PRINCIPLES OF RADAR
(ECEN 4126)

Time Allotted : 3 hrs   **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and
<u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

    (i)   Which factor determines the range resolution of a radar?
           (a) Size of antenna   (b) Centre frequency of radar
           (c) Bandwidth of transmitted pulse   (d) Gain of antenna.

    (ii)   What type of antenna is generally used in a pulsed Radar?
           (a) Yagi Antenna   (b) Parabolic Antenna
           (c) Conical Antenna   (d) Horn Antenna.

    (iii) If the minimum range is to be doubled in a Radar, peak power has to be increased by
           a factor of
           (a) 4   (b) 8   (c) 16   (d) 32.

    (iv)   Resonance frequency of oxygen is
           (a) 24 GHz   (b) 50 GHZ   (c) 60 GHZ   (d) 68 GHz.

    (v)   The radar in which both transmission and reception is done using the same antenna
           is called
           (a) Monostatic radar   (b) Bistatic Radar
           (c) Monopole Radar   (d) Dipole radar.

    (vi)   The term Radar Cross Section means
           (a) Scattering ability of the target
           (b) Power radiating ability of the radar
           (c) Amount of energy scattered by unwanted objects
           (d) Cross section of radar area through which energy is emitted.

    (vii) Radar principle is used in
           (a) Telephony   (b) Electron Microscope
           (c) Detection of Aircraft   (d) All of the above.

    (viii) A high noise figure in a radar receiver means
           (a) poor minimum detectable signal   (b) a good detectable signal
           (c) receiver bandwidth is reduced   (d) high power loss.

(ix) A stationary CW Radar is operating at 5 GHz. What is the Doppler Frequency Shift, if the target is moving at 108 km/hr speed?
(a) 1000 Hz   (b) 3.6 kHz   (c) 500 Hz   (d) 1800 Hz.

(x) For pulse radar with maximum ambiguous range of 60 km, what is the allowable pulse repetition frequency?
(a) 5×10^5 pps   (b) 2×10^4 pps   (c) 4×10^5 pps   (d) 2.5×10^3 pps.

Group - B

2. (a) Derive the range equation of the radar. [(CO1)(Understand/LOCQ)]
   (b) Analyze the correlation of the target range to the minimum detectable signal by the Radar. [(CO2)(Analyze/IOCQ)]
   (c) Discuss what is false alarm and how its chances can be reduced in target detection. [(CO1)(Apply/IOCQ)]
   (d) Discuss about the frequencies that are used in radars. [(CO1)(Remember/LOCQ)]
   5 + 2 + 3 + 2 = 12

3. (a) Explain the measurement of phase and amplitude of radar signal. [(CO2)(Understand/LOCQ)]
   (b) Analyse the effect of clutter in target detection of radar. Suggest some methods to improve the performance of radar. [(CO3)(Analyse/IOCQ)]
   5 + 7 = 12

Group - C

4. (a) Illustrate how the different atmospheric effects result in increased target range. [(CO2)(Analyze/IOCQ)]
   (b) A pulsed radar operating at 10GHz has an antenna gain of 28 dB and a transmitter power of 2 kW. It is defined to detect a target with a cross-section of 12 m^2 and minimum detectable signal is P_{min}=-90 dBm.
   Evaluate the maximum range of radar. [(CO1)(Evaluate/HOCQ)]
   (c) Associate how the Doppler Effect is applicable in Radar target detection. [(CO3)(Understand/LOCQ)]
   6 + 4 + 2 = 12

5. (a) Illustrate on the processes and materials that can be used to reduce the radar cross section of targets. [(CO3)(Analyze/IOCQ)]
   (b) Discuss the effects of integration of radar pulses. [(CO3)(Understand/LOCQ)]
   (c) Discuss the effects of atmospheric absorption and back scattering on radar signals. [(CO3)(Understand/LOCQ)]
   5 + 3 + 4 = 12

Group - D

6. (a) What is the peak power of radar whose average power is 200 w, pulse width (PW) is 1 μs and has PRF of 1000 Hz? Also calculate the range of this ground based air surveillance radar if it has to detect a target with a radar cross section of 2 m^2 when

it operates at a frequency of 2.9 GHz with a rectangular shaped antenna that is 5 m wide, 2.7 m height, antenna aperture efficiency of 0.6 and mds is 10^{-12} w.

[(CO1)(Analyse/IOCQ)]

(b) What do you understand by term MTI? Describe the working of Non-coherent MTI Radar with the help of block diagram. [(CO5)(Understand/LOCQ)]

(c) Explain the reasons why most of the radar receivers are considered as envelope detectors while calculating the SNR. [(CO4)(Analyze/IOCQ)]

4 + 5 + 3 = 12

7. (a) Discuss about a matched filter receiver. Derive its frequency response function.

[(CO4)(Understand/LOCQ)]

(b) Explain in detail various system losses involved in radar system.

[(CO4)(Analyze/IOCQ)]

(c) Define: (i) Blind speed (ii) Squint angle. [(CO4)(Remember/LOCQ)]

6 + 4 + 2 = 12

Group - E

8. (a) Explain the concept of staggered PRFs in MTI radar. [(CO5)(Understand/LOCQ)]

(b) Establish a relation between doppler frequency shift and radial velocity of a moving target. [(CO5)(Apply/IOCQ)]

(c) Outline the basic concept of phased array antennas. [(CO6)(Apply/IOCQ)]

5 + 4 + 3 = 12

9. (a) Draw the block diagram of MTI radar using range gates and filters and explain each block. [(CO5)(Understand/LOCQ)]

(b) Express the effect of Beam steering on the beam width in a phased array radar and also give the expression for the beam width. [(CO6)(Apply/IOCQ)]

(c) Radar angular measurements are referenced to true north and local horizontal plane. With reference to them, define azimuth and elevation angles and their ranges.

[(CO6)(Apply/IOCQ)]

6 + 3 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	46.87	48.96	4.17

Course Outcome (CO):

After the completion of the course students will be able to:

1. Understand the concept and characteristics of Radar operation.
2. Know the role of probability in the Radar communication.
3. Understand the importance of shape and material for Radar targets.

4. Develop the idea of Radar Transmission and Reception and in what aspects it is different from data communication.
5. Classify between different types of Radars and their distinct areas of application.
6. Have the concept of the specific design considerations of the antennas under the use for Radar communication.

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