ATMO 445/545 MID-TERM EXAM

1. RADAR IS AN ACRONYM FOR?

RAdio Detection And Ranging (Text p. 1)

2. Explain how a "BISTATIC" RADAR FUNCTIONS.

Bistatic RADAR - CONTINUOUS WAVE transmitter SEPARATE FROM A SECOND RECEIVING ANTENNA, USUALLY LOCATED some distance AWAY to AVOID EXCESS POWER from SIDELOBES OR VERY CLOSE TARGETS (TEXT p4,5)

3. What is an "ISOTROPIC" ANTENNA?

An ANTENNA that transmits radiation of EQUAL INTENSITY IN All Directions. Power density equal on surface of all spheres with center at the ANTENNA. (Text p. 26 & 66)

4. What is a PPI display?

THE Plan Position Indicator Displays RADAR DATA, USUALLY power returned in dBZ, Doppler velocity, spectrum width, or composite reflectivity ON A polar COORDINATE MAP OR BACKGROUND USING Azimuth AND RANGE (i.e., 2D).
(Text p. 40)

5. THE WIDTH OF THE MAIN BEAM, OR LOBE, OF A RADAR IS DEFINED AS?

The BEAMwidth is defined as the Angular width of the Antenna beam measured from the point where the power is half of what it is, AT SAME RANGE, ON THE CENTER of the beam. (Text p. 29 & Fig 2.6)

6. RESTATE # 5 IN DECIBELS.

The power at the Angular edges of the beam width is −3 dB relative to the power at the center of the beam. (p. 30, legend Fig. 2.6)

7. THE VALUE of the GAIN USED IN Eq. 4.3 is in?

4.3 $P_\sigma = \frac{P_t\, g\, A_\sigma}{4\pi r^2}$ where the linear value of antenna gain is used, i.e. $g = P_1/P_2$ 2.1 and is unitless. (Text eq. 4.3 and p. 67 and p. 28)

8. Why do weather radars on aircraft tend to have short wavelengths?

REASONABLY NARROW BEAMwidths, i.e. angular resolution, requires larger antennas for longer wave lengths – thus because of weight and space limitations AIRCRAFT radar tend to have short wave lengths. (Discussed in class lectures)

9. The refractive index of the ATMOSPHERE below 15-20 Km MSL depends on?

REFRACTIVE INDEX is A FUNCTION OF PRESSURE, TEMPERATURE AND VAPOR PRESSURE. (TEXT p. 51)

10. Standard linear refraction means

We ASSUME that N, refractivity, DECREASE AT A LINEAR, i.e., CONSTANT, RATE with increasing height above the surface of the EARTH. STANDARD refraction ASSUMES that N decreases at -39 N-UNITS per KM. (Text p. 53)

11. FOR CONDITIONS of subrefraction what is the speed of light at the top of the radar beam relative to that AT THE TOP of the EXACT SAME beam experiencing standard refraction?

UNDER SUBREFRACTION speed of light will be less than if STANDARD REFRACTION WERE OCCURRING. (Refer to text p. 55)

12. Explain what ducting means.

DUCTING MEANS that the vertical gradient of N is so great that the radar beam becomes completely trapped within AN ATMOSPHERIC layer. (Text p. 61)

13 - If A RADAR, beam width of 1 degree, is operating in a VCP mode that obtains 12 different elevation tilts of data in 6 minutes, AND its PRF is $1200\,s^{-1}$, HOW MANY pulses ARE transmitted DURING EACH 1 degree radial?

12 complete rotations in 6 min → 30 s/rotation

$$\frac{30\,s}{360\ 1^\circ\ \text{radials}} = 8.3333 \times 10^{-2}\,s/\text{radial}$$

$$\left(8.3333 \times 10^{-2}\,\frac{s}{\text{radial}}\right)\left(1200\,\frac{\text{pulses}}{s}\right) \doteq 100\,\frac{\text{pulses}}{\text{radial}}$$

14 - Explain why theoretical ESTIMATES OF THE POWER THAT SHOULD BE RETURNED FROM DISTRIBUTED Rayleigh SCATTERERS WERE too high prior to the work of Probert-Jones. His correction to the radar equation reduces the calculated P_r by how many decibels?

