

**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) 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.
- (ii) What is the primary function of a performance measure in an AI agent?
 - (a) To determine the agent's beliefs about its environment
 - (b) To select the best action for a given state
 - (c) To measure the agent's success in achieving its goals
 - (d) To represent the agent's decision-making process.
- (iii) What role does mutation play in Genetic Algorithms (GAs)?
 - (a) Mutation improves the fitness of individuals in the population
 - (b) Mutation introduces new genetic material into the population to maintain diversity
 - (c) Mutation selects the fittest individuals for reproduction
 - (d) Mutation evaluates the quality of candidate solutions in the population.
- (iv) How does a utility-based agent make decisions?
 - (a) By selecting actions that minimize uncertainty
 - (b) By choosing actions with the highest expected utility
 - (c) By following pre-defined rules and heuristics
 - (d) By prioritizing actions based on their immediate rewards.
- (v) How does SDR contribute to spectrum efficiency?
 - (a) By limiting the range of supported communication protocols
 - (b) By relying on fixed hardware configurations
 - (c) By enabling dynamic spectrum allocation and modulation schemes
 - (d) By using proprietary encryption algorithm.

- (vi) What is the primary advantage of Software Defined Radio (SDR) technology?
 - (a) Fixed hardware configuration
 - (b) Limited frequency agility
 - (c) Dynamic re-configurability of radio parameters
 - (d) Static modulation techniques.
- (vii) What is the relationship between "knobs," "meters," and "goals" in AI systems?
 - (a) Knobs adjust parameters, meters evaluate performance, and goals define objectives
 - (b) Goals adjust parameters, meters evaluate performance, and knobs define objectives
 - (c) Meters adjust parameters, goals evaluate performance, and knobs define objectives
 - (d) Knobs adjust parameters, goals evaluate performance, and meters define objectives.
- (viii) Which strategy focuses on maximizing immediate rewards without seeking new options or information?
 - (a) Exploration
 - (b) Adaptation
 - (c) Exploitation
 - (d) Innovation.
- (ix) What does a higher Signal-to-Noise Ratio (SNR) indicate in communication systems?
 - (a) Stronger noise interference
 - (b) Weaker signal strength
 - (c) Better quality of communication
 - (d) Slower data transmission.
- (x) What does Bit Error Rate (BER) measure in communication systems?
 - (a) The number of bits transmitted per second
 - (b) The probability of incorrect bit reception in a transmission
 - (c) The duration of time required for data transmission
 - (d) The signal strength of transmitted bits.

Fill in the blanks with the correct word

- (xi) _____ is a set of non-dominated solutions, being chosen as optimal, if no objective can be improved without sacrificing at least one other objective.
- (xii) In an _____ environment, there is a series of one-shot actions and only the current percept is required for the action.
- (xiii) _____ represents the amount of information transferred in a given channel and is measured in bps/Hz.
- (xiv) The _____ is the component that translates between the cognitive engine and the radio platform.
- (xv) The structure of an intelligent agent is a combination of _____ and agent program.

Group - B

2. (a) Explain how is a Cognitive radio different from SDR?

[[CO2](Understand/LOCQ)]

- (b) State examples of each 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) Explain with a proper block diagram about GNU radio framework structure. *[[CO2](Understand/LOCQ)]*
- (b) Criticize Turing's criteria for computer software being "intelligent". *[[CO1](Analyze/IOCQ)]*
- (c) Define primary network and secondary network of Cognitive radio network. *[[CO1](Remember/LOCQ)]*
6 + 4 + 2 = 12

Group - C

4. (a) In order to explain the dependencies of various objectives, write the three sets of parameters in optimization of radio resources. *[[CO3](Apply/IOCQ)]*
- (b) Discuss with proper examples how population-based analysis and Pareto ranking methods are useful in evaluating performance in multiobjective problems. *[[CO4](Understand/LOCQ)]*
6 + 6 = 12
5. (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

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 consists 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) Identify two requirements to be satisfied by a problem in order to be suitably solvable by GA? *[[CO5](Analyze/IOCQ)]*
(5 + 3) + 4 = 12

7. (a) Point out the major stopping conditions that a genetic algorithm may implement for termination. [[CO5](Analyze/IOCQ)]
 (b) Differentiate the application of exploration and exploitation in genetic algorithm. [[CO5](Analyze/IOCQ)]
6 + 6 = 12

Group - E

8. (a) “The Pareto-ranking approach uses the concepts of inferiority and superiority”- Explain with proper example. [[CO5](Understand/LOCQ)]
 (b) Discuss the list of forgetfulness function used in case based decision theory. [[CO5](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. [[CO6](Understand/LOCQ)]
4 + 4 + 4 = 12
9. (a) Explain the objectives of Distributed Artificial Intelligence (DAI) and how it aims to solve the reasoning, planning, learning, and perception problems of artificial intelligence. [[CO6](Understand/LOCQ)]
 (b) “The simplest approach to enabling communications among cognitive radio nodes is through a static control channel.”- Discuss with proper example. [[CO6](Remember/LOCQ)]
6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	54.17	37.50	8.33

Course Outcome (CO):

The students after studying this course will be able to:

1. Understand difference between passive radios and cognitive radios.
2. Explain difference between SDR and cognitive Radios
3. Apply in AI in radios.
4. Analyze weakness on cognitive radios
5. Develop radios based on Genetic Algorithm (GA).
6. Evaluate radio performance.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*