PS7 Toomey

$$G_T = \frac{4\pi}{\theta^2}$$

$$n = \frac{\Omega}{\theta^2} = \frac{\Omega G_T}{4\pi}$$

$$n\,\frac{\hat{P}\tau}{T} = P \quad \text{why} \div \text{by } T$$

Radar Range eq

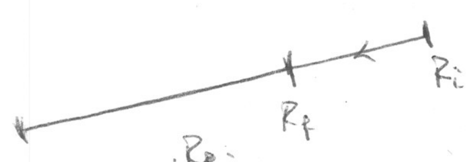
$$\hat{P}\tau = \left(\frac{S}{N}\right)\frac{(4\pi)^2 R^4 k T_s L_s}{G_T A_r \sigma}$$

Multiply by $\frac{n}{T} = \frac{\Omega G_T}{4\pi T}$

$$P = \left(\frac{S}{N}\right)\frac{(4\pi) R^4 k T_s L_s\, \Omega}{T A_r \sigma} = \left(\frac{S}{N}\right)\frac{\Omega (4\pi) R^4 k T_s L_s}{T A_r \sigma}$$

$$\left(\frac{S}{N}\right)(\Omega) = k\, \underline{P}\, \underline{A_r} \qquad w/\ k = \frac{T\sigma}{(4\pi) R^4 k T_s L_s}$$

transmit power



$$\left(\frac{S}{N}\right)_T = \int d(S/N) = k\int_{R_f}^{R_i} \frac{dr}{R^4} = k\left(\frac{-1}{3R^3}\right|_{R_f}^{R_i}$$

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w/ $k = T$

$$\left(\frac{S}{N}\right) = \underbrace{\frac{\hat{P}\tau G_T A_r \sigma}{(4\pi)^2 k T_s L_s}}_{k} \frac{1}{R^4}$$

$$\left(\frac{S}{N}\right)_T = -+\frac{k}{3}\left(\frac{1}{R_i^3} - \frac{1}{R_f^3}\right) = \frac{k}{3R_f^3}$$

$R_f = 1000$ km.

Pj 10 Toomay

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Jammer w/ characteristics $\frac{P_j G_j}{B_j}$

Radar Range eq

$$\frac{S}{N} = \frac{\hat{P} \tau G_T A_r \sigma}{(4\pi)^2 R^4 k T_S L_S}$$

$$\frac{S}{J} = \frac{\hat{P} G_T \sigma_{target}}{(4\pi) R^2} \left(\frac{\tau A_r}{4\pi R^2 k T_S L_S} \right)$$

Replace $\tau = 1/B$?

$$\frac{S}{J} = \frac{\hat{P} G_T \sigma_{target}}{(4\pi) R^2} \left(\frac{B_j}{P_j G_j B} \right)$$ How get?

$$\frac{\left(\frac{P_j G_j}{B_j}\right)(SL)}{4\pi R_j^2}$$

pg 11 Toomey

(1) $P \cdot \boxed{A_r} = 3 \cdot 10^6$ watts$/m^2$

$\sigma = 1 m^2$ $\quad S/N = 10$

$$\left(\frac{S}{N}\right) = \frac{(\hat{P} A_r \cancel{G_T})\sigma}{(4\pi)^2 R^4 k T_s L_s}$$

$$\Rightarrow R^4 = \frac{\cancel{\beta}\,(\hat{P} A_r G_T)\sigma}{(4\pi)^2 k T_s L_s (S/N)} \qquad k = 1.3 \cdot 10^{-23}\ J/K.$$

$$= \frac{3 \cdot 10^6}{}$$

Scanning 1/8 hemisphere is $\cancel{1}/8\,(2\pi)$ sphere has solid $\cancel{\angle}$ 4π.

$\neq$ T on pg 7 = 10s

Using eq From notes on ~~pg~~ from pg 7

$$\left(\frac{S}{N}\right)\Omega = k \underbrace{P A_r}_{\text{power-aperture product.}} \qquad w/\ k = \frac{T\sigma}{(4\pi)R^4 k T_s L_s}$$

$$\Rightarrow \frac{(S/N)\Omega}{P A_r} = \frac{T\sigma}{(4\pi)R^4 k T_s L_s}$$

$$R^4 = \frac{T\sigma\ (\beta A_s)}{(4\pi)\cancel{R^4}\ k T_s L_s\ (S/N)(\Omega)}$$

$$= \frac{(10s)(1m^2)(3\cdot 10^6\ \cancel{\text{Watts}}\ \text{Watts}\cdot m^2)}{(4\pi)(1.3\cdot 10^{-23}\ J/K)(1000\ K)(10)(10)(\frac{\pi}{4})} = O(m^4)$$

$$= \frac{3\cdot 10^7}{\pi^2(10^5)(1.3\cdot 10^{-23})} = \frac{3\cdot 10^7}{\pi^2(1.3\cdot 10^{-18})}$$

$$R = 1.23\cdot 10^6\ m. = 1.23\cdot 10^3\cdot km =$$

pg 11 Toomay

(2) $\frac{S}{J}$ From jamming section

$$\frac{S}{J} = \frac{\hat{P} G_T \sigma_{target}}{4\pi R^2 \underbrace{P_j G_j}_{\text{effective radiated power.}}} \left(\frac{B_j}{B}\right)$$

$$1 = \frac{(1 \cdot 10^6 \text{ watts})(3 \cdot 10^3)(1 m^2)}{4\pi (200 \text{ miles})^2 \; P_j G_j} \left(100\right)$$

*

1 mile = 1609.3 m

$\Rightarrow P_j G_j = \cancel{9.218 \cdot 10^3 \text{ watts}}$ 0.2305 watts

$$4 = \frac{(10^6 \text{ watts})(3 \cdot 10^3)(1 m^2)(100)}{4\pi R^2 (0.2305 \text{ watts})} \Rightarrow R = 1.609 \cdot 10^5 \text{ m}$$

$= 99.989$ miles.

PJ II Toomay

(3) $A_r = 100 m^2$

$T_S = 1000 k$

$R = 200$ miles $=$ ~~[illegible]~~ $200(1609.3\ m) = 321860\ m$

want $\frac{J}{N} = ?$

From $\frac{S}{N} = \frac{\hat{P}\tau G_T A_r \sigma}{(4\pi)^2 R^4 k T_s L_s}$ $\tau = ?\ L_s = ?$

$+ \quad \frac{S}{J} = \frac{\hat{P} G_T \sigma_{target}}{4\pi R^2 P_j G_j}\left(\frac{B_j}{B}\right)$ $\div$ these two gives

$$\frac{J}{N} = \frac{\cancel{\hat{P}}\tau \cancel{G_T} A_r \cancel{\sigma}}{(4\pi)^2 R^4 k T_s L_s} \cdot \frac{\cancel{4\pi R^2} P_j G_j}{\cancel{\hat{P}}\cancel{G_T}\cancel{\sigma_{target}}}\left(\frac{B_j}{B}\right)$$ don't know τ + L_s?

$$= \frac{\tau A_r}{(4\pi) R^2 k T_s L_s} P_j G_j \left(\frac{B_j}{B}\right)$$

$$= \frac{A_r P_j G_j}{4\pi (R)^2 k T_s}\left(\frac{B_j}{B}\right)\frac{\tau}{L_s}$$

$$= \frac{(100 m^2)(.2305 \text{ watts})}{4\pi(200 \cdot 1609.3 m)^2(1.3 \cdot 10^{-23} J/k)(1000 k)}\left(100\right)\frac{\tau}{L_s}$$

$$= \frac{2305}{1.69 \cdot 10^{-8}}\left(\frac{\tau}{L_s}\right) = 1.36 \cdot 10^{11}\ \frac{\tau}{L_s} \quad ?$$

(4)

$$Cost = \overset{\cancel{C_p}}{C_p} + C_A + C_0$$

$$\parallel$$

$$Cost \quad \overset{\cancel{C_p}}{C_{kw} N_{kw}} + C_{m^2} N_{m^2} + C_0$$

$$Cost(N_{kw}, N_{m^2}) = C_{kw} N_{kw} + C_{m^2} N_{m^2} + C_0$$

given a fixed power aperture product $\Rightarrow$ $PA_r = N_{kw} \cdot N_{m^2} = C_1$

Then

$$Cost(N_{m^2}) = C_{kw} \frac{C_1}{N_{m^2}} + C_{m^2} N_{m^2} + C_0$$

$$\frac{dC_{cost}}{dN_{m^2}} = -\frac{C_{kw} C_1}{N_{m^2}^2} + C_{m^2} = 0$$

$$\Rightarrow N_{m^2}^2 = [redacted] \frac{C_{kw} C_1}{C_{m^2}} \Rightarrow N_{m^2} = \sqrt{\frac{C_{kw} C_1}{C_{m^2}}}$$ ✓

Now: Then

$$N_{kw} = \frac{C_1}{N_{m^2}} = \frac{C_1}{\sqrt{\frac{C_{kw} C_1}{C_{m^2}}}} = \sqrt{\frac{C_{m^2} C_1}{C_{kw} \cancel{C_1}}}$$ ✓

~~$C_p = C_{kw}$~~

Thus $C_p = C_{kw} N_{kw} = \sqrt{\frac{C_{kw} C_{m^2} C_1}{\cancel{C_1}}} + C_A = C_{m^2} N_{m^2}$

$$C_A = C_{m^2} N_{m^2} = \sqrt{C_{kw} C_{m^2} G_1}$$ equel !!

- - - - Check

$$C = ax + by + c \qquad xy = d \qquad y = \frac{d}{x}$$

$$= ax + \frac{bd}{x} + c$$

$$\frac{dC}{dx} = a + -\frac{bd}{x^2} = 0 \Rightarrow \frac{1}{x^2} = \frac{a}{bd} \Rightarrow x^2 = \frac{bd}{a} \Rightarrow x = \sqrt{\frac{bd}{a}}$$

$$y = \frac{d}{x} = \frac{d}{\sqrt{\frac{bd}{a}}} = \sqrt{\frac{ad}{b}}$$

Th $ax = \sqrt{bda}$

$by = \sqrt{abd}$] equel!

