ram 02-22-03

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PROBLEM SET 2

Atmo 445/545

Spring 2003

Due 03-03-03

OUR HYPOTHETICAL RADAR

IT IS A Doppler WEATHER RADAR WITH THE FOLLOWING CHARACTERISTICS:

WAVELENGTH, λ, = 10cm = 1×10^{-1} m

PULSE DURATION, τ, = 3.3333 μs = 3.3333×10^{-6} s

Pulse Length, h, = 1×10^{3} m = 1 Km

Power transmitted at the ANTENNA, P_t, = 0.5 MW = 5×10^{5} W = 5×10^{8} mW

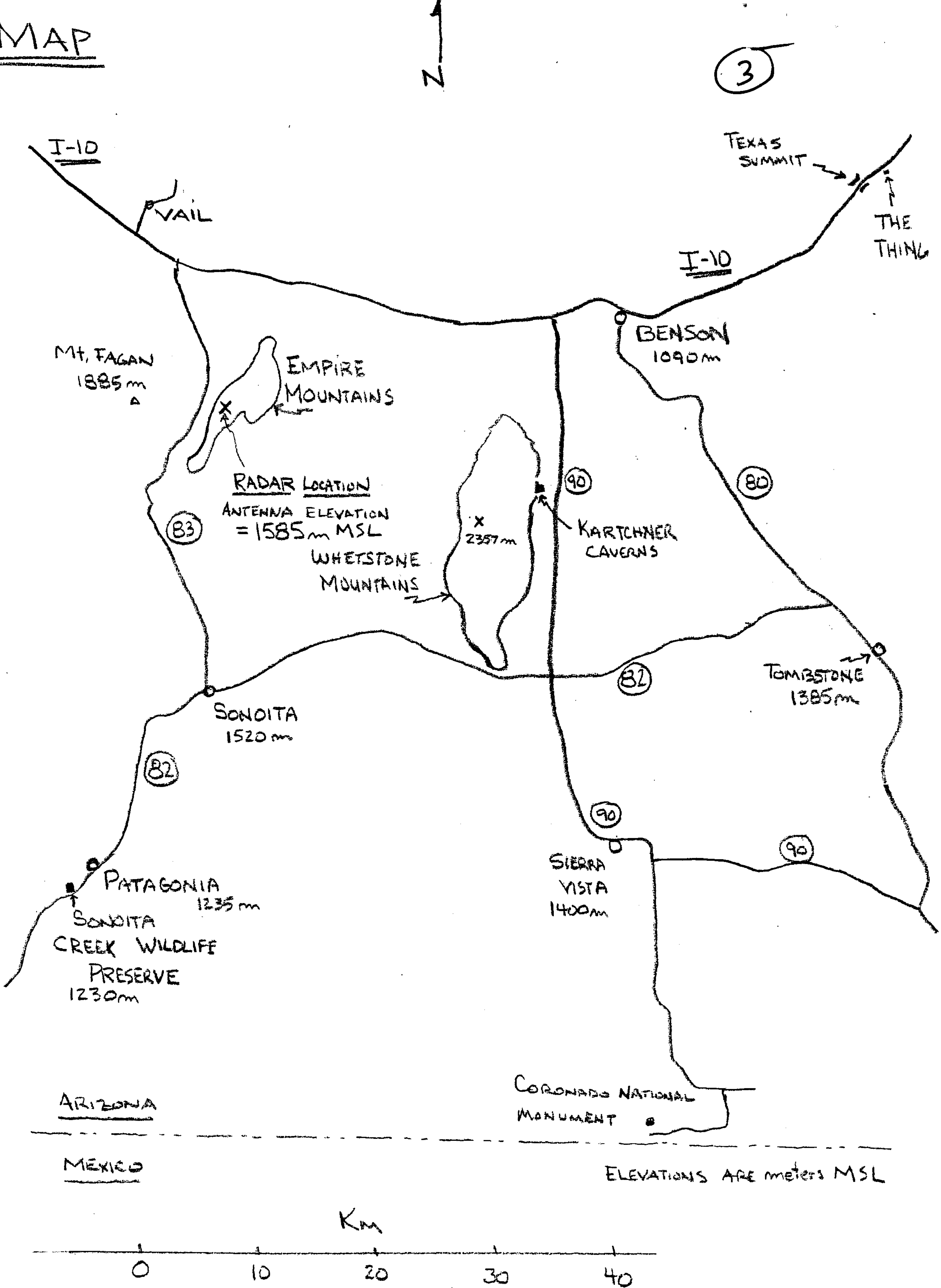
BEAM WIDTH = 1 degree with $\theta = \phi = 1° = 0.0175$ RADIANS

