**System Design for EMC:** Changing the Way We Think about Electrical Phenomena, Printed Circuit Board (PCB) Design, System Configuration and Design, Diagnostic Tools.

**Mixed-Mode S-Parameters:** Mode Definitions, Mode-Specific Waves and Impedances, Normalized Power Waves, Mixed-Mode Scattering Parameters, Standard S-Parameter/Mixed-Mode S-Parameter Transformation.

**Transmission Lines and Systems:** Traveling Waves and Transmission-Line Concepts, Mode Specific S-Parameters, Distributed Mixed-Mode S-Parameter to R, L, G, and C Model, Single-Ended Signal Application in Mixed-Mode Terms.

**Books Recommended:**

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| 1. Introduction to Electromagnetic Compatibility | Clayton R. Paul |
| 2. Microwave Differential Circuit Design  Using Mixed-Mode S-Parameters | William R. Eisenstadt  Bob Stengel  Bruce M. Thompson |