Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**NECD511**	Principles to Design 5G New Radio (NR) Wireless Standards	3	0	0	3

Course Objective
The students will gain knowledge on the L1, L2 and L3 protocols to design 5G wireless communication standards.
Learning Outcomes
This knowledge will be very much helpful for the students to do the research work and to develop products related to wireless communication technologies considering the 5G new-radio (NR) standards.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Overview of 5G-NR Air Interface: Overview of FDMA principles: Access network evolution overview. Orthogonal frequency division multiplexing concept. 5G-NR radio interface introduction: 5G numerology and frame structure, Channel structure , Time domain structure for FDD and TDD, Frequency domain structure	9	Acquire an understanding of the basic knowledge of the physical layer waveform used for 5G NR and the corresponding transmit frame structures.
2	Overview of 5G-NR downlink/uplink physical channels: Cell search, primary synchronization signals, secondary synchronization signals, reference signals, Physical broadcast channel: MIB and SIB, Physical uplink/downlink control channel, Physical uplink/downlink shared channel, Physical random access channel.	9	Develop an understanding about the reference signal design for the downlink and uplink physical channels.
3	Physical layer procedures: Timing advance, Random Access (RA), Resource allocation (type 0, 1 and 2), MIMO, UE reporting, Modulation order and transport block size determination, UL power control.	8	Understand the concept of physical layer procedures for MIMO applications.
4	5G protocol architecture: Introduction (SAP, OSI model), NG-RAN protocol layer, Non-access stratum (NAS) and access stratum (AS), User plane and Control plane and protocol architectures.	6	Understand the concept of various 5G protocol architecture.
5	NGAP protocol architecture, XnAP protocol architecture, F1AP protocol architecture, Intra-NR, Inter RAT, SDAP protocol architecture, PDCP protocol architecture, RLC protocol architecture, MAC protocol architecture	7	Understand the concept of various latest 5G protocol architecture.
6	Overview of 5G-NG ORAN Architecture	3	Understand the basics of 5G ORAN architecture
	Total	42	

Textbook:

1. **5G NR: The Next Generation Wireless Access Technology** Erik Dahlman, Stefan Parkvall, and Johan Sköld Elsevier 2018
2. **4G LTE/LTE-Advanced for Mobile Broadband** Erik Dahlman, Stefan Parkvall, and Johan Sköld Elsevier 2011

References:

1. Sesia, Stefania, Issam Toufik, and Matthew Baker. *LTE-the UMTS long term evolution: from theory to practice*. John Wiley & Sons, 2011.
2. Khan, Farooq. *LTE for 4G mobile broadband: air interface technologies and performance*. Cambridge university press, 2009.