GAIN = 45 dB or $g = 3.16 \times 10^{4}$

MINIMUM DETECTABLE SIGNAL = −115 dBm = 3.1623×10^{-12} mW

Pulse Repetition Frequency (PRF) = VARIABLE from 500 to 1500/s

MAP



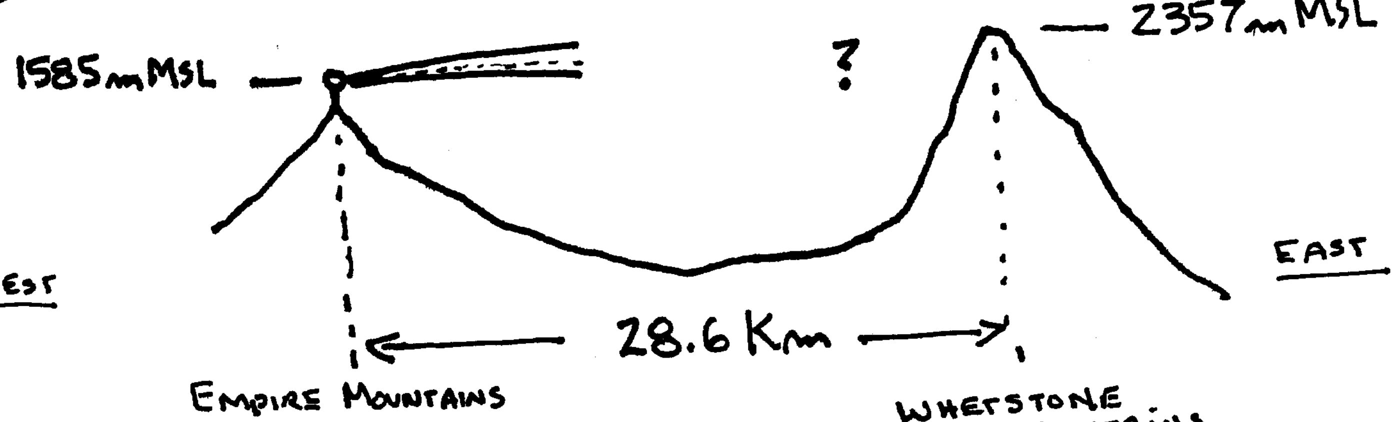
N
I-10
VAIL
TEXAS SUMMIT
THE THING
I-10
BENSON
1090 m
Mt. FAGAN
1885 m
EMPIRE MOUNTAINS
RADAR LOCATION
ANTENNA ELEVATION
= 1585 m MSL
90
80
83
2357 m
KARTCHNER CAVERNS
WHETSTONE MOUNTAINS
82
TOMBSTONE
1385 m
SONOITA
1520 m
82
90
90
SIERRA VISTA
1400 m
PATAGONIA
1235 m
SONOITA CREEK WILDLIFE PRESERVE
1230 m
ARIZONA
CORONADO NATIONAL MONUMENT
MEXICO
ELEVATIONS ARE meters MSL
Km
0
10
20
30
40

PROBLEM 1 - BEAM BLOCKAGE IN COMPLEX TERRAIN

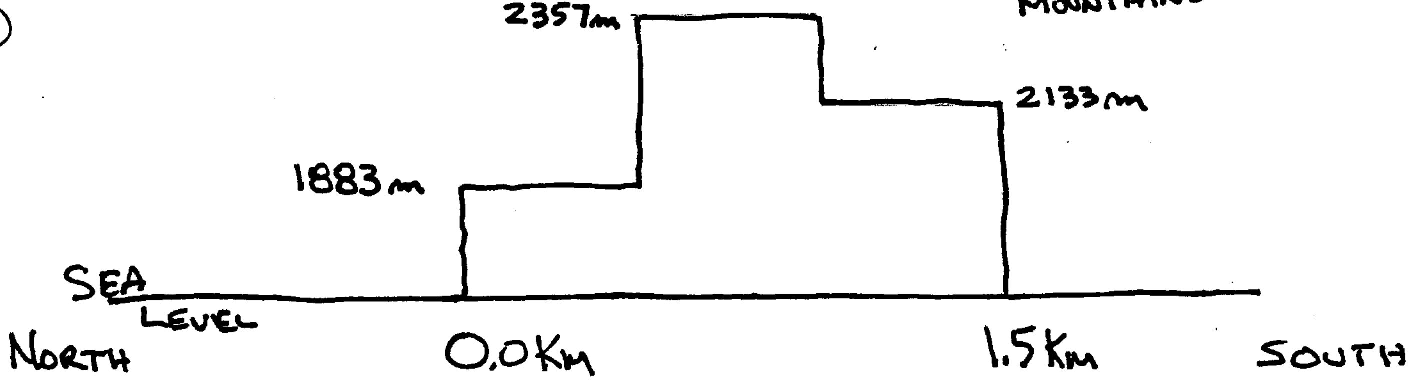
..... REFER TO MAP .....

