Homework 7

ECE 4370

Problem 1:

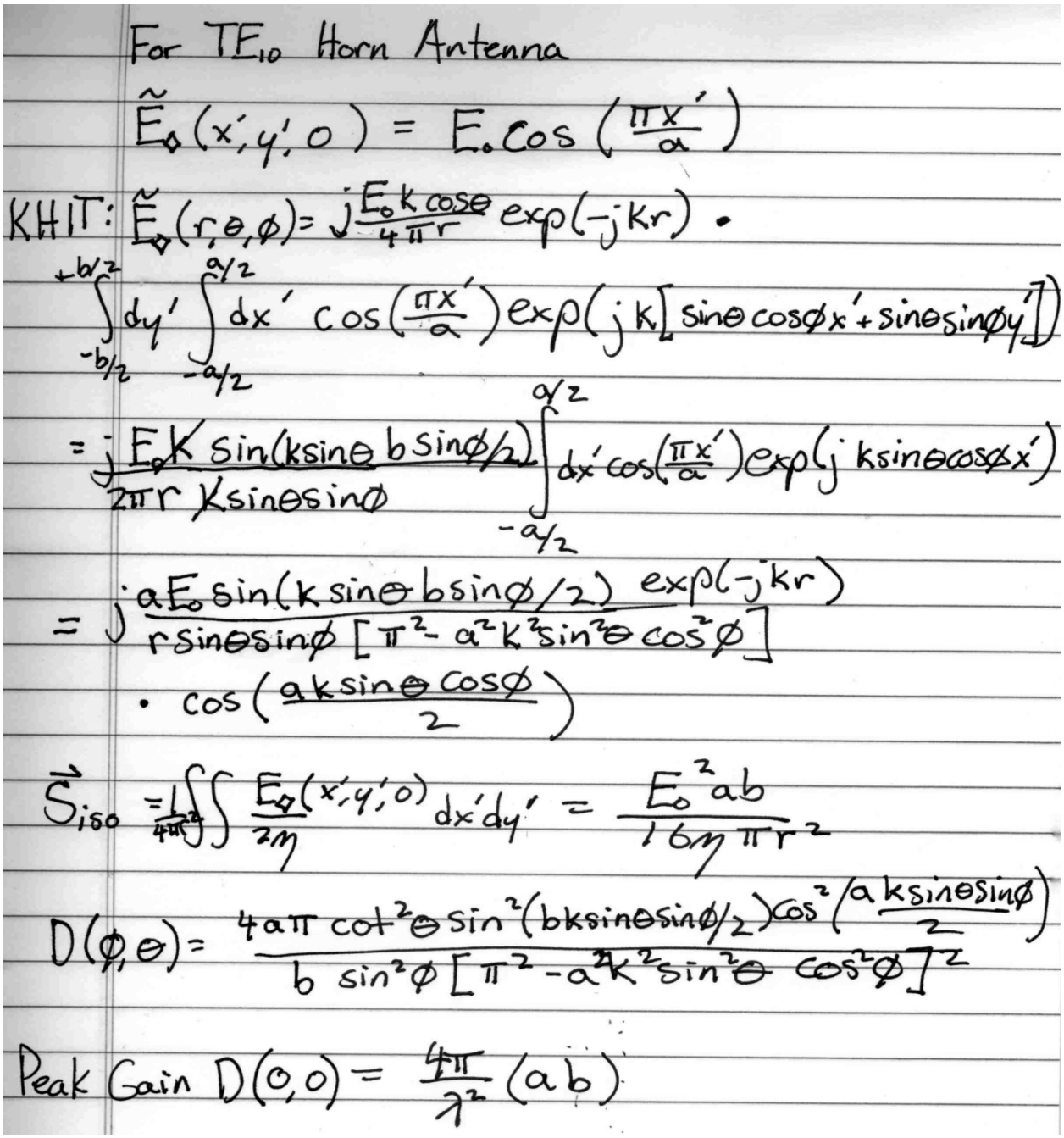
Assuming an ideal field distribution with uniform phase from the TE_{10} mode of a rectangular waveguide has been propagated to the aperture of a horn antenna with width A and height B, calculate the directivity pattern and ideal peak gain (assuming 100% radiation efficiency) in terms of A, B, and λ. (10 points)

Problem 2:

You must design a 4 GHz horn antenna with maximum peak gain, fed by a standard rectangular waveguide ($a = 2b = \lambda/2$). The maximum length of the flared horn antenna, R_p, must not exceed 50 cm. Provide an engineering diagram, fully dimensioned, for your company's metal shop to produce. (10 points)

Solution to Homework 7

Problem 1:



For TE_{10} Horn Antenna

$$\tilde{E}_\phi(x',y',0) = E_0 \cos\left(\frac{\pi x'}{a}\right)$$

KHIT:

$$\tilde{E}_\phi(r,\theta,\phi) = j\frac{E_0 k \cos\theta}{4\pi r}\exp(-jkr)\cdot \int_{-b/2}^{+b/2} dy' \int_{-a/2}^{a/2} dx' \cos\left(\frac{\pi x'}{a}\right)\exp\left(jk\left[\sin\theta\cos\phi x' + \sin\theta\sin\phi y'\right]\right)$$

$$= \frac{jE_0 k \sin(k\sin\theta\, b\sin\phi/2)}{2\pi r\, k\sin\theta\sin\phi}\int_{-a/2}^{a/2} dx' \cos\left(\frac{\pi x'}{a}\right)\exp(jk\sin\theta\cos\phi x')$$

$$= j\frac{aE_0 \sin(k\sin\theta\, b\sin\phi/2)\exp(-jkr)}{r\sin\theta\sin\phi\left[\pi^2 - a^2k^2\sin^2\theta\cos^2\phi\right]}\cdot\cos\left(\frac{ak\sin\theta\cos\phi}{2}\right)$$

$$\vec{S}_{iso} = \frac{1}{4\pi r^2}\iint \frac{E_\phi(x',y',0)}{2\eta}dx'dy' = \frac{E_0^2 ab}{16\eta\pi r^2}$$

$$D(\phi,\theta) = \frac{4a\pi\cot^2\theta\sin^2(bk\sin\theta\sin\phi/2)\cos^2\left(\frac{ak\sin\theta\sin\phi}{2}\right)}{b\sin^2\phi\left[\pi^2 - a^2k^2\sin^2\theta\cos^2\phi\right]^2}$$

Peak Gain $D(0,0) = \frac{4\pi}{\lambda^2}(ab)$

Problem 2:

Horn Antenna Calculator		
Frequency	4000	MHz
Wavelength	0.075	m
Waveguide Width, a	0.038	m
Waveguide Width, b	0.019	m
Flare Length, Rp	0.500	m
Aperture Width, A	0.340	m
Aperture Width, B	0.276	m
H-Taper Depth, RH	0.562	m
E-Taper Depth, RE	0.536	m
Ideal Peak Gain	23.2	dBi