$\sin\theta \cong \frac{B}{D/2}$ A null occurs when $B \cong \frac{\lambda}{2}$

+ $B \cong \frac{n\lambda}{2}$ $n = 1, 3, 5, 7, \ldots$

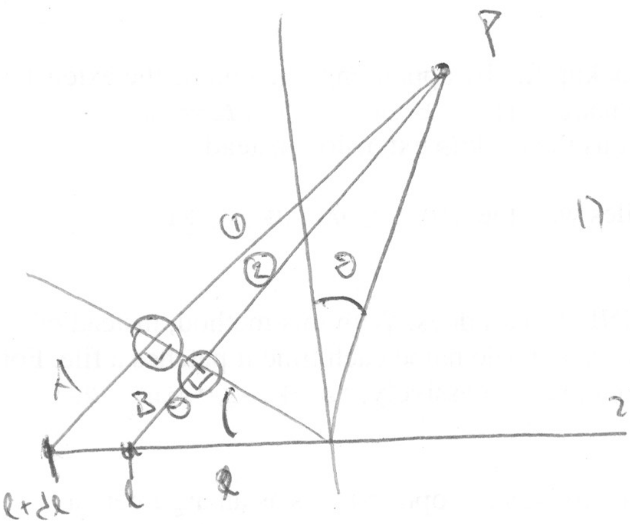
$\theta \cong \frac{\lambda/2}{D/2} = \frac{\lambda}{D}$

$\therefore \theta_n = \frac{n\lambda}{D}$ $n = 1, 3, 5, 7, \ldots$

Don't think would have $n = 2, 4, 6, \ldots$ etc. they should result in constructive interference.

$\begin{bmatrix} 1 & 0 \\ 1/2 & 1 \end{bmatrix}$

$\begin{bmatrix} 1 & 0 \\ -1/2 & 1 \end{bmatrix}$ Same matrix w/ minus sign.



1) Right ∡s approximate But represent

$\begin{bmatrix} 1 & 0 \\ 1/2 & 1 \end{bmatrix}^2$

2) Lengths 1 + 2 approx equal

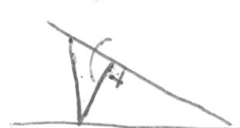
$\begin{bmatrix} 2 & 5 \\ 1 & 3 \end{bmatrix} -$

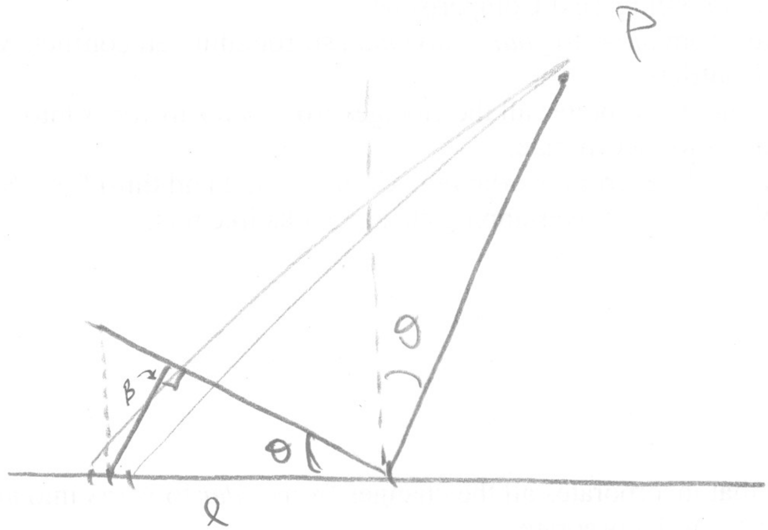
$= \begin{bmatrix} 1 & 5/3 \\ 1/2 & 1 \end{bmatrix} \begin{bmatrix} 2 & 0 \\ 0 & 3 \end{bmatrix}$

difference in path Attributed to only diff in length A + B

~~$B \cong$ additional distance~~ l

$B =$ Additional distance radiation from segment $d\ell$ has to travel relative to that at the center point. $B =$





$\sin\theta = \beta/l \Rightarrow \beta = l\sin\theta$ β is a distance in λ

or phase difference $(2\pi\ )\frac{\beta}{\lambda}$

$\Rightarrow \beta = \frac{2\pi}{\lambda} l\sin\theta$

E field at point P is

$$\left(\frac{E}{k}\right) dl \sin\left(\omega t + \frac{2\pi}{\lambda} l\sin\theta\right)$$

Then total voltage

$$\frac{E}{k}\int_{-D/2}^{+D/2} \sin\left(2\pi f t + \frac{2\pi}{\lambda} l\sin\theta\right) dl$$

$$\frac{E}{k}\, dl \sin\left(2\pi f t + \frac{2\pi}{\lambda} l \sin\theta\right)$$

$$V_t = \frac{E}{k}\int_{-D/2}^{+D/2} \sin\left(2\pi f t + \frac{2\pi}{\lambda} l \sin\theta\right) dl$$

$$= \frac{E}{k}\,\frac{(-1)\cos\left(2\pi f t + \frac{2\pi}{\lambda} l \sin\theta\right)}{\frac{2\pi}{\lambda}\sin\theta}\Bigg|_{-D/2}^{+D/2}$$

$$= \frac{E}{k}\,\frac{\lambda}{2\pi\sin\theta}\left[\cos\left(2\pi f t - \frac{\cancel{2}\pi}{\lambda}\frac{D}{\cancel{2}}\sin\theta\right) - \cos\left(2\pi f t + \frac{\cancel{2}\pi}{\lambda}\frac{D}{\cancel{2}}\sin\theta\right)\right]$$

$$= \frac{E}{k}\,\frac{\lambda}{2\pi\sin\theta}\Bigg[\cancel{\cos(2\pi f t)\cos\left(\frac{\pi}{\lambda}D\sin\theta\right)} + \sin(2\pi f t)\sin\left(\frac{\pi}{\lambda}D\sin\theta\right)$$

$$- \left(\cancel{\cos(2\pi f t)\cos\left(\frac{\pi}{\lambda}D\sin\theta\right)} + - \sin(2\pi f t)\sin\left(\frac{\pi}{\lambda}D\sin\theta\right)\right)\Bigg]$$

$$= \frac{E\lambda}{k\,2\pi\sin\theta}\; 2\sin(2\pi f t)\sin\left(\frac{\pi D}{\lambda}\sin\theta\right)$$

$$V_t(\theta) = \underbrace{\frac{ED}{k}\left[\frac{\sin\left(\frac{\pi D}{\lambda}\sin\theta\right)}{\frac{\pi D}{\lambda}\sin\theta}\right]} \sin(2\pi f t)$$

Modifier due to presence of sample point is not on axis.

Arriving signal from $x=0$ location

Uniform illumination $\Rightarrow$ turn on pulse at constant $\frac{E}{k}$ from $-\frac{D}{2}$ to $+\frac{D}{2}$

?

$$g(\phi) = \frac{1}{2\pi}\cancel{\int_{-\infty}^{+\infty} \frac{E}{k}} e^{-j\omega t}$$

$$= \frac{1}{2\pi}\int_{-D/2}^{+D/2} \frac{E}{k} e^{-j\phi l}\,dl = \frac{E}{2\pi k}\frac{e^{-j\phi l}}{-j\phi}\Bigg|_{-D/2}^{+D/2}$$

$$= -\frac{E}{2\pi k\phi}\frac{\left(e^{-j\phi D/2} - e^{+j\phi D/2}\right)}{j} = \frac{E}{k\phi\pi}\frac{\left(e^{j\phi D/2} - e^{-j\phi D/2}\right)}{2j}$$

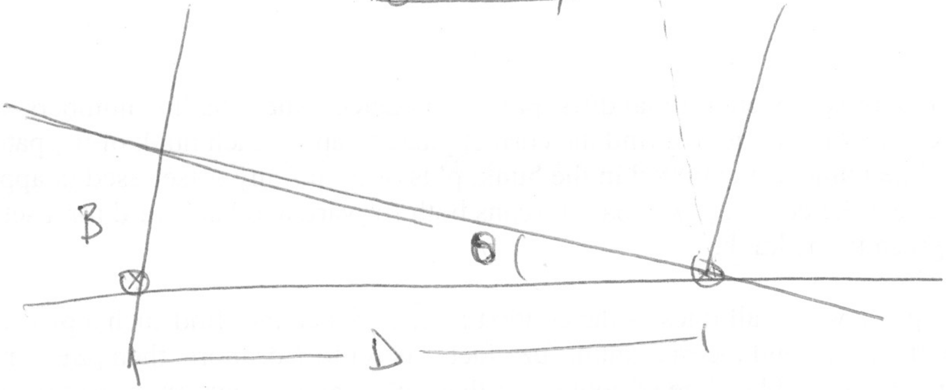
$$= \frac{E}{k\phi\pi}\sin(\phi D/2) = \frac{ED}{2\pi k}\frac{\sin(\phi D/2)}{(\phi D/2)}$$

$\phi = \sin\theta$ $\qquad \frac{D}{2} \Rightarrow \frac{(D/2)(2\pi)}{\lambda} = \frac{\pi D}{\lambda}$ $\qquad$ $D/2$ becomes radians

$$g(\phi) = g(\sin\theta) = \frac{ED}{(2\pi)k} \frac{\sin\left(\frac{\pi D}{\lambda}\sin\theta\right)}{\left(\frac{\pi D}{\lambda}\right)\sin\theta}$$

