Problem(a) 2

$f = 5.75 \times 10^9;$
$\lambda = 3 \times 10^8 / f \rightarrow \lambda = 0.052\,m$

$Pfa = 10^{-10};\ Pd = 0.98;$
$prf = 1250;\ \omega rpm = 15;\ \theta B = 2.5°$

a)

raio da abertura / aperture radius

$$a = \frac{29.2\,°}{2.5\,°}\lambda \rightarrow 0.609$$

$$G = \left(\frac{2\pi a}{\lambda}\right)^2 \rightarrow 5386. \rightarrow 37.31\,dB$$

ka Sin(θ)=5.15 corresponde à localização do lobo secundário (consultar gráfico)
corresponds to the secondary lobe location (see plot)

$$\theta s = \text{ArcSin}\left(\frac{5.15}{2\pi a/\lambda}\right);\ \theta s/° \rightarrow 4.0°$$

b)

Estimativa do número de impulsos integrados/
Estimation of the number of integrated pulses

$$n = \frac{\theta B\,prf}{6\,\omega rpm} \rightarrow 34.7\ (\text{tome - se / take } 35)$$

Fator de melhoria e eficiência do integrador/ Improvement factor and efficiency

$$IdB(n) = 6.79\,(1 + 0.235\,Pd)\left(1 + \frac{\text{Log10}(1/Pfa)}{46.6}\right)\text{Log10}(n)\left(1 - 0.14\,\text{Log10}(n) + 0.0183\,(\text{Log10}(n))^2\right)$$

$IdB(n) \rightarrow 12.9$

em unidades lineares/ in linear units

$Ilin = 10^{IdB(n)/10} \rightarrow 19.7$

$Ei = Ilin/n \rightarrow 0.566$

SNR por impulso / SNR per pulse

$Pfa = 10^{-10};\ Pd = 0.98;$
$A = \text{Log}(0.62/Pfa);\ B = \text{Log}(Pd/(1 - Pd));$
$SNR1 = A + 0.12\,A\,B + 1.7\,B \rightarrow 39.69$

$SNR1dB = 10\ \text{Log10}(SNR1) \rightarrow 15.99$

Acresce 0.85 dB por se detetar um impulso retangular com um filtro retangular
0.85 dB should be added due the filter efficiency (rectangular pulse, rectangular filter)

$SNR1dB = SNR1dB + 0.85 \rightarrow 16.84$

$SNR1 = 10^{SNR1dB/10} \rightarrow 48.28$

Temperatura de ruído/ Noise equivalent temperature

$Ta = 350;\ Ti = 1500;\ Teq = Ta + Ti \rightarrow 1850$

Largura de banda/ bandwidth

$\tau = 1.5 \times 10^{-6};$
$\Delta f = 1.37/\tau$, Hz $\rightarrow 9.133 \times 10^5$

Potência de ruído/ Noise power

$Neq = 1.38 \times 10^{-23}\,Teq\,\Delta f \rightarrow 2.33 \times 10^{-14}$

$R = 75\,000\ m;\ \sigma = 10\ m^2;$

$Pt = \frac{(4\pi)^3\ Neq\ SNR1 \times R^4}{\lambda^2\ G^2\ \sigma\ n\ Ei}$ (* watts *) → 4550

c) primeiro há que encontrar a relação S/N de limiar, SNRT
First we should find the threshold value of SNR (SNR_T)

SNRT = -Log(Pfa) → 23.0

$PdSW3(SNR1, SNRT) = \left(1 + \frac{2\ SNR1\ SNRT}{(2 + SNR)^2}\right) e^{-\frac{2\ SNRT}{2+SNR}}$ → 0.752

Problem(a) 3

Dedução nos apontamentos/ See derivation in the course notes

$|\Delta/\Sigma| = \mathrm{Tan}(\varphi/2), \quad \varphi = \frac{2\pi d}{\lambda} \mathrm{Sin}(\Theta)$

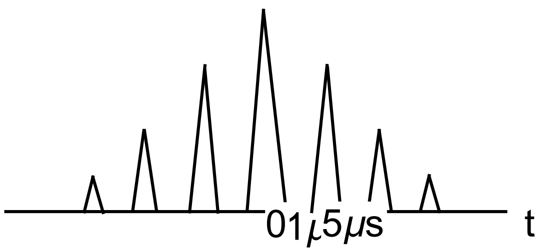
$\varphi = 2\ \mathrm{ArcTan}(1/10);\ \varphi deg = \varphi/° \rightarrow 11.4$

