

**ARTIFICIAL INTELLIGENCE IN RADIO COMMUNICATION  
(ECEN 3221)**

**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) Limited dynamic range in digital RF system can be improved by which of the following?
  - (a) Digital filter
  - (b) Digital amplifier
  - (c) Digital equalizer
  - (d) Digital suppressor
- (ii) What distinguishes an agent from its environment in the context of AI?
  - (a) Agents are responsible for perceiving the environment, while environments perform actions
  - (b) Agents are passive entities, while environments are active entities
  - (c) Agents act upon the environment, while environments provide feedback to agents.
  - (d) Agents and environments are indistinguishable in AI systems
- (iii) What role does spectrum sensing play in Cognitive Radio (CR) networks?
  - (a) It determines the transmission power of CR devices.
  - (b) It identifies available spectrum opportunities for opportunistic transmission
  - (c) It regulates the frequency bands allocated to CR devices
  - (d) It enhances encryption for secure communication
- (iv) How does forgetfulness contribute to the efficiency of Case-Based Decision Theorem (CBDT)?
  - (a) By minimizing the exploration of past cases
  - (b) By reducing the need for computational resources
  - (c) By eliminating irrelevant or outdated cases from memory
  - (d) By maximizing the exploitation of past decisions
- (v) What distinguishes points on the Pareto front from other solutions?
  - (a) They are dominated by other solutions
  - (b) They are infeasible solutions
  - (c) They represent compromises between objectives
  - (d) They are outliers in the objective space

- (vi) Which factor affects the convergence speed of a Genetic Algorithm in frequency assignment?
  - (a) The number of bits used in modulation
  - (b) The population size and mutation rate
  - (c) The transmission power of antennas
  - (d) The distance between the sender and receiver
- (vii) In adaptive beamforming for antennas, how does Genetic Algorithm contribute?
  - (a) It helps in finding optimal antenna array configurations
  - (b) It replaces signal modulation techniques
  - (c) It increases the transmission noise
  - (d) It reduces antenna power consumption without optimization
- (viii) Which IEEE standard commonly uses in-band signaling for control information?
 

(a) IEEE 802.3	(b) IEEE 802.11
(c) IEEE 802.15.4	(d) IEEE 802.16
- (ix) What is a key challenge in using FFT amplitude-based detection for beaconing signals?
  - (a) High power consumption
  - (b) Lack of security features
  - (c) No clear explanation of performance in multipath or fading channels
  - (d) Difficulty in implementing OFDM-based systems
- (x) Why is parallel processing gaining importance in distributed AI applications?
  - (a) It simplifies the implementation of genetic algorithms
  - (b) The shift towards multicore processors makes it more feasible
  - (c) It eliminates the need for optimization algorithms
  - (d) It prevents network failures in cognitive radio systems

*Fill in the blanks with the correct word*

- (xi) A \_\_\_\_\_ is the application of intelligent processing and adaptation to a wireless communication system.
- (xii) An agent can be viewed as perceiving its environment through \_\_\_\_\_.
- (xiii) \_\_\_\_\_ is a set of non-dominated solutions, being chosen as optimal, if no objective can be improved without sacrificing at least one other objective.
- (xiv) Multi-agent reinforcement learning (MARL) allows multiple agents to learn and adapt by interacting with their \_\_\_\_\_.
- (xv) GNU Radio can be used with hardware platforms such as USRP (Universal Software Radio Peripheral) and other \_\_\_\_\_ receivers.

### Group - B

- 2. (a) Explain how is a Cognitive radio different from SDR? [[CO2](Understand/LOCQ)]
- (b) State each example with proper explanation of deterministic environment and dynamic environment. [[CO2](Understand/LOCQ)]

- (c) Illustrate the various phases involved in Cognition cycle with neat diagram. [[CO2](Analyse/IOCQ)]  
**3 + 4 + 5 = 12**
3. (a) Define Artificial intelligence? List down some real time examples of artificial intelligence? [[CO1](Remember/LOCQ)]
- (b) Explain the fundamental differences between Software-Controlled Radio (SCR) and Software-Defined Radio (SDR) using simple examples. [[CO2](Understand/LOCQ)]
- (c) Describe the actions of Mitola's loop in cognitive engine with proper diagram? [[CO2](Understand/LOCQ)]  
**(2 + 2) + 3 + 5 = 12**

### Group - C

4. (a) Discuss the potential goals of each node in a network for optimizing the resource allocation. [[CO4](Understand/LOCQ)]
- (b) "In SDR technology, power consumption maps almost directly to the computational complexity of an algorithm"-Explain. [[CO3](Apply/IOCQ)]
- (c) Define objective space in optimization problems. [[CO3](Remember/LOCQ)]  
**5 + 5 + 2 = 12**
5. (a) Write the dependencies of spectral efficiency and power. [[CO3](Apply/IOCQ)]
- (b) Analyze in details about the various ways to consider the objective analysis of resources in radio communication. [[CO4](Analyze/IOCQ)]
- (c) Define greedy approach algorithm. [[CO4](Remember/LOCQ)]  
**4 + 5 + 3 = 12**

### Group - D

6. (a) Suppose a genetic algorithm uses chromosomes of the form  $x = abcdefgh$  with a fixed length of eight genes. Each gene can be any digit between 0 and 9. Let the fitness of individual  $x$  be calculated as:  $f(x) = (a + b) - (c + d) + (e + f) - (g + h)$ , and let the initial population consist of four individuals with the following chromosomes:  
 $x_1 = 6\ 5\ 4\ 1\ 3\ 5\ 3\ 2$   
 $x_2 = 8\ 7\ 1\ 2\ 6\ 6\ 0\ 1$   
 $x_3 = 2\ 3\ 9\ 2\ 1\ 2\ 8\ 5$   
 $x_4 = 4\ 1\ 8\ 5\ 2\ 0\ 9\ 4$
- (i) Evaluate the fitness of each individual, showing all your workings, and arrange them in order with the fittest first and the least fit last.
- (ii) Perform the following crossover operations: Cross the fittest two individuals using one-point crossover at the middle point. [[CO5](Evaluate/HOCQ)]
- (b) What are the two requirements should a problem satisfy in order to be suitable for solving it by a GA? [[CO5](Analyze/IOCQ)]  
**(5 + 3) + 4 = 12**

7. (a) Define the key components of a Genetic Algorithm used in cognitive radio networks. [[C05](Remember/LOCQ)]  
 (b) Apply GA to optimize power allocation in a multi-user radio environment, considering signal-to-noise ratio (SNR) as a fitness measure. [[C05](Apply/IOCQ)]  
**6 + 6 = 12**

### Group - E

8. (a) “The wireless system genetic algorithm (WSGA) is a MOGA designed to optimize a waveform through genetic and evolutionary processes”-Justify [[C06](Evaluate/HOCQ)]  
 (b) Explain the features of distributed artificial intelligence. [[C06](Understand/LOCQ)]  
 (c) Define the term temporal forgetfulness. [[C06](Remember/LOCQ)]  
**5 + 4 + 3 = 12**
9. (a) “The Pareto-ranking approach uses the concepts of inferiority and superiority”- Explain with proper example. [[C05](Understand/LOCQ)]  
 (b) Discuss the list of forgetfulness function used in case based decision theory. [[C05](Understand/LOCQ)]  
 (c) Explain the concept of in-band signaling in cognitive radio networks and how it facilitates the dissemination of new waveform information among radio nodes. [[C06](Understand/LOCQ)]  
**4 + 4 + 4 = 12**

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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	56.25	30.21	13.54