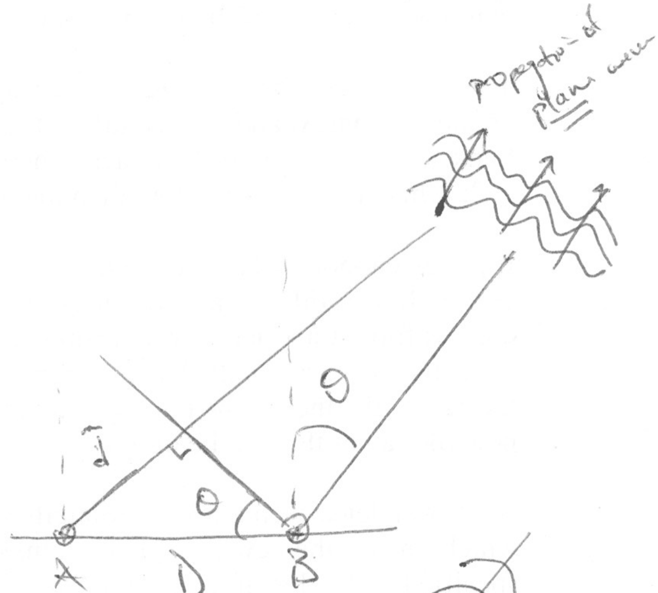
?

$$\frac{\pi D}{\lambda}\sin\theta = \pi \quad \sin\theta = \frac{\lambda}{D} \Rightarrow \quad \theta \cong \frac{\lambda}{D} \qquad D \gg \lambda$$



β in A

$$F(\theta) = E\cos\omega t + E\cos(\omega t + \beta)$$

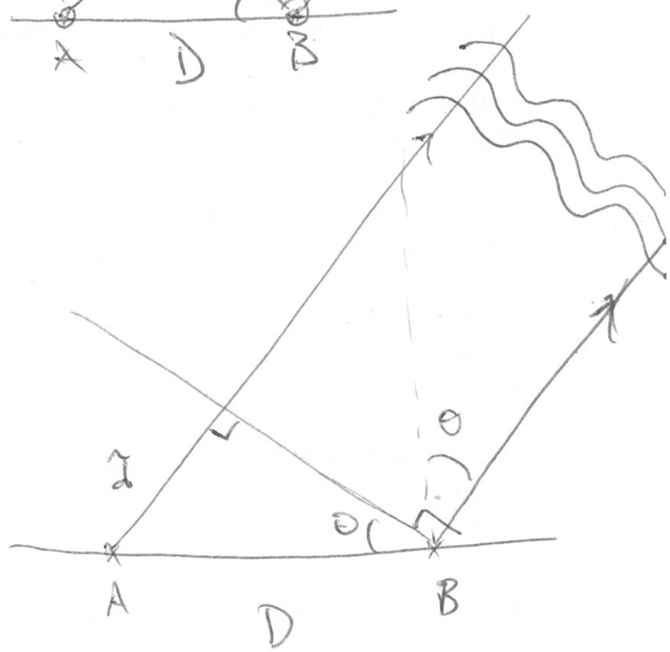


Additional distance in length that source at A must propagate through is length d.

Then phase difference of plane wave arriving at far field is due to extra distance $\hat{d}$.

or

$$\beta = \left(\frac{\hat{d}}{\lambda}\right)2\pi = \frac{D\sin\theta}{\lambda}2\pi$$



1st null is when $\hat{\delta} = \frac{\lambda}{2}$

$\Rightarrow$ ~~β=~~

$$\Rightarrow \frac{(\lambda/2)}{\lambda}(2\pi) = \frac{D\sin\theta}{\lambda}(2\pi)$$

$$\frac{\hat{d}}{D} = \sin\theta$$

$$\Rightarrow \sin\theta = \frac{\lambda}{2D} \Rightarrow \theta \approx \frac{\lambda}{2D}$$

$$\hat{d} = D\sin\theta$$

Gain $G = \frac{4\pi}{\theta^2} > 1$

D = diameter of "dish" or antenna. $A = \frac{\pi D^2}{4}$

A = Area of dish or antenna.

$$G = \frac{4\pi}{\left(\lambda/2D\right)^2} = \frac{4\pi(4)D^2}{\lambda^2}$$

$$D = \frac{2\sqrt{A}}{\sqrt{\pi}}$$

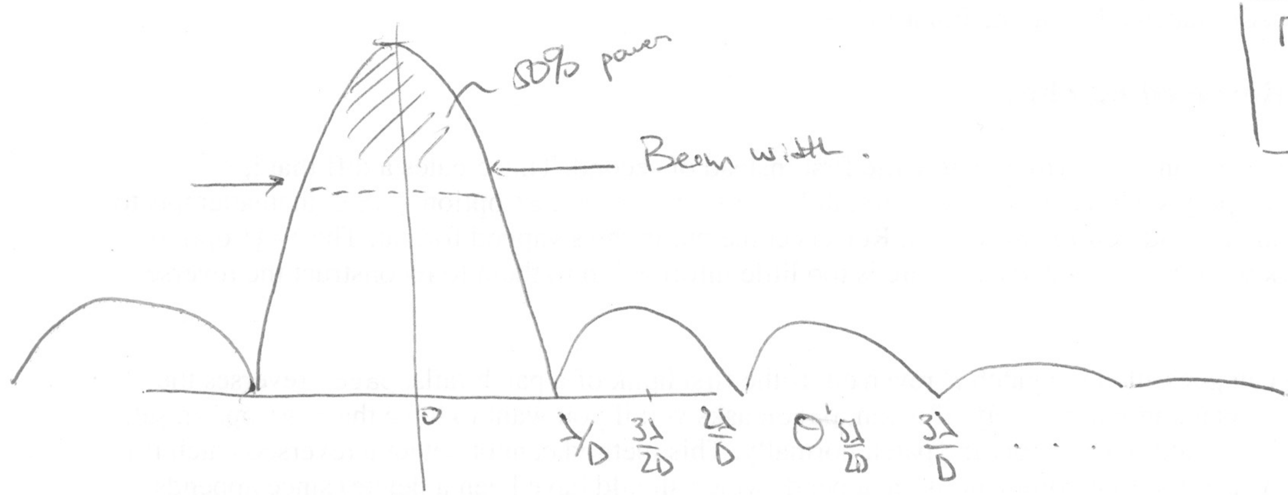
$$= \frac{4\pi(4)}{\lambda^2}\frac{4A}{\pi}$$

$$= \frac{4\pi}{\lambda^2}\underbrace{\left(\frac{16A}{\pi}\right)}_{A_{eff}}$$

?. Why is gain $= \frac{4\pi}{\theta^2}$ why square on θ? I see that it is a fraction of the solid ∡ of a sphere but why this square & what is θ exactly?

$4\pi =$

$\boxed{\text{Medical Apptmt } 11{:}10.}$



90% in 1st Beamwidth

$$\frac{\sin^2\left(\frac{3\pi}{2}\right)}{\left(\frac{3\pi}{2}\right)^2} =$$

$$\left(\frac{2}{\pi}\right)^2 \frac{1}{(21)^2} = 9.1901 \cdot 10^{-4}$$

$$\left(\frac{2}{\pi}\right)^2 \frac{1}{19^2} =$$

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$$g(\theta) = \frac{1}{2\pi}\int_{-D/2}^{+D/2} \cos l \, e^{-j\theta l} \, dl = \frac{1}{2\pi}\int_{-D/2}^{+D/2} \left(\frac{e^{jl} + e^{-jl}}{2}\right) e^{-j\theta l} \, dl$$

$$= \frac{1}{2 \cdot 2\pi}\int_{-D/2}^{+D/2} \left(e^{j(l-\theta l)} + e^{-j(l+\theta l)}\right) dl$$

$$= \frac{1}{4\pi}\left[\frac{e^{jl(1-\theta)}}{j(1-\theta)} + \frac{e^{-jl(1+\theta)}}{-j(1+\theta)}\right]\Bigg|_{-D/2}^{+D/2}$$

$$= \frac{1}{4\pi}\left[\frac{e^{jD/2(1-\theta)} - e^{-jD/2(1-\theta)}}{j(1-\theta)} + \frac{e^{-jD/2(1+\theta)} - e^{jD/2(1+\theta)}}{-j(1+\theta)}\right]$$

$$= \frac{1}{4\pi}\left[\frac{2\sin\left(\frac{D}{2}(1-\theta)\right)}{1-\theta} + \frac{2\sin\left(\frac{D}{2}(1+\theta)\right)}{1+\theta}\right]$$

$$= \frac{1}{2\pi}\left[\frac{\sin\left(\frac{D}{2}(1-\theta)\right)}{(1-\theta)} + \frac{\sin\left(\frac{D}{2}(1+\theta)\right)}{1+\theta}\right]$$

If length is π then $D/2 = \frac{\pi}{2}$ & $g(\theta)$ becomes

$$= \frac{\cancel{4}}{2\pi}\,\frac{1}{2^2}\left[\frac{\sin\left(\frac{\pi}{2}(1-\theta)\right)}{(\pi/2)(1-\theta)} + \frac{\sin\left(\frac{\pi}{2}(1+\theta)\right)}{\frac{\pi}{2}(1+\theta)}\right]$$

Why don't they have my factor of 4?

$$g(4) = \frac{\sin\left(\frac{\pi}{2}(-3)\right)}{\frac{\pi}{2}(-3)} + \frac{\sin\left(\frac{\pi}{2}(5)\right)}{\frac{\pi}{2}(5)} = -.0849$$

$$= -21.4 \text{ dB}$$

$$g(6) = \frac{\sin\left(\frac{\pi}{2}(-5)\right)}{\frac{\pi}{2}(-5)} + \frac{\sin\left(\frac{\pi}{2}(7)\right)}{\frac{7\pi}{2}}$$

I got different results?