Early work Assumed that All transmitted power WAS confined to the half-power beam width – an obviously invalid assumption! Probert-Jones carefully derived equations to account for both the true distribution of power transmitted (and also considered the assumption that scatters were isotropic – also invalid but not discussed in text). Amazingly, all this work led to the inclusion of the very simple correction of adding $2\ln(2)$ to the denominator of the radar equation!

The reduction in calculated P_r is equal to $\frac{1}{2\ln(2)}$

Which is $1/1.386 = 0.7215$ which in dB is

$$10\log_{10}(0.7215) = \underline{\underline{-1.418\ dB}}$$

(see text p. 86)

20 - IF you were going to design A "STEALTH" AIRCRAFT, i.e., ONE that could only be detected by RADAR AT VERY SHORT RANGES, what would your design need to ACHIEVE?

You could say that you needed to design an aircraft that would completely absorp all incident microwave radar pulse energy - but not realistic or physically possible. Thus, your design would need to minimize the effective cross section area of the aircraft, i.e., $\sigma \rightarrow 0$ dBm for all possible viewing angles. (refer to text p. 76 & 77 & Fig 4.3)

21 - Explain WHY RADAR REFLECTIVITY FACTOR, z, is SAID to be AN ACTUAL PHYSICAL ATTRIBUTE OF A GIVEN WEATHER ECHO - CONTRAST WITH η radar reflectivity.

Consider eq. 5.13 $\eta = \frac{\pi^5 |K|^2 z}{\lambda^4}$ and eq. 5.14 $z = \sum_{vol} D^6$

η depends upon the radar wave length whereas z depends only upon the summation of the cross sectional areas of all scatterers in sample volume, as per eq. 5.7. THUS, z depends only upon the shape and size of the hydrometeors present within a weather echo. (Text p. 88 - 90)

22 - EXPLAIN THE "Doppler dilemma" AND ILLUSTRATE IT QUANTITATIVELY.

The "Doppler dilemma" means that maximum UNAMBIGOUS range CAN NOT BE increased without reducing the maximum unambiguous Doppler radial velocity.

This can be illustrated quantitatively using equations 6.7, 6.9, 6.11, and 6.12 and/or computing actual values for particular radar parameters. (refer to text p. 103-109)

23 - SHOW NUMERICALLY THAT, FOR UNAMBIGUOUS RADIAL VELOCITIES, AN OUTBOUND TARGET MUST PRODUCE A POSITIVE PHASE SHIFT.

The change of phase from one pulse to the next is given by eq. 6.2 $\frac{d\phi}{dt} = \frac{4\pi}{\lambda}\frac{dr}{dt}$, for an outbound target r increases with time so that

$\frac{dr}{dt} > 0$ and $\frac{d\phi}{dt}$ must be positive.

(Text p. 99)

29 - EXPLAIN AND ILLUSTRATE WHAT A "RANGE ALIASED" ECHO IS. HOW CAN IMPACTS OF RANGE ALIASING BE REDUCED?

"RANGE ALIASED" ECHO is one that is at a range beyond r_{max} so that its reflected power returns to receiver after another pulse has occurred - thus, processor locates its position as being much closer than it actually is. Manipulating the PRF is the only way to detect/reduce range aliasing. (Text p110-114)

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30- REFER TO PROBLEM 4, PROBLEM SET 2, AND USE THE LOGARITHMIC FORM of THE RADAR EQUATION, i.e., eq. 5.19

Using the value we calculated for $C_3 = 58$ for THE 3-CM λ VARIANT of our radar, NOW CALCULATE THE POWER RETURNED FROM A RANGE OF 100 Km if:

a) η for A UNIT volume in the beam is $1 \times 10^{1}\ mm^6/m^3$

b) η for A UNIT volume in the beam is $1 \times 10^{5}\ mm^6/m^3$

c) IF ALL the TARGETS from a) and b) WERE PRESENT WITHIN THE UNIT VOLUME AT 100 Km RANGE, WHAT WOULD BE Z?

Discuss the implications OF YOUR CALCULATIONS.

