

**ARTIFICIAL INTELLIGENCE IN RADIO COMMUNICATION
(ECE3221)**

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) Which algorithm is commonly used to update weights in a neural network?
(a) Clustering (b) Backpropagation
(c) Sorting (d) Searching
- (ii) Which scenario best justifies the use of deep learning over traditional machine learning?
(a) Small dataset with simple patterns (b) Large dataset with complex patterns
(c) No data available (d) Linear relationships only
- (iii) If a model has high bias, what is the appropriate solution?
(a) Increase model complexity (b) Reduce training data
(c) Increase noise (d) Stop training
- (iv) A joint channel and power allocation GNN model in resource allocation incorporates
(a) A shared message computation layer
(b) Layer dedicated to channel allocation task
(c) Layer dedicated to power allocation task
(d) All of the above
- (v) An associative Q-learning based scheme is adopted for
(a) Allocation of resources in downlink Non-Orthogonal Multiple Access (NOMA) wireless networks
(b) Allocation of resources in downlink Orthogonal Multiple Access wireless networks
(c) Allocation of resources in uplink Non-Orthogonal Multiple Access (NOMA) wireless networks
(d) Allocation of resources in uplink Orthogonal Multiple Access wireless networks

- (vi) Benefits of network slicing include multi-tenancy which means
 - (a) Multiple virtual networks can share common physical infrastructure
 - (b) Single virtual network use single physical infrastructure
 - (c) Multiple virtual networks require different physical infrastructure
 - (d) None of the above
- (vii) In Spectrum Management Framework (SMF), Cognitive Radio Networks (CRN) rely on
 - (a) Spectrum Sensing (SS) and Spectrum decision (SD)
 - (b) Spectrum Sharing (SSh)
 - (c) Spectrum Mobility (SM)
 - (d) All of the above
- (viii) How does predictive analytics help in congestion control in wireless networks?
 - (a) By randomly allocating resources
 - (b) By predicting traffic patterns and optimizing resource allocation
 - (c) By reducing transmission power permanently
 - (d) By disabling users during peak hours
- (ix) Which of the following strategies best addresses ethical challenges in AI-based communication?
 - (a) Ignoring bias in datasets
 - (b) Implementing transparent and accountable AI models
 - (c) Reducing data usage completely
 - (d) Eliminating AI from systems
- (x) In terahertz communication, IRS is mainly used to:
 - (a) Increase attenuation
 - (b) Compensate for high signal loss
 - (c) Reduce bandwidth
 - (d) Stop signal propagation

Fill in the blanks with the correct word

- (xi) _____ networks are inspired by the structure and functioning of the human brain.
- (xii) Automatic Modulation Recognition (AMR) is used for spectrum _____.
- (xiii) Network slicing can support _____ (flexible/rigid) network management.
- (xiv) Terahertz communication is mainly used in _____ generation wireless systems.
- (xv) Intelligent Reflecting Surfaces (IRS) are used to _____ signal propagation.

Group - B

2. (a) Examine how cognitive radio improves spectrum utilization in wireless communication systems. [[CO2](Analyse/IOCQ)]
- (b) Discuss the impact of dynamic spectrum access on primary and secondary users. [[CO2](Understand/LOCQ)]
- (c) Explain with a proper block diagram about GNU radio framework structure. [[CO2](Understand/LOCQ)]

4 + 4 + 4 = 12

3. (a) Differentiate between Feed-Forward and Feedback Artificial Neural Networks. [[C01](Analyze/IOCQ)]
 - (b) Explain the function of activation functions in ANN. [[C01](Understand/LOCQ)]
 - (c) Analyse the advantages and limitations of Artificial Neural Networks. [[C01](Analyze/IOCQ)]
- 4 + 4 + 4 = 12**

Group - C

4. (a) Briefly explain the Deep Reinforcement Learning (DRL) based resource allocation technique in Wireless Communication Network (WCN). [[C04](Understand/LOCQ)]
 - (b) Comment on the impact this machine learning technique on the energy consumption in a device-to-device (D2D) NOMA-enabled vehicular network. [[C04](Apply/IOCQ)]
 - (c) Can DRL be applied for dynamic resource allocation, multi-agent system, traffic-aware resource allocation? Justify your answer. [[C04](Apply/IOCQ)]
- 6 + 3 + 3 = 12**
5. (a) Briefly explain the Federated Reinforcement Learning (FRL) based resource allocation technique in Wireless Communication Network (WCN). [[C04](Understand/LOCQ)]
 - (b) Compare the performance of decentralized RL scheme with meta FDRL framework. [[C04](Apply/IOCQ)]
 - (c) Can FRL be applied for multi-agent spectrum allocation, power control optimization, load balancing? Justify your answer. [[C04](Apply/IOCQ)]
- 6 + 3 + 3 = 12**

Group - D

6. (a) Illustrate spectrum sensing using three different networks operate in separate frequency bands. [[C05](Apply/IOCQ)]
 - (b) Briefly explain decision metric and threshold value concept in conventional spectrum sensing scheme. [[C05](Understand/LOCQ)]
 - (c) List few methods of advanced spectrum sensing scheme. [[C05](Remember/LOCQ)]
- 6 + 4 + 2 = 12**
7. (a) Briefly discuss the challenges for 6G and Artificial Intelligence (AI) – powered Multiple Access (MA) systems. [[C05](Understand/LOCQ)]
 - (b) Can Cognitive Radio Network (CRN) support intelligent mobility management? Justify your answer. [[C05](Apply/IOCQ)]
- 6 + 6 = 12**

Group - E

8. (a) Illustrate how AI-based techniques can be applied to optimize beamforming in dynamic wireless environments with varying channel conditions. [[C06](Apply/IOCQ)]

- (b) Compare conventional beamforming techniques with AI-driven beamforming in terms of adaptability and efficiency. Analyze their advantages and limitations. [[CO6](Analyze/IOCQ)]
- (c) Describe the application of beamforming in 5G/6G networks for improving spectral efficiency and coverage. [[CO6](Apply/IOCQ)]
- 4 + 4 + 4 = 12**
9. (a) Describe how terahertz communication can be utilized to achieve high data rates in next-generation (6G) networks. [[CO6](Apply/IOCQ)]
- (b) Analyze the advantages and limitations of combining IRS with terahertz communication in future wireless systems. [[CO6](Analyze/IOCQ)]
- (c) Explain the major ethical issues associated with the deployment of AI in communication systems. [[CO6](Understand/LOCQ)]
- 4 + 4 + 4 = 12**
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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	41.67	58.33	0