Think Bandwidth is defined as the width of the main pulse beam that gives 1/2 peak power.

$$g^2(\theta=0) = \frac{1}{16}\left[\frac{1}{\left(\frac{\pi}{2}\right)} + \frac{1}{\left(\frac{\pi}{2}\right)}\right]^2 = \frac{1}{16}\left(\frac{4}{\pi}\right)^2 = \frac{1}{\pi}$$

Normalize by Multiplying by π, I would imagine that the normalized power would be set at 1 thus $g^2(\theta=0) = 1$.

How much wider is the new main beam by using a cosine illumination. Bandwidth w/ pulsed illumination is $\frac{\lambda}{D}$ w/ cosine illumination it is $1.37\frac{\lambda}{D}$ $\Rightarrow$ 37% increase

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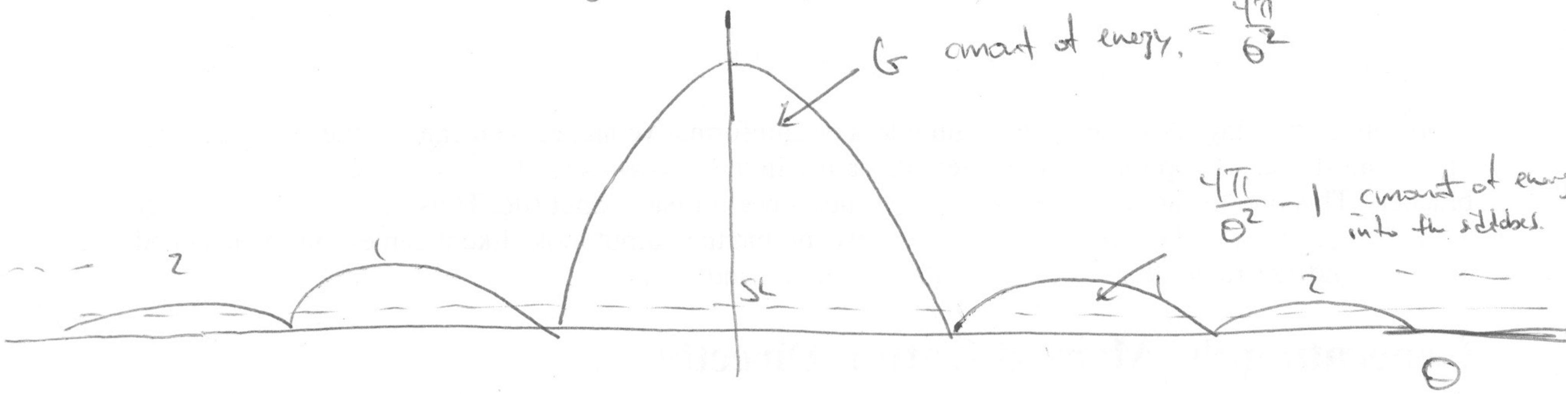


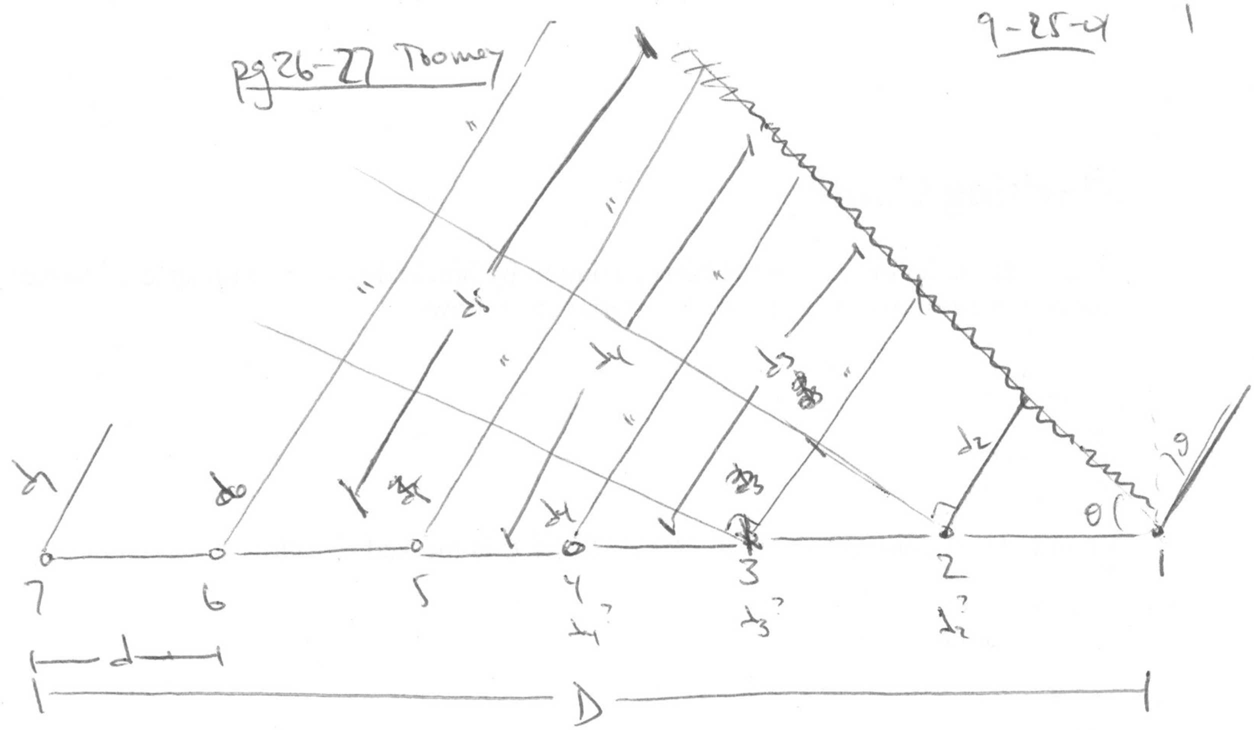
Assume the Average height of the side lobes are SL

$$SL\left(\frac{4\pi}{\theta^2} - 1\right) = \frac{1}{2}$$

$\frac{4\pi}{\theta^2} \gg 1$ $\qquad SL \cong \frac{1}{2G}$ "Average" decrease in side lobe height w/ given antenna gain G.

$\parallel$

G



To match the phase at the output line l (so as to have a plane wave propagating outward)

Input is θ output set of times at which to turn on the radars at

$$B_2 = \left(\frac{d_2}{\lambda}\right) 2\pi = 2\pi n_2$$

$$B_3 = \left(\frac{d_3 + d_2}{\lambda}\right) 2\pi = 2\pi n_3 .$$

$$\theta = \sin^{-1}\left(\frac{c\,\Delta t}{d}\right)$$

$$Nn \cdot \Delta t = 10^2 \cdot 10^3 \Delta t = 10^5 \Delta t .$$

$$c\tau \gg D$$

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3 bit phase shifter 45°, 90°, 180°

0°
45°
90°
135° = 45° + 90°
180
225
270
315

$$\sigma_0 \cong \frac{\sigma_{rms}\,\lambda}{2\pi D}$$

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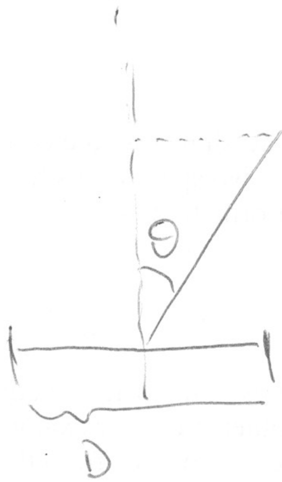

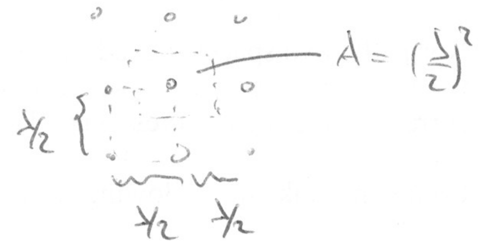

$$g = \frac{4\pi A_{eff}}{\lambda^2} = \frac{4\pi}{\lambda^2}\left(\frac{\lambda}{2}\right)^2 = \pi.$$

$$A_{eff} = \left(\frac{\lambda}{2}\right)^2$$

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① $\lambda = 20\,\mu m.$ $\quad G = 10^6 \quad A = ?$

$$G = \frac{4\pi A}{\lambda^2} \Rightarrow A = \frac{\lambda^2 G}{4\pi} = \frac{(20\cdot10^{-6})^2 (10^6)}{4\pi}$$

$$= 3.18\cdot10^{-5}\ m^2$$

$$A = \frac{\pi D^2}{4} \Rightarrow D = \sqrt{\frac{4A}{\pi}} = .0064\,m = 6.4\,mm$$

$$D \sim \sqrt{A} = .0056 = 5.6\,mm = .56\,cm.$$

$$A = \frac{\lambda^2 G}{4\pi} = \frac{c^2 G}{4\pi f^2} = \frac{(3\cdot10^8\,m/s)^2 (10^6)}{4\pi(3000\cdot10^6\,1/s)^2} = 795,7747$$

$\lambda = \frac{c}{f}$

$$D \sim \sqrt{A} = 28,209$$

* See notes

② $A = 100\,m^2 \quad \lambda \sim 1m.$

$$G_{dish} = \frac{4\pi A}{\lambda^2} = \frac{4\pi(100\,m^2)}{(1m)^2} = 400\pi$$

for an equivalent aperture radar.

$$G = N\pi = 400\pi \Rightarrow N = 400 \Rightarrow \sqrt{N} \triangleq \#\,elements/side$$
$$= 20$$

each spaced ½ apart $= .5\,m \Rightarrow$ length of side $= 10m$

$\Rightarrow$ Physical area $= 100\,m^2$.