30 Eq 5.19 $Z = C_3 + P_r + 20\log_{10}(r)$ or

$$P_r = Z - C_3 - 20\log_{10}(r)$$

$C_3 \equiv 58$ for our 3-cm radar

$r = 100$ Km so

$$20\log_{10}(r) = 40$$

a) $Z = 10$ dBZ

$P_r = 10 - 58 - 40 = -88$ dBm OR

$P_r \cong 2 \times 10^{-9}$ mW

b) $Z = 50$ dBZ

$P_r = 50 - 58 - 40 = -48$ dBm OR

$P_r \cong 1.6 \times 10^{-5}$ mW

4 orders of magnitude greater than a) !

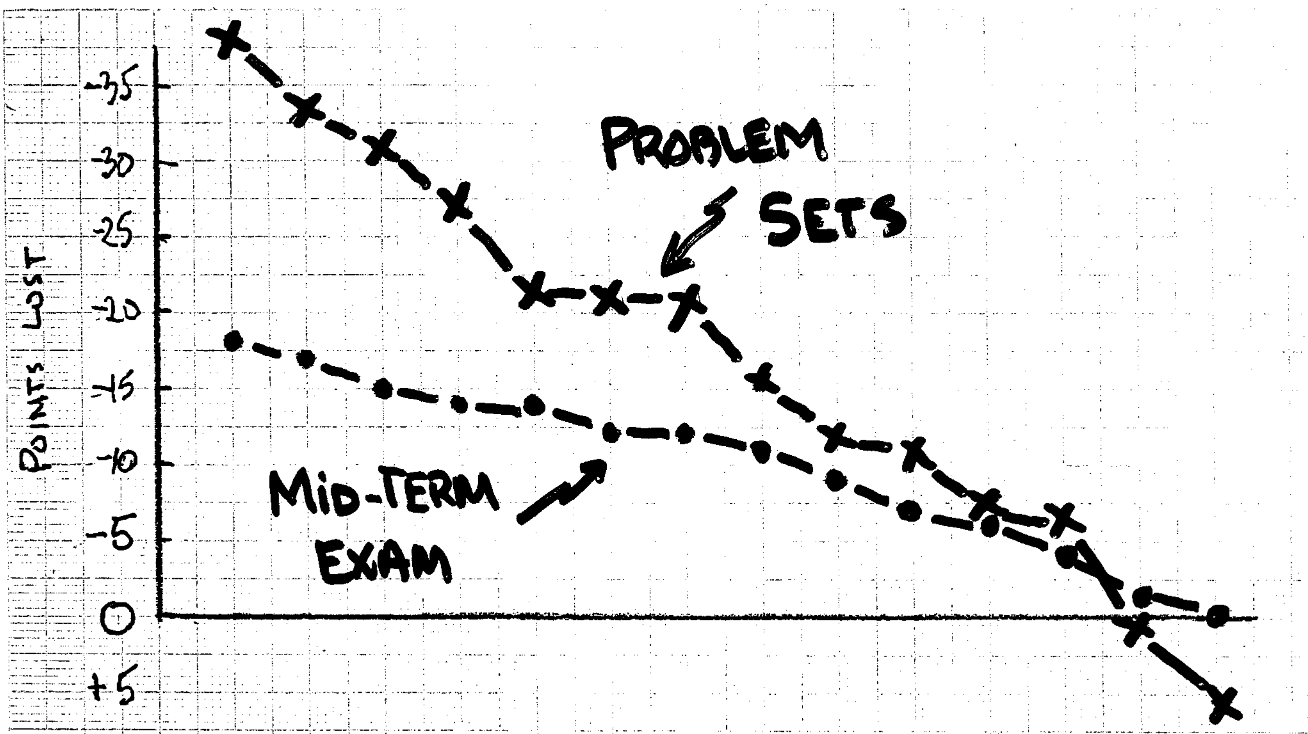
c) all targets from a) & b) in the sample volume means

$P_r \cong 1.6002 \times 10^{-5}$ mW or

-47.9583 dBm so that

$$Z = 58 - 47.9583 + 40 \cong 50.0417 \text{ dBZ}$$

Implication η or Z is extremely dependent upon the cross sectional area of the scatterers in sample volume and is highly dominated by LARGE scatterers.



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