$f = 2.6 \times 10^9;\ \lambda = 3 \times 10^8 / f \rightarrow 0.115$

$d = \frac{\lambda\ \varphi}{2\pi\ \mathrm{Sin}(0.1°)} \rightarrow 2.097\ m$

Problem(a) 4
a)

$2\tau = 2\mu s,\ T_R = 5\ \mu s$



b)

$(2E/N0)_1 \rightarrow 501$

$(2E/N0)_{20} = 20 \times (2E/N0)_1$

Usar a expressão/ use the expression

$\delta f = \frac{\sqrt{3}}{\pi\ \tau \sqrt{20 \times (2E/N0)_1}} \rightarrow 550.7$

$freq = 12 \times 10^9;\ \lambda = 3. \times 10^8 / freq \rightarrow 0.025\ m$

$v = \delta f\ \lambda/2 \rightarrow 6.88$

$v_{km/h} = v\ 3.6 \rightarrow 24.8$

Um alvo com velocidade superior a 24.78 km/h origina um desvio Doppler superior ao valor da incerteza da medida. Logo, se o alvo tiver uma velocidade superior a esta é necessário efetuar a deteção com compensação do desvio no espectro.

Problema 5

$$\text{Sin}(\theta 1) - \text{Sin}(\theta 0) = \pm \frac{\lambda}{n\, d}$$

n = 30

$\theta 0 = 20\,°$; $d = 0.015\,\text{m}$; $\lambda = 0.05\,\text{m}$;

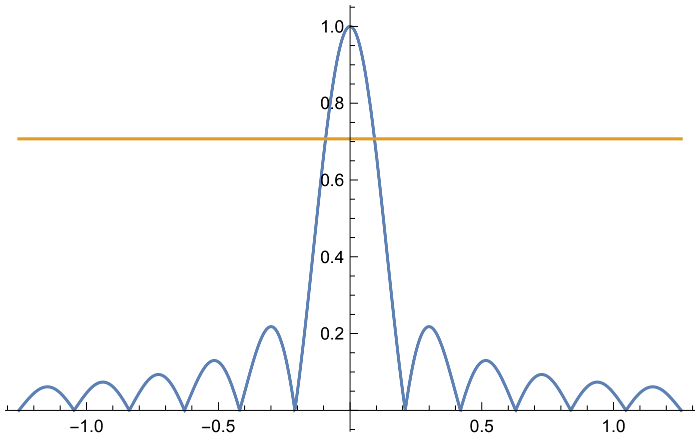
$$\phi = \frac{2\,\pi\, d}{\lambda}\,\text{Sin}(\theta 0);$$

$\phi\text{deg} = \phi / ° \rightarrow 36.9$

Note : (*FindRoot$\left[\frac{1}{n}\text{Abs}[\text{Sin}(n\ \psi/2)/(\text{Sin}(\psi/2))\right) == 1\big/\sqrt{2}, \{\psi, 1.391/n\}\big]$*)

$\{\psi \rightarrow 0.09282\}$

Note : Plot$\left[\left\{\frac{1}{n}\text{Abs}(\text{Sin}(n\,\psi/2)/(\text{Sin}(\psi/2))), 1\big/\sqrt{2}\right\}, \{\psi, -2\,\pi/5, 2\,\pi/5\}\right]$



$\psi 3\text{dB} = \frac{2.782}{n}$; $\psi 3\text{dB} / ° \rightarrow 5.31$

Direções de queda a -3dB/ HP directions

$$\theta 2 = \text{ArcSin}\left(\frac{\lambda}{2\,\pi\, d}(\phi + 2 \times 1.391 / n)\right) \rightarrow 23.0\,°$$

$$\theta 1 = \text{ArcSin}\left(\frac{\lambda}{2\,\pi\, d}(\phi - 2 \times 1.391 / n)\right) \rightarrow 17.03\,°$$

Largura de feixe a -3 dB/ HPBW

$\theta 2 - \theta 1 \rightarrow 6.0\,°$