③ *

$$f(x) = \begin{cases} \frac{1}{\theta} e^{-x/\theta} & x > 0 \\ 0 & \text{else} \end{cases}$$

Mean:

$$\mu = \int_{-\infty}^{\infty} x f(x)\,dx = \int_0^{+\infty} \frac{x}{\theta} e^{-x/\theta}\,dx \qquad v = x/\theta \quad dv = dx/\theta$$

$$= \theta \int_0^{+\infty} v e^{-v}\,dv = \theta \left[\frac{v e^{-v}}{(-1)} \Big|_0^{+\infty} + \int_0^{+\infty} (1) e^{-v}\,dv \right]$$

$$= \theta \left[\frac{e^{-v}}{(-1)} \Big|_0^{+\infty} \right] = \theta(0+1) = \theta$$

Variance

$$\sigma^2 = \int_{-\infty}^{+\infty} x^2 f(x)\,dx = \int_0^{+\infty} \frac{x^2}{\theta} e^{-x/\theta}\,dx \qquad v = x/\theta \quad dv = dx/\theta$$

$$= \int_0^{+\infty} \frac{\theta^2 v^2}{\cancel{\theta}} e^{-v} \cancel{\theta}\,dv = \theta^2 \int_0^{+\infty} v^2 e^{-v}\,dv$$

$$= \theta^2 \left[\cancel{\frac{v^2}{(-1)} e^{-v}} \Big|_0^{+\infty} - \frac{1}{(-1)} \int_0^{+\infty} 2v e^{-v}\,dv \right] = \theta^2 \left[2 \int_0^{+\infty} v e^{-v}\,dv \right] = 2\theta^2$$

$\sigma^2 = 2\theta^2$

$$P(x \geq 10\theta) = \int_{10\theta}^{+\infty} f(x)\,dx = \int_{10\theta}^{+\infty} \frac{1}{\theta} e^{-x/\theta}\,dx = \frac{1}{\theta}\,\frac{e^{-x/\theta}}{(-1/\theta)}\Bigg|_{10\theta}^{+\infty}$$

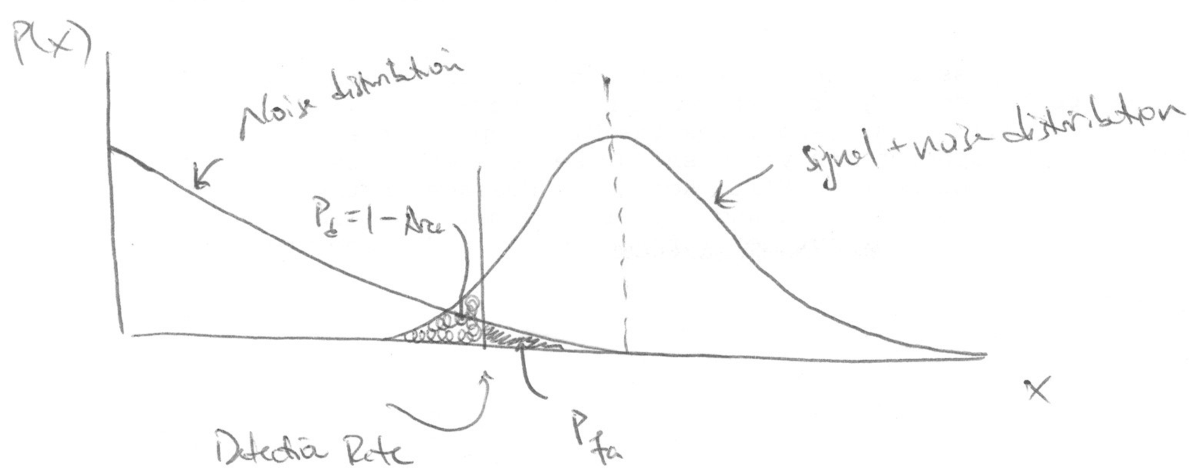
$$= e^{-10} \approx 4.5 \cdot 10^{-5}$$

$$P(x \geq n\theta) \leq 10^{-6}$$
$$\parallel$$
$$e^{-n} \leq 10^{-6}$$

$$-n \leq -6\ln(10)$$

$$n \geq 6\ln(10) = 1.38 \cdot 10^{1} \approx 14.$$

- Normal Dist to describe signal + Noise



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$$\mathrm{erf}(x) = \frac{2}{\sqrt{\pi}} \int_{u}^{t} e^{-x^2}\,dx$$

$$\mathrm{erf}\left(\sqrt{S/N} - \sqrt{n\theta}\right)$$

$$\sqrt{\frac{2S}{N}} = \frac{V_s}{N_o} \qquad \frac{nV_s}{\sqrt{n}\,N_o} = \frac{\sqrt{n}\,V_s}{N_o}$$

power   voltage

$$\frac{2nS}{N} = n\left(\frac{V_s}{V_o}\right)^2$$

$$P_d = p^5 + 5p^4(1-p) + 10p^3(1-p)^2$$

$$P_d\left(\tfrac{1}{2}\right) = \frac{1}{32} + \frac{5}{16}\left(\frac{1}{2}\right) + \frac{10}{8}\left(\frac{1}{4}\right) = \frac{1+5+10}{32} = \frac{1}{2}$$

$$P_{fa} = (\quad)^5 + 5(\quad)^4(\quad) + 10(\quad)^3(\quad)^2$$

$$P_{fa}(10^{-2}) =$$

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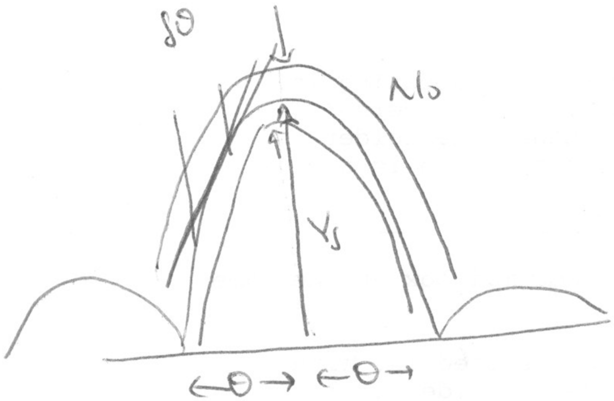

$$\frac{\delta\theta}{\theta} = \frac{N_o}{V_s}$$

$$\delta\theta = \frac{\theta}{\left(\frac{V_s}{N_o}\right)}$$

$$\delta\theta = \frac{\theta}{\frac{\sqrt{2}\,V_s}{N_o}} \qquad \frac{V_s}{N_o} = \sqrt{2\,S/N} \qquad \theta \cong \frac{\lambda}{D}$$

$$\delta\theta \cong \frac{\lambda/D}{\sqrt{2}\sqrt{2(S/N)}} = \frac{\lambda}{2D\sqrt{S/N}}$$

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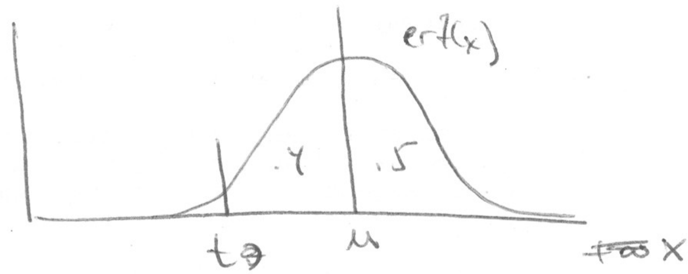
(1) Require $P_d = .9$

$P_{fa} = 10^{-6}$



Require

$$\frac{1}{\sqrt{\pi}} \int_{\mu}^{t} e^{-x^2} dx = -.4$$

$$\parallel$$

$$\frac{1}{2} \operatorname{erf}(t) =$$

$P(x \geq n\theta) \leq 10^{-6} \Rightarrow n \geq 14.$

Don't follow?

(2) $G = n$

$P_d = .5$

$P_{fa} = 10^{-2}$

?

(3) ~~P_d~~

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(3) $n=4$

$P_d = .9$

$P_{fa} = .1$

$n=0$			1		
$n=1$		1		1	
$n=2$		1	2	1	
$n=3$	1	3		3	1
$n=4$	1	4	6	4	1
# of crossings :	4	3	2	1	0

$(p+q)^4 = p^4 + 4p^3q + 6p^2q^2 + 4pq^3 + q^4$

$p=.9 \; q=.1$

	4	3	2	1	0
P_d	$.9477 - 4(.9)^3(.1) = .6561$	$.9963 - 6(.9)^2(.1)^2 = .9477$	$.9999 - 4(.9)(.1)^3 = .9963$	$1.0 - (.1)^4 = .9999$	1.0

$p=.1, q=.9$

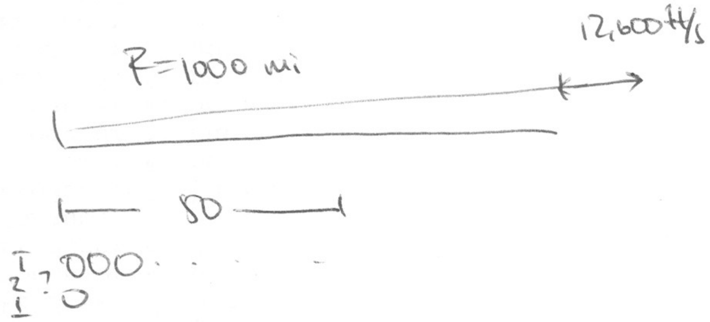
P_{fa}	$.0037 - 4(.1)^3(.9) = .0001$	$.0523 - 6(.1)^2(.9)^2 = .0037$	$.3439 - 4(.1)(.9)^3 = .0523$	$1 - (.9)^4 = .3439$	1.0

(4) $P_d = .5$ $P_{fa} = 10^{-4}$ } single pulse information.

How much improvement can be made w/ 4 pulses?

? Compute signal to noise ratio somehow & then Assuming Fig 3.6 is plotted 4 pulses which I couldn't find true anywhere ?

(5)



?