...... BEAM GEOMETRY PLOTS ARE INADEQUATE HERE ......

(a)



(b)



Note sketches a & b are NOT to scale

1- How many 1° BEAM radials are there from 0 to 1.5 Km? Sketch their positions the Sea level line and number them from North to South. Edge (northern) of radial #1 is positioned exactly at 0.0 Km

2- CALCULATE THE % of the beam that is blocked by the terrain of the WHETSTONE MOUNTAINS AS SKETCHED ABOVE. Do this for each numbered radial for elevation tilts 1 through 3.

3- THE highest TERRAIN SKETCHED ABOVE IS located BETWEEN THE RADAR AND TOMBSTONE. CALCULATE THE HEIGHT, OVER TOMBSTONE, OF THE BEAM CENTER OF THE LOWEST ELEVATION TILT THAT has NO TERRAIN BLOCKAGE.

Assumptions $\Delta N / \Delta h = -39$ N-UNITS/Km

RANGE TO WHETSTONE MOUNTAINS IS CONSTANT IN SKETCH b

RADAR is SCANNING AS PER WSR-88D VCP-11

PROBLEM 2 – POINT TARGETS

....REFER TO MAP.... (5)

A magnificent Golden Eagle is soaring across the skies of southeastern Arizona, headed for its nesting grounds at the Patagonia/Sonoita Creek Wildlife Preserve. Although the bird is a great flyer, it can not climb higher than 5 Km MSL.

The average radar cross-section for this eagle is $1\ m^2$ at S-band wavelength. $\Delta N/\Delta H = -39$ N-units/Km everywhere

1- Is the eagle a Mie or optical scatter? Be sure to show your calculations.

2- All calculations are valid only if eagle is flying ....

3- Calculate the maximum range at which our radar, if it were operating at <u>sea level</u>, could detect the eagle.

4- Calculate the power returned to our radar operating on the Empire Mountains as the eagle soars over the P/S Creek Wildlife Preserve.

5- Calculate the power returned to our radar operating on the Empire Mountains when the eagle began its flight home from high above Organ Pipe National Monument – NOTE: the range from our radar to Organ Pipe is 200 Km.

PROBLEM 3 - DISTRIBUTED TARGETS

FIRST, THROW THE HANDOUT FROM LAST CLASS - i.e., 21 Feb 2003 CLASS MEETING # 16 - AWAY! I GOOFED UP THE CALCULATIONS AND WE'LL TRY TO GET THEM RIGHT IN THIS PROBLEM.

1 - For our radar, calculate the radar constants c_1, c_2, & c_3 be sure to show units in your answers and calculations

2 - CALCULATE THE EFFECTIVE SAMPLE VOLUME, V, AT A RANGE OF 200 KM

3 - IF THERE ARE 300 IDENTICAL SPHERICAL DROPS OF DIAMETER 1mm per m^3 distributed through V at 200 KM range, calculate the RADAR REFLECTIVITY FACTOR, z.

4 - Calculate the P_r for above conditions IF THE SPHERICAL DROPS ARE COMPOSED ENTIRELY OF WATER.

5 - WHAT WOULD P_r BE IF DROPS ARE ENTIRELY ICE?

6 - WHAT IS THE LOGARITHMIC RADAR REFLECTIVITY FACTOR, Z, FOR EACH SCENARIO, i.e., for #s 4 & 5?

5 BONUS POINTS - IDENTIFY THE MISTAKES I MADE ON FRIDAY'S HANDOUT.

PROBLEM 4 - DISTRIBUTED TARGETS

LET'S CONSIDER A RADAR THAT'S SLIGHTY DIFFERENT THAN OUR HYPOTHETICAL RADAR - AS PER: ALL PARAMETERS similar EXCEPT

$$\lambda = 3\text{cm} \quad \text{AND} \quad \theta = \phi = 0.5 \text{ degree}$$

1- COMPARE THE EFFECTIVE ANTENNA AREAS FOR THE TWO RADARS.

2- Calculate THE LOGRITHMIC RADAR CONSTANT, C_3, FOR THIS 3cm wavelength RADAR, as per eq. 5.19

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

3- Show A UNITS ANALYSIS of eq. 5.19 to VERIFY that Z IS INDEED IN UNITS of dBZ

4- If dBZ is 50 for A TARGET AT RANGE OF 100 KM, USE eq. 5.19 to CALCULATE P_r for THE TARGET.

5- Calculate η, RADAR REFLECTIVITY, For this TARGET.

6- List THE ASSUMPTIONS you MADE TO DO these CALCULATIONS.

