No. Acd./ 8264 /IAPC-151                    Dated: May 26 , 2025

**Head, Department of Electronics and Communication Engineering**

The IAPC, in its 151st meeting held on 23.04.2025 vide Item No. 151.2.7 (7), has approved the course outline of the following PECs of the new PG curriculum of the Department of Electronics and Communication Engineering:

### M.Tech. Terahertz and Communication Sensing (New PECs)

a) ECL-641: Advanced Machine Learning for THz Sensing
b) ECL-642: Applied Optimization for THz Communication and Sensing
c) ECL-643: Special Topics in THz Communication and Sensing
d) ECL-644: Introduction to TinyML
e) ECL-645: Introduction to Internet of Things (IoT)
f) ECL-646: Introduction to Quantum Machine Learning
g) ECL-647: Terahertz Optics and Metamaterials
h) ECL-648: Advance Topics in THz Communication
i) ECL-649: Optical Communication and Networks
j) ECL-650: Advanced Data Networks

### M.Tech. (Microelectronics and VLSI)

a) ECL-553: Advanced Analog IC Design

The approved course outline are attached as **Appendix-A.**

**Assistant Registrar**
**(Curriculum)**

Encl. Appendix-A

**Copy to** (through e mail):-

1. All faculty
2. Chairperson, DAPC of Department of Electronics and Communication Engineering
3. Dean, Academic Affairs
4. Associate Dean of Academic Affairs (Curriculum)
5. Deputy Registrar, Academic Affairs Office
6. Channel i/ Academic webpage of iitr.ac.in

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

**NAME OF DEPARTMENT:** Department of Electronics and Communication Engineering

**Subject Code:** ECL-641          **Course Title:** Advanced Machine Learning for THz Sensing

**L-T-P:** 3-1-0          **Credits:** 4          **Subject Area:** PEC

**Course Outline:** Deep feedforward networks, Regularization for Deep Learning, Optimization for Training Models, Convolution Networks, Autoencoders, Deep generative models; Preprocessing, feature extraction, supervised and unsupervised learning; signal classification, anomaly detection, spectral analysis, regression models, clustering, transfer learning, real-time processing, performance metrics, and application of ML algorithms in THz sensing challenges.

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT:** Department of Electronics and Communication Engineering

**Subject Code:** ECL-642      **Course Title:** Applied Optimization for THz Communication and Sensing

**L-T-P:** 3-1-0      **Credits:** 4      **Subject Area:** PEC

**Course Outline:** Introduction to Optimization Problems, Convex Sets and Convex Functions; Unconstrained Optimization; Constrained Optimization (Karush-Kuhn-Tucker (KKT) Conditions); Lagrange Multiplier Algorithms; Duality Theory; Applications in THz communication and sensing: Beamforming Optimization, Channel Estimation and Equalization, Resource Allocation, Antenna Array Design, Sensing and Localization Optimization, and Waveform Design for Joint Sensing and Communication.

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT:** Department of Electronics and Communication Engineering

**Subject Code:** ECL-643          **Course Title:** Special Topics in THz Communication and Sensing

**L-T-P:** 3-1-0          **Credits:** 4          **Subject Area:** PEC

**Course Outline:** Parameter estimation, Hypothesis testing, Bayesian estimation, Maximum Likelihood Estimation (MLE), Minimum Mean Square Error (MMSE), Cramér-Rao bound, Fisher information, Kalman filters, Bayesian networks; Beamforming, channel estimation, frequency estimation, Doppler shift estimation, delay estimation, phase noise estimation, sparse signal recovery; Monte Carlo methods, linear regression, regularization, sampling theory, THz channel characteristics.

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT:** Department of Electronics and Communication Engineering

**Subject Code:** ECL-644　　　　　　　　　**Course Title:** Introduction to TinyML

**L-T-P:** 3-1-0　　　　　　**Credits:** 4　　　　　　**Subject Area:** PEC

**Course Outline:** Microcontroller basics, embedded systems, on-device ML, model compression, edge AI, supervised learning, unsupervised learning, neural networks, feature extraction, sensor integration, inference optimization; TensorFlow Lite, Edge Impulse, anomaly detection, image recognition, audio classification, speech recognition, time-series data; Deployment challenges, dataset creation, accuracy trade-offs, system design, data augmentation, optimization techniques, wearable devices.