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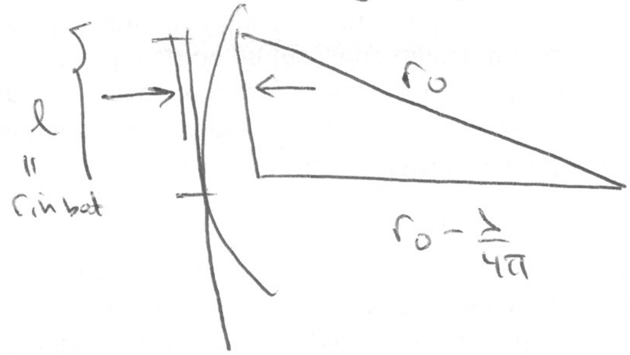
Assuming $\lambda/4\pi$? How know?

$$\sigma = \frac{4\pi A^2}{\lambda^2}$$



$$\ell = \sqrt{r_0^2 - (r_0 - \lambda/4\pi)^2}$$

$$= \sqrt{r_0^2 - \left(r_0^2 - \frac{2r_0\lambda}{4\pi} + \frac{\lambda^2}{16\pi^2}\right)}$$

$$= \sqrt{\frac{r_0\lambda}{2\pi} - \frac{\lambda^2}{(4\pi)^2}} \simeq \sqrt{\frac{r_0\lambda}{2\pi}}$$

w/ $r_0 \gg \frac{2\pi}{\lambda}$

$$\frac{r_0\lambda}{2\pi} \gg 1$$

~~Then RCS~~ $\cancel{\sigma = \pi r^2 = \pi\left(\frac{r_0\lambda}{2\pi}\right)}$

Then $A = \pi r^2 = \pi \frac{2r_0\lambda}{4\pi}$

Now $$\sigma = \frac{4\pi A^2}{\lambda^2} = \frac{\cancel{4\pi}\ \pi^2\left(\frac{4r_0^2\cancel{\lambda^2}}{(4\pi)^{\cancel{2}}}\right)}{\cancel{\lambda^2}} = \frac{\cancel{4}\pi^2 r_0^2}{\cancel{4}\pi} = \pi r_0^2$$

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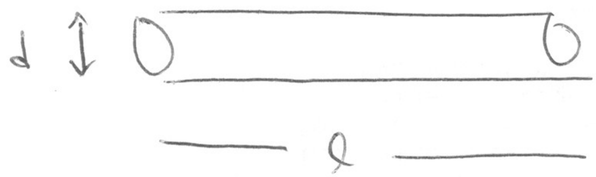

$\underset{\text{(projected)}}{\text{Area}} \cong dl$

$\text{beamwidth} = \dfrac{\lambda}{l}$ (why?)

$\therefore \; G = \dfrac{2\pi}{\text{beamwidth}} = \dfrac{2\pi l}{\lambda}$

$\sigma_{broadside} = GA = \dfrac{2\pi l^2 d}{\lambda}$

$\sigma_{broadside} = \pi l^2$?

$d \approx 2ft$ $\lambda(VHF) = 6ft$

~~Res~~ Check $2\pi a \sim \lambda$ $a = d/2$

$2\pi(\frac{2ft}{2}) \sim 6\ ft$ yes.

Then $RCS = \pi a^2 = \pi(1) \approx 3.14\ m^2$

1in nose radius S-band ⇒ $\lambda \approx .1$ m

$$\sigma = \pi(1\text{inch})^2 = \pi(.0254)^2 = 2.02 \cdot 10^{-3}$$

1inch = .0254 m

$$10\log_{10}(\;\downarrow\;) = -26.93 \text{ dB}$$

$\checkmark$ $1/500 \approx .002$ m^2

$$\sigma = \sigma_0 \cos^2\theta$$

$$\bar{\sigma} = \frac{2}{\pi}\sigma_0 \int_0^{\pi/2} \cos^2\theta \, d\theta = \frac{2}{\pi}\sigma_0 \frac{1}{2}\int_0^{\pi/2} (1 + \cos(2\theta))d\theta$$

whatis this formula?

$$= \cancel{\frac{\sigma_0}{2}} \frac{\sigma_0}{\pi}\left[\frac{\pi}{2} + \frac{\sin(2\theta)}{2}\Big|_0^{\pi/2}\right]$$

$$= \frac{\sigma_0}{2}$$

$$\bar{\sigma}_{HH} = \frac{2\sigma_0}{\pi}\int_0^{\pi/2} \cos^4\theta \, d\theta = \frac{2\sigma_0}{\pi}\int_0 \frac{(1+\cos 2\theta)^2}{4} d\theta = \frac{\sigma_0}{2\pi}\int_0 \underbrace{1 + 2\cos 2\theta + \cos^2 2\theta}$$

$$1 + 2\cos 2\theta + \frac{1 + \cos(4\theta)}{2}$$

$$= \text{[illegible]}$$

$$= \frac{\sigma_0}{2\pi}\left[\frac{\pi}{2} + 0 + \frac{1}{2}\left(\frac{\pi}{2}\right) + 0\right] = \frac{\sigma_0}{4}\left(1 + \frac{1}{2}\right) = \frac{3\sigma_0}{8}$$

$$\bar{\sigma}_{Hv} = \frac{2\sigma_0}{\pi}\int_0^{\pi/2} \cos^2\theta \sin^2\theta \, d\theta = \frac{2\sigma_0}{\pi}\int_0^{\pi/2} \left(\cos^2\theta - \cos^4\theta\right) d\theta$$

$$= \frac{2\sigma_0}{\pi}\left[\frac{\pi}{2\cancel{\sigma_0}}\frac{\cancel{\sigma_0}}{2} - \frac{\pi}{2\cancel{\sigma_0}}\cdot\frac{3\cancel{\sigma_0}}{8}\right]$$

$$= \frac{2\sigma_0}{\pi}\left[\frac{\pi}{4} - \frac{3\pi}{16}\right] = \frac{2\sigma_0}{\cancel{\pi}}\frac{\cancel{\pi}}{16} = \frac{\sigma_0}{8}$$

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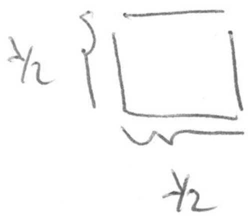
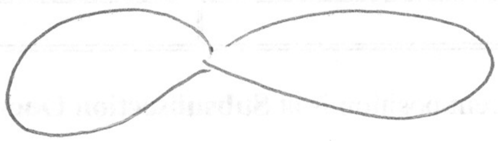


$A = (\lambda/2)^2 = \lambda^2/4$

$G = \frac{4\pi}{4} = \pi$

dipole



$\frac{2\pi D}{\lambda}$, $D = \frac{\lambda}{2}$

$\hat{\sigma} = \sigma_{max} = \frac{\pi\lambda^2}{4} = .785\lambda^2 \overset{?}{\approx} \pi r^2$ w/ $r = (\lambda/2)$

No: $\bar{\sigma} = GA = \pi\left(\frac{\lambda}{2}\right)^2 = \frac{\pi\lambda^2}{4}$

gain times area.

$$\bar{\sigma} = \hat{\sigma}\frac{4}{\pi^2}\iint_0^{\pi/2} \sin^4\theta\cos^2\phi \, d\theta \, d\phi$$

$$= \hat{\sigma}\frac{4}{\pi^2}\int_0^{\pi/2}\left(\frac{1+\cos 2\phi}{2}\right)d\phi \int_0^{\pi/2}\left(\frac{1-\cos(2\theta)}{2}\right)^2 d\theta$$

$$= \hat{\sigma}\frac{2}{\pi^2}\left[\left(\frac{\pi}{2}\right)\right]\frac{1}{4}\left[\int_0^{\pi/2}\left(1 - 2\cos(2\theta) + \cos^2(2\theta)\right)d\theta\right]$$

$$= \frac{\hat{b}}{4\pi} \left[\frac{\pi}{2} + \int_0^{\pi/2} \left(\frac{1+\cos(4\theta)}{2} \right) d\theta \right]$$

$$\left[\frac{\pi}{2} + \frac{1}{2}\frac{\pi}{2} \right]$$

$$= \frac{\hat{b}}{4\cancel{\pi}} \frac{\cancel{\pi}}{2} \left[1 + \frac{1}{2} \right] = \frac{3}{2}\frac{\hat{b}}{8} = \frac{3\hat{b}}{16}$$

w/ $\hat{b} = \frac{\pi}{4} s^2$

$$= \frac{3\pi}{64} s^2 = .147\, s^2$$

$$\hat{b} = N\hat{b} = .785\, N s^2$$

$$\bar{b} = N\bar{b} = .15\, N s^2$$

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$$\theta = 2\pi\left(\frac{\Delta t}{T}\right) \quad \& \quad \theta = \frac{\lambda}{2D}$$

$$\frac{\lambda}{2D} = 2\pi\left(\frac{\Delta t}{T}\right) \rightarrow D = \frac{\lambda}{2(2\pi\,\Delta t/T)} = \frac{\lambda T}{4\pi\,\Delta t}$$

10-1-01 |

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(1) (a) $\cancel{\sigma_{broadside}} = \cancel{\frac{2\pi l^2 d}{\lambda_{Lband}}}$

$\cancel{\sigma_{broadside}}$

Use RCS of a flat plate $\sigma = \frac{4\pi A^2}{\lambda^2}$

$\sigma = \frac{4\pi A^2}{\lambda_{XBand}^2}$

(b) 50% of A

(2) $d = .1 - .5$ inch $= .00254 - .0127$ m. $\Rightarrow a = 1.27 \cdot 10^{-3} - 6.35 \cdot 10^{-3}$ m

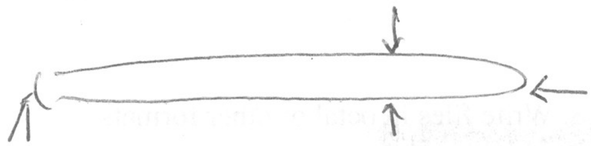
Require $\frac{2\pi a}{\lambda} \gg 1$

$2\pi a = 7.97 \cdot 10^{-3} - 3.989 \cdot 10^{-2}$ m $= O(10^{-2}$ m$)$

Take $\lambda = 10^{-3}$ m or smaller.

