1. (a)

Electrically   Electrically $\lambda/2$ λ
small   short

(b) R_r small < short < $\frac{\lambda}{2}$ < λ

(c) D small $\approx$ short < $\frac{\lambda}{2}$ < λ
           or <

(d) low radiation efficiency , narrow FBW

2. (a) large Z_{in} ($\approx 500\Omega$)   narrow FBW

(b)

← cavity

→ zero fields

(c)

zero fields

$Z_{in} = \frac{(\eta/4)^2}{300} \approx 120\Omega$

E plane   EF=1
x-y

H plane
y-z

EF $\propto \sin\theta$

3. a) AF

scan to 30°

$-kd - \pi$

$-kd$ $\psi = -2\pi$ $\psi = 0$ $kd - \pi$ $\psi = 2\pi$

$+kd$
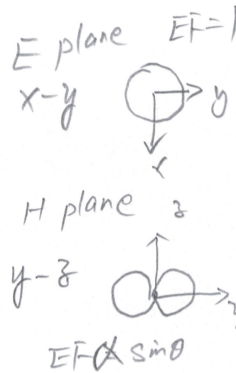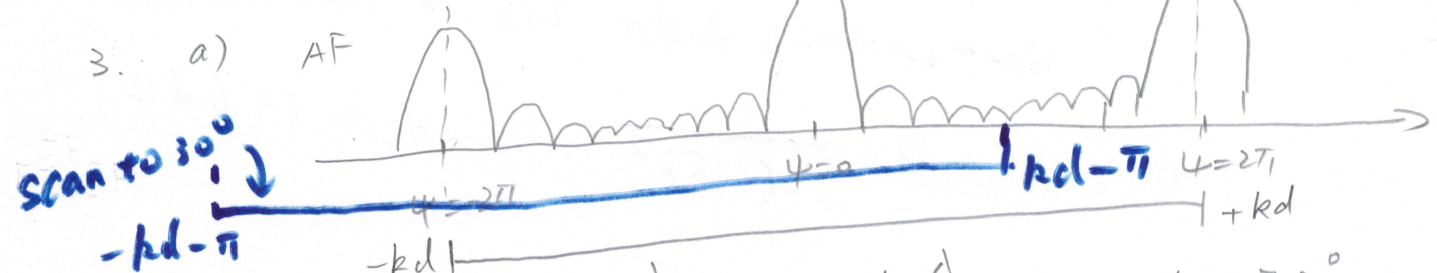
b) HPBW $\approx 0.886 \frac{\lambda}{Nd} \approx 0.886 \frac{\lambda}{7\lambda} = 0.1266 \approx 7.2°$
   $\rightarrow$ or 6

c) 1st SLL -13 dB
   2nd SLL $\approx \dfrac{\sin\frac{3\pi}{2}}{\frac{5\pi}{2}} \approx -17.9$ dB   (using sinc function)
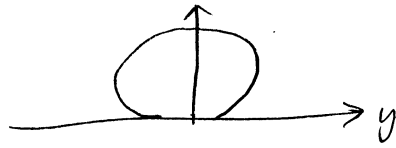
d) $D \approx \frac{2L}{\lambda} \approx 14$ (or 12)

e) $\psi = kd\sin\theta + \alpha$ $\alpha = -kd\sin 30° = -2\pi \sin 30° = -\pi$

   Grating   60° 30°   main
   Lobe   lobe

f)   o   o   o   o   o   o   o $\rightarrow$ y
    3π 2π π 0 $-\pi$ -2π -3π

g) HPBW $\approx \dfrac{7.2°}{\cos 30°} = 8.31°$ (Beam widening due to scanning)

h) $D \approx 14\cos 30° \approx 12$

i)   antennas EF with nulls @ $\theta = 0°$ and $180°$

For Example : patch

j) $d < \frac{\lambda}{2}$

k)   Uniform illumination. $D = \frac{4\pi A}{\lambda^2} \approx 4\pi \times 11^2$

        Boresight $\approx 1520 = 31.8 \, dB$

scan to $30°$

$$D = \underbrace{\pi \, Dx \, Dy}_{1520} \underbrace{\cos \theta_0}_{0.866} = 1316 \approx 31.2 \, dB$$

chebyshev

Beam Widening factor 1.15 in each plane

$$D = \frac{1520}{(1.15)^2} = 1150 = 30.6 \, dB$$