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT:** Department of Electronics and Communication Engineering

**Subject Code:** ECL-645          **Course Title:** Introduction to Internet of Things (IoT)

**L-T-P:** 3-1-0          **Credits:** 4          **Subject Area:** PEC

**Course Outline:** Sensors, Actuators, Microcontrollers, Communication protocols (SPI, I2C, UART), Basics of Networking, Cloud integration, Edge computing, IoT architecture, data security, MQTT; Wireless networks: BLE, WiFi, Zigbee, LPWAN; Sensor Networks; Introduction to Micro-Python programming, Implementation of IoT with Raspberry Pi, Fog Computing, real-time processing; Tiny ML; Case Study: Smart Cities and Healthcare.

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT:** Department of Electronics and Communication Engineering

**Subject Code:** ECL-646  **Course Title:**  Introduction to Quantum Machine Learning

**L-T-P:** 3-1-0  **Credits:** 4  **Subject Area:** PEC

**Course Outline:** Quantum computing fundamentals, quantum circuits, and tools like Qiskit and PennyLane. Explores optimization techniques (QAOA, VQE, Grover's algorithm) and machine learning methods (quantum SVMs, neural networks, GANs). Emphasizes hands-on implementation of algorithms on quantum simulators, blending mathematical rigor with practical coding applications.

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT:** Department of Electronics and Communication Engineering

**Subject Code:** ECL-647        **Course Title:**  Terahertz Optics and Metamaterials

**L-T-P:** 3-1-0               **Credits:** 4            **Subject Area:** PEC

**Course Outline:** Electromagnetic theory of light, Electromagnetic properties of material, Drude-Lorentz model, Polarization of light, Fresnel equations, Optical properties of metals, Surface Plasmon Polaritons, Localized surface plasmons, Metamaterial fundamentals, Effective-medium theories, Negative-permittivity and negative-permeability, Perfect absorbers, Super- and Hyper-lens, Transformation Optics, Invisibility Cloaks, Metasurfaces, theory, simulation, and experimental techniques at Terahertz Frequencies.

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT:** Department of Electronics and Communication Engineering

**Subject Code:** ECL-648        **Course Title:** Advance Topics in THz Communication

**L-T-P:** 3-1-0        **Credits:** 4        **Subject Area:** PEC

**Course Outline:** Terahertz band, terahertz technologies: terahertz electronics, terahertz photonics, metasurfaces, optical sources, detectors; terahertz communication systems design: signal propagation, multiplexing, diversity; terahertz network design: physical layer, link layer, and network layer protocols; software-defined networking, data center networking.

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT:** Department of Electronics and Communication Engineering

**Subject Code:** ECL-649        **Course Title:** Optical Communication and Networks

**L-T-P:** 3-1-0                **Credits:** 4                **Subject Area:** PEC

**Course Outline:** Introduction to optical communication and applications; Basics concepts of optical sources; Basic concept of optical detectors; Optical amplifiers, Coupler, Arrayed waveguide grating, and other devices, Theory for optical propagation, Characteristics of fibers, Cutoff wavelength, Propagation losses, Introduction to optical networks, Optical packet and circuit switching, wavelength division multiplexing.

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT:** Department of Electronics and Communication Engineering

**Subject Code:** ECL-650                    **Course Title:**  Advanced Data Networks

**L-T-P:** 3-1-0                    **Credits:** 4                    **Subject Area:** PEC

**Course Outline:** Introduction to data networks, OSI layering, Application layer to physical layer, Queuing: MM1 to MG1, Modeling and measurement of network traffic, Discrete event simulation of various queues, Simulation issues, Wire and wireless networks, Software defined networking, Cross-layer optimizations, Emerging network types: data center, self-healing networks, Emerging applications.

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT:** Department of Electronics and Communication Engineering

**Subject Code:** ECL-553 **Course Title:** Advanced Analog IC Design

**L-T-P:** 3-1-0 **Credits:** 4 **Subject Area:** PEC

**Course Outlines:** Noise in CMOS amplifiers - common source (CS), common gate (CG) and common drain (CD), differential amplifiers. Effects of device mismatch - Pelgrom equation, analog layout effects. Op-amp design - Miller compensation, Nested Miller compensation, Common Mode Feedback (CMFB), Feed-forward compensation. Wideband analog-to-digital converters (ADC) - pipelined ADC, signal reconstruction and SNDR, effect of nonidealities, continuous time pipelined ADC. Oscillators and Phase Locked Loops (PLL) - LC and Ring oscillators, Type-1 and Type-2 PLL. Advanced circuits - Low noise amplifiers, current and voltage references, filters, dc-dc converters.