$f = \frac{c}{\lambda} = \frac{3 \cdot 10^8 \text{ m}}{10^{-3} \text{ m}} = 3 \cdot 10^{11}$ 1/s. $= 300$ GHz.

(3)



Beamwidth $= 1.44 \frac{\lambda}{D}$

$$\lambda = \frac{c}{900 \cdot 10^9 \, 1/s} = \frac{3 \cdot 10^8}{900 \cdot 10^9} = 3{,}33 \cdot 10^{-4}$$

?

(4) $\sigma = GA$ w/ $G = \frac{4\pi A}{\lambda^2}$

Sphere $\sigma = \frac{4\pi A}{\lambda^2}(\pi a^2) = \frac{4\pi(\pi a^2)(\pi a^2)}{\lambda^2}$

$V = \frac{4}{3}\pi a^3$?

(5) $N = 100{,}000$ $\lambda = 1 ft =$

$$\bar{\sigma} = .15(N)\lambda^2 = .15(10^5)(3{,}048 \cdot 10^{-1})^2 = 1.39 \cdot 10^3 \, m^2$$

$$= 1390 \, m^2$$

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$$f(t) = V\cos\omega_0 t \xrightarrow{\mathcal{F}} \frac{\sin x}{x} \qquad \omega_0 \sim O(10^9\ Hz)$$

$$f(t) = V \qquad -\frac{T}{2} < v < \frac{T}{2}$$

$$g(\omega) = \frac{1}{2\pi}\int_{-\tau/2}^{+\tau/2} V e^{-j\omega t}\,dt = \frac{1}{2\pi} V \left.\frac{e^{-j\omega t}}{(-j\omega)}\right|_{-\tau/2}^{+\tau/2}$$

$$= \frac{V}{2\pi}\frac{1}{(-j\omega)}\left[e^{-j\omega\tau/2} - e^{+j\omega\tau/2}\right]$$

$$= \frac{V}{\pi\omega}\sin(\omega\tau/2) = \frac{V\tau}{2\pi}\,\frac{\sin\left(\frac{\omega\tau}{2}\right)}{\frac{\omega\tau}{2}}$$

power spectrum $\quad g(\omega)^2 = \left(\frac{V\tau}{2\pi}\,\frac{\sin\left(\frac{\omega\tau}{2}\right)}{\frac{\omega\tau}{2}}\right)^2$

let ω increase

define Bandwidth distance from 0 to 1st zero of $\sin\left(\frac{\omega\tau}{2}\right) = 0$

$$\Rightarrow \frac{\omega\tau}{2} = \pi \qquad \omega = \frac{2\pi}{\tau}$$

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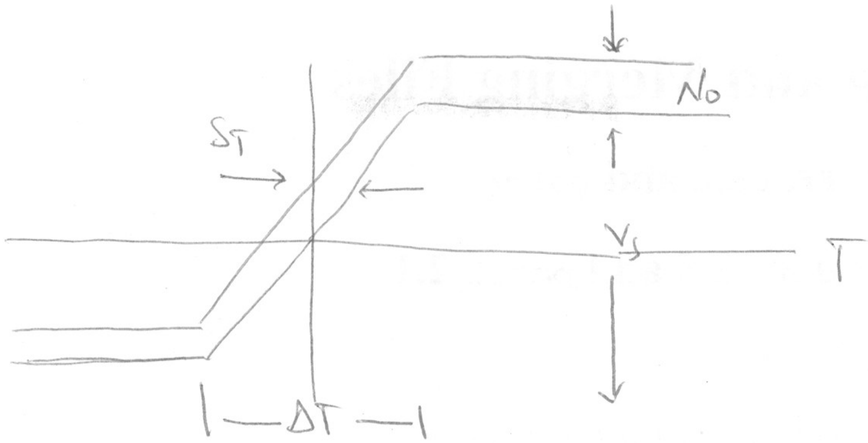

$$\text{Slope} = \frac{V_s}{\Delta T}$$

Then increase in height by N_0 results in widening of gap by

$$\delta_T = \frac{N_0}{\text{slope}} = \frac{N_0}{\frac{V_0}{\Delta T}} = \frac{\Delta T}{V_s} N_0$$

$$\frac{\delta_T}{\Delta T} = \frac{N_0}{V_s\sqrt{2}}$$

How get factor of 2 difference?
put it in assuming ~~[illegible]~~ on of the terms
is the RMS value

$$\delta_R = (c/2)\, \delta_T$$

$$\delta_R = \left(\frac{c}{2}\right) \frac{\Delta T}{\sqrt{2}} \frac{N_0}{V_s} = \left(\frac{c}{2}\right)\frac{1}{B}\left(\frac{1}{\sqrt{2}}\right)\sqrt{\frac{N}{2S}}$$

$$= \frac{c}{4B\sqrt{S/N}}$$

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$$f_d = \frac{2v}{\lambda}$$

$$f_d = \frac{2v}{\lambda}\left[1 + \frac{v}{c} + \left(\frac{v}{c}\right)^2 + \dots\right]$$

$$f_d = \frac{1}{\tau} \qquad \Delta v = \frac{1}{\tau}\left(\frac{\lambda}{2}\right) = \frac{\lambda}{2\tau}$$

$$\dot{R} = \frac{R_2 - R_1}{t} = \frac{R_2 + \sqrt{2}\,\delta_{R_1} - R_1 * - \sqrt{2}\,\delta_{R_2}}{t}$$

$$= \frac{R_2 - R_1 + \sqrt{2}(\delta_{R_1} - \delta_{R_2})}{t} = \frac{R_2 - R_1}{t} + \underbrace{\frac{\sqrt{2}}{t}(\delta_{R_1} - \delta_{R_2})}_{\delta_{\dot{R}}}$$

$$\frac{\delta_v}{\delta_{\dot{R}}} = \frac{\dfrac{\lambda}{\gamma\tau\sqrt{\cancel{\mathcal{S}}/N}}}{\dfrac{c}{\gamma B\sqrt{\cancel{\mathcal{S}}/N}}} = \frac{\lambda}{\tau}\cdot\frac{B}{c} = \frac{B}{\tau f_c}$$

$$\frac{c}{\lambda} = f$$

$$B \sim (5\text{-}10\%) f_c \qquad \frac{\delta_v}{\delta_{\dot{R}}} = \sqrt{2}\,(.1)$$

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$$\frac{dv}{dt} = -\frac{d}{2\tau^2}$$

$$Q_R = \left(\frac{c}{2B}\right) \Delta f_d \tau \quad = \quad \frac{c\tau}{2} \quad \frac{\Delta f_d}{B}$$

$\tau = 20 \mu s$

$\Delta f_d = 5$

$\tau = 50 \mu s$

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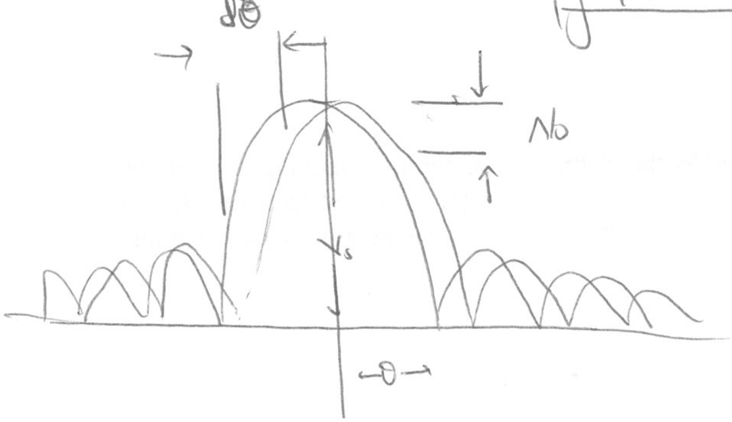
①



slope $\approx \frac{V_s}{\theta}$

δ

procedurally this is the same as on page 55. I don't however see the new definition of the terms

② $\delta_r = 100\,ft = \frac{c}{4B\sqrt{S/N}}$ λ is known $\lambda = \frac{c}{10 \cdot 10^9\ 1/s}$

$\delta_v = 50\ ft/s = \frac{\lambda}{4\tau\sqrt{S/N}}$

How solve for either β or τ? 2 eqs +

③ dead zone is range inside pulse

$R_{dead} \le \frac{c}{2}\tau$ w/ τ given from the problem [illegible]

(4) $R_{dead} = \frac{c}{2}\tau = 1 \text{ mi}$

R_{max} ?

(5) ?

(6) ?

(7) (a) $B = 100 \text{ MHz}$ $\tau\beta = (100 \text{ MHz})(200 \mu s)$

$\tau = 200 \mu s$

(b)

(c) $\frac{c\tau}{2}$

(d)

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$$\frac{\int_0^{PRF} G^2\,df}{4(PRF)} = \frac{\cancel{4}\int_0^{PRF} \sin^2\left(\frac{\pi f}{PRF}\right) df}{\cancel{4}\,PRF}$$

$$= \frac{\int_0^{PRF}\left(\frac{1}{2} - \frac{1}{2}\cos\left(\frac{2\pi f}{PRF}\right)\right) df}{PRF} = \frac{\frac{1}{2}PRF - \cancel{\frac{1}{2}\frac{\sin\left(\frac{2\pi f}{PRF}\right)}{\frac{2\pi}{PRF}}}\Big|_0^{PRF}}{PRF}$$

0

$$= \frac{1}{2}$$

$$C(f) = C_0 \int_0^{PRF/2} \frac{1}{f_c} e^{-f/f_c}\,df = \frac{C_0}{f_c} e \Big|_0^{PRF/2} = e^{[\,]} - 1$$

Don't here.

$$C = \frac{\int G(f)C(f)\,df}{\int C(f)\,df} = \int_0^{PRF} 2\sin\left(\frac{\pi f}{PRF}\right)$$

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$D = vT$ v = plane velocity.