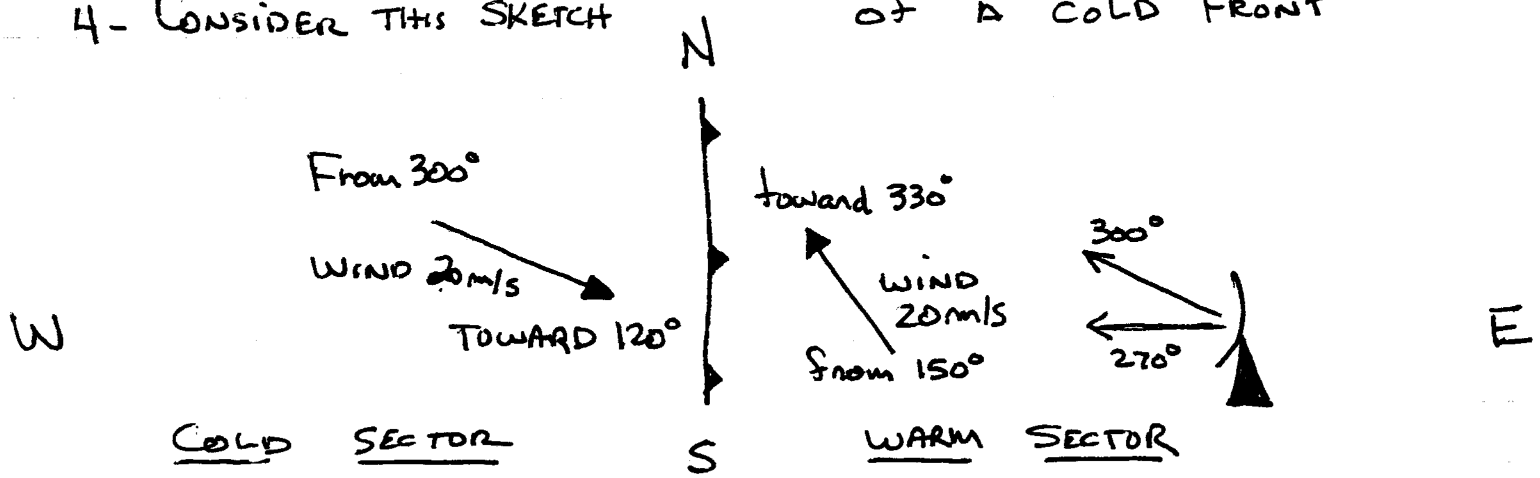
Problem 5 - Doppler Velocity

1- For both of our hypothetical Doppler radars, i.e. the 10 & 3 cm versions, operating at a PRF of 500/s, determine the maximum unambiguous ranges and radial velocities.

2- Determine the same for both radars operating at 1500/s PRF.

3- At PRF 1500/s, determine the radial velocity of an inbound target, for both radars, that produces a phase shift of exactly $2\pi/3$ radians

4- Consider this sketch of a cold front



Winds are horizontally and vertically uniform on both sides of front. There are abundant dust and insect scatters blowing with the wind to allow detection of the radial velocities. Our 10 cm radar is operating at a PRF that gives $V_{r_{max}} > 20$ m/s

1- Calculate V_r radar would measure on each side of front when it scans front at 270° azimuth.

2- Calculate V_r's as above when radar scans front at 300° azimuth.

3- Repeat all calculations for #1 & #2, but let the wind in the warm sector blow at 20 m/s from 240° toward 60° - No change cold sector.

BOUNDARY CONDITIONS

INDIVIDUAL WORK EFFORTS

ALL CALCULATION AND WORK PAGES
MUST BE ATTACHED
TO YOUR ANSWERS

PROBLEMS DUE START OF CLASS MAR 3

LATE - MINUS 10% PER DAY

MAX PENALTY 5 DAYS

GRADING

SENIORS – Pick either problem 3 OR 4 for 40 points OR, if you wish, DO ALL 5 problems As per the GRADS, AND ADD a BONUS of 10 points

PROBLEM 1

Part	
1	5
2	10
3	5
	20pts

PROBLEM 2

Part	
1	3
2	2
3	5
4	5
5	5
	20pts

PROBLEM 3

Part		
1	6	(12)
2	2	(4)
3	2	(4)
4	4	(8)
5	4	(8)
6	2	(4)
	20pts	40pts

Problem 4

Part		
1	3	(6)
2	4	(8)
3	4	(8)
4	3	(6)
5	3	(6)
6	3	(6)
	20pts	40pts

PROBLEM 5

Part	
1	3
2	3
3	5
4	9
	20pts

BONUS ON QUESTION NUMBER THREE CAN BE DONE BY ANYONE.