| Subject Code: | Course Title: 5G Wireless Technology | Total Contact Hours: 40 | L:3 | T: | P: | C: 3 |
| --- | --- | --- | --- | --- | --- | --- |
| Pre-requisite: Digital communication | | Year: 1 (PG) | Semester: 2 | | | |
| Type of Course: Program Core | | | | | | |

\*\*L🡪Lectures, T🡪Tutorials, P🡪Practical, C🡪Credit

**Learning Objective:** 5G wireless is the latest deployed communication technology, termed as the 5G New Radio (5G NR), which is promised to fulfill the demand for higher capacity, reliability and energy efficiency in mobile broadband services. This course highlights the key and pertinent technology advancements that build the 5G NR, which include the physical layer radio interface, flexible waveform and modulation formats, massive MIMO and mm-wave techniques, advanced channel coding, radio access and networking for 5G and the versatile concepts of cloud radio access network (CRAN), network function virtualization (NFV) and multi-access edge computing (MEC).

**Course outcomes (COs):**

| **On completion of this course, the students will have the ability:** | | **Bloom’s Level** |
| --- | --- | --- |
| **CO-1** | To **recognize** the importance and applications of 5G networks’ architecture, physical layer algorithms, MAC layer protocols, and 5G standards | **2** |
| **CO-2** | To **apply** 5G physical layer radio channel modelling for 5G test bed experimentation | **3** |
| **CO-3** | To **design**, **analyze** and **implement** 3D beamforming algorithm for massive MIMO systems | **6, 4, 3** |
| **CO-4** | To **design** and **develop** ‘small cell’ networks using OFDM numerology and knowledge of inter-cell interference | **6, 6** |
| **CO-5** | To **design**, **formulate** and **build** solution to QOE and profit aware resource allocation in 5G CRAN | **6, 6, 6** |
| **CO-6** | To **design** and **develop** efficient off-loading and load balancing in 5G HetNets using Software defined Networking (SDN) based resource management | **6, 6** |

| **Course Topics** | **Lecture Hours** |
| --- | --- |
| **UNIT-1 Introduction** | **8** |
| * 1. Mobile broadband wireless evolution |
| 1.2 LTE and LTE-Advanced state-of-the-art technology |
| 1.3 Drivers for 5G NR: vision, service requirements and targets, 5G current scenario and future trends |
| 1.4 5G Use cases: 5G for IOT, AI/ML in 5G |
| 1.5 5G standards: 3GPP, ITU-R, IMT-2020, 3GPP New Radio (NR) |
|  |  |
| **UNIT- 2 Physical layer technologies for 5G NR** | **10** |
| 2.1 3GPP radio channel modelling and specifications |
| 2.2 Flexible modulations: OFDM, FBMC, UFMC, GFDM |
| 2.3 multi-antenna solutions, massive MIMO, FD-MIMO |
| 2.4 mm-wave techniques: 3D beamforming, beam tracking |
| 2.5 Small cells concept, interference issues and their mitigation |
| 2.6 Advanced channel coding: LDPC, CRC-aided polar codes |
| 2.7 Scalable OFDM numerology for small cell deployment |
| 2.8 Spatial modulation (SM), Index modulation (IM), SM-IM, OFDM-IM, media-based modulation, full-duplexing |
|  |  |
| **UNIT- 3 5G Radio Access Technology** | **8** |
| 3.1 4G OFMA, NOMA techniques |
| 3.2 Sparse-code and interleave division multi-access schemes |
| 3.3 Dual-connectivity for non-standalone access (LTE and NR) |
| 3.4 Flexible frame structure for diverse services viz. emBB, MTC, IoT, ultra-reliable low latency communication (URLLC) |
| 3.5 Dynamic spectrum sharing, licensed-assisted spectrum access (LAA) for 5G |
| 3.6 Co-existence issues in Cognitive radio (CR) and D2D networks  and HetNets. |
|  |  |
| **UNIT- 4 5G Network Technology** | **8** |
| 4.1 5G network architectures |
| 4.2 Cloud-RAN technology, CRAN split-options,  4.2.3 RAN characteristics: capacity, mobility management, multicasting, compute and energy efficiency  4.2.4 CRAN system with SDN transport, O-RAN |
| 4.3 Network slicing, RAN slicing |
| 4.4 5G network internetworking |
|  |  |
| **UNIT- 5 Mobile Edge Computing for 5G** | **6** |
| * 1. Introduction to NFV |
| * 1. NFV Architecture: NFVI, VNF, hypervisors, NFV MANO |
| * 1. 5G next-generation virtualized core |
| * 1. Scaling of control and data plane, virtualizing control plane |
| 5.5 Multi-access edge computing (MEC): advantages, deployment scenario, MEC orchestration |
| 5.6 Mobile augmented reality (AR) through MEC |

**Textbooks:**

1. Osseiran, Afif, Jose F. Monserrat, and Patrick Marsch, eds. *5G mobile and wireless communications technology*. Cambridge University Press, 2016.
2. Wong, Vincent WS, et al., eds. *Key technologies for 5G wireless systems*. Cambridge university press, 2017.
3. Dahlman, Erik, Stefan Parkvall, and Johan Skold. *5G NR: The next generation wireless access technology*. Academic Press, 2020.

**Reference books:**

1. Cox, Christopher. *An introduction to LTE: LTE, LTE-advanced, SAE and 4G mobile communications*. John Wiley & Sons, 2012.
2. Dahlman, Erik, Stefan Parkvall, and Johan Skold. *4G: LTE/LTE-advanced for mobile broadband*. Academic press, 2013.

**Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.):**

1. 5G White paper (2016) 5G Forum
2. 5G Network Architecture: Huawei Technologies Co. Ltd.
3. White paper : Exploring 5G New Radio, Qualcomm

| **Evaluation Method** | |
| --- | --- |
| **Item** | **Weightage (%)** |
| Quizzes and Assignments | 30 |
| Mid Semester Examination | 30 |
| End Semester Examination | 40 |

**CO and PO Correlation Matrix**

| **CO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** | **PSO3** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **CO1** | **3** | **3** | **1** |  |  |  |  |  | **2** | **1** |  | **3** | **3** | **1** |  |
| **CO2** | **3** | **3** | **2** |  |  |  |  |  | **2** | **1** |  | **3** | **3** | **1** |  |
| **CO3** | **3** | **3** | **1** |  |  |  |  |  | **2** | **1** |  | **3** | **3** | **1** |  |
| **CO4** | **3** | **2** | **1** |  |  |  |  |  | **2** | **1** |  | **3** | **3** | **1** |  |
| **CO5** | **3** | **3** | **1** |  |  |  |  |  | **2** | **1** |  | **3** | **3** | **1** |  |
| **CO6** | **3** | **3** | **3** | **2** |  |  |  |  | **2** | **1** |  | **3** | **3** | **2** | **2** |

**Last Updated On:**

**Updated By: Prof. Ranjan Gangopadhyay**

**Approved By:**