$\theta \approx \frac{\lambda}{D}$

$Res_{max} = R\theta = \frac{R\lambda}{D}$ $R_H = \frac{2D^2}{\lambda}$

$Res_{max} = \frac{R_H \lambda}{D} = \frac{2D^2}{\lambda}\frac{\lambda}{D} = 2D$

$Res_{max} = \frac{R_H \lambda}{2D} = D$

$\tau = \frac{R\theta}{V_{a/c}}$

$\frac{2V_{a/c}\sin\theta}{\lambda} \approx \frac{2V_{a/c}\,\theta}{\lambda}$.

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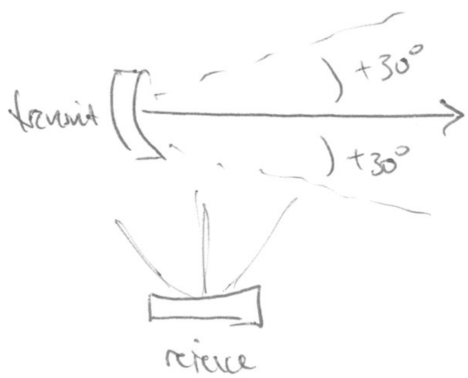
(1)



?

(2) $R_{max} \leq \frac{c}{2PRF}$

$f = 3000$ MHz

$V_{max} = 3000$ ft/s

$\delta R = 100$ ft

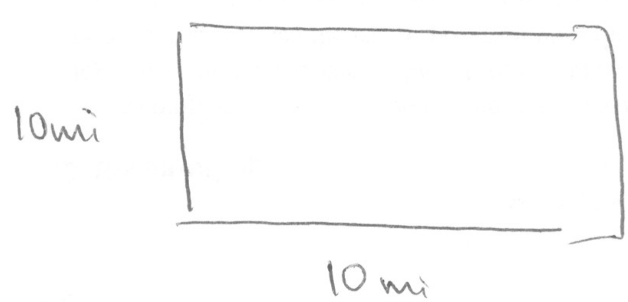
$\delta V = 50$ ft/s

(3) Problems w/ movement. Need GPS.

(4) ?

(5) ?

(6)



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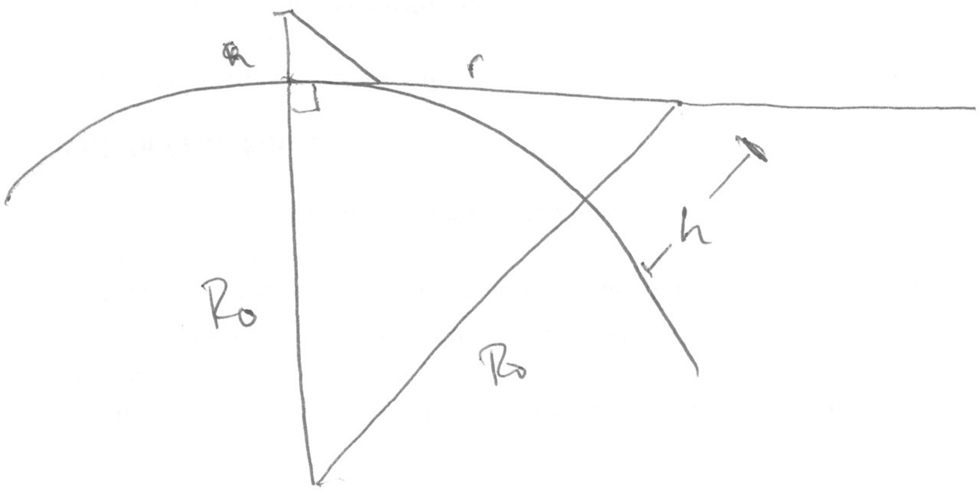

$$r^2 + \cancel{R_0^2} = (R_0+h)^2$$

$$= \cancel{R_0^2} + 2R_0h + h^2$$

$$r^2 = 2R_0h + h^2 \sim 2R_0h \qquad r \sim \sqrt{2R_0h}$$

$$r \sim \sqrt{\frac{2(4000)}{5280}\, h_{ft}}$$

$R_0 \cong 4000$ st. mi

$h \sim 5280$

$$\sim \sqrt{2h_{ft}}$$

$h_{ft} = 5280\, h_{mi}$

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$$\alpha = \frac{2.9 \cdot 10^4 N_e \nu}{\omega^2 + \nu^2}$$

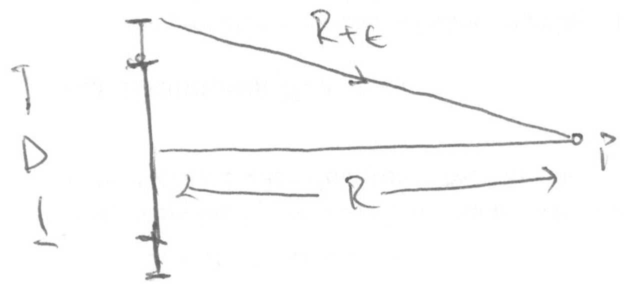
$$\alpha \approx \frac{2.9 \cdot 10^4 N_e \nu}{\omega^2} = \frac{2.9 \cdot 10^4 N_e \nu}{4\pi^2 f^2} = 7.34 \cdot 10^2 \frac{N_e \nu}{f^2}$$

$$\eta \cong \left(1 - \frac{N_e}{10^4 f^2}\right)^2$$

$N_e < 10^9 \text{ cm}^{-3}$

$f > 10 \cdot 10^6 \text{ Hz}$

$$\Omega = \frac{6.3 \cdot 10^{20}}{f^2} \approx \frac{10}{180} \cdot \pi \Rightarrow f \cong 6 \cdot 10^{10} \text{ Hz}$$



$$(R+\epsilon)^2 = \frac{D^2}{4} + R^2$$

$D \ll R$

$\epsilon \ll R$?

$$2R\epsilon + \epsilon^2 = \frac{D^2}{4}$$

$$R \cong \frac{D^2}{8\epsilon}$$

$$\epsilon = 45° \overset{?}{=} \frac{\lambda}{8}$$

$$R_{ff} \cong \frac{D^2}{\lambda}$$

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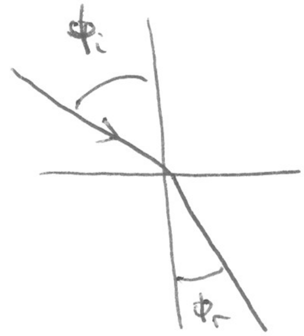
(1) $N_e = 10^4 - 10^5 \ cm^{-3}$

λ ~ microwave. X-band ⇒ 3000 MHz

$3 \cdot 10^9$ Hz

$$\alpha \cong 4 \cdot 10^{-3} \frac{N_e}{f^2} = \frac{4 \cdot 10^{-3}(10^4)}{(3 \cdot 10^9)^2} =$$



$$\eta \cong \left(1 - \frac{N_e}{10^4 f^2}\right)^2$$

index of refraction

$$= \left(1 - \frac{(10^4)}{10^4 (3 \cdot 10^9)^2}\right)^2$$

$\sin\phi_i = \eta \sin\phi_r$

$$\Omega = \frac{6.3 \cdot 10^{20}}{(3 \cdot 10^9)^2} =$$

S-band $f = 2$-3000 MHz

(2) $$R_{ff} \cong \frac{2D^2}{\lambda} = \frac{2D^2 f}{c} = \frac{2(1000\ ft)^2 (430 \cdot 10^6\ 1/s)}{3 \cdot 10^8\ m/s}$$

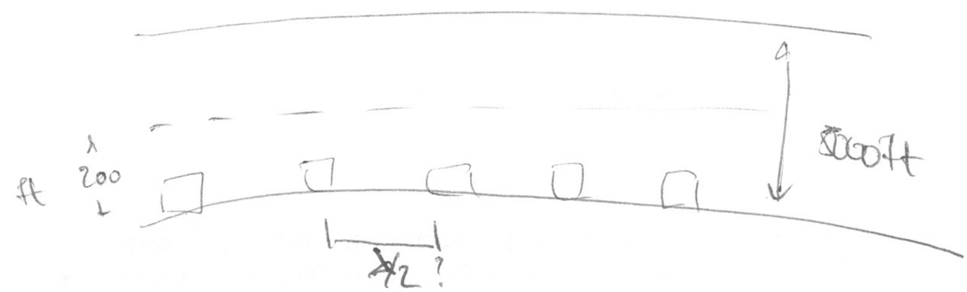
$D = 1000 ft = 3{,}048 \cdot 10^2$ m

$= \cancel{2E}\ 8.6 \cdot 10^5$ ft

1 ft = .304 m

1 m = 3,3 ft

3



$$R_{ff} \cong 8000\,ft = \frac{2D^2}{\lambda}$$

$$200\,ft = \frac{2D^2}{\lambda'}$$

$\div$ $\quad 25 = \frac{\lambda'}{\lambda}$

$\lambda' = 25\lambda$

guess $= 15\left(\frac{25}{2}\right) \cong 187$ nodes?

4 $\quad R_{ff} \cong 20{,}000\,ft \qquad ?$

$$\frac{2D^2}{\lambda}$$

5 $\quad R_{ff} = \dfrac{2(180\,ft)^2}{2\,ft} = \ldots$

didn't mult by 8!!

6 $\quad R_{ff} = \cancel{2(8)}^2 \qquad \dfrac{2(.0254)^2}{(.5\cdot 10^{-6})} = 2580\ m$

1 inch $= .0254$ m

$\downarrow$ mult by 64

$=$

102 mi