Electrical Engineering 118
Spring 2001 Midterm 1 Solutions
Professor Gustafson

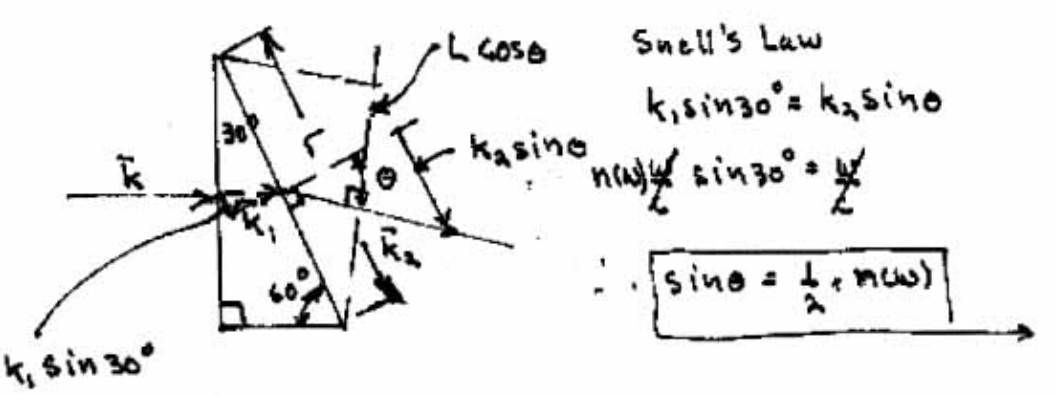
Problem #1 (30 points)

5pts a) k = w/c = (2*pi*f)/c

5pts b) k_1 = (w/c)*n = 2*pi*(f/c)*n with n evaluated at w

5pts c) k_2 = w/c

5pts d)



5pts e) 1/2 [n(w) + (dn/dw)*(delta w)] = sin(theta + delta theta) = sin(theta)*cos(delta theta) + cos(theta)*sin(delta theta) = sin(theta) + cos(theta)*(delta theta)

Therefore, 1/2 [dn/dw] * (delta w) = cos(theta)*(delta theta) and (delta theta)/(delta w) = 1/2*dn/dw*1/cos(theta) = 1/2*(dn/dw)*[1 - 1/4*n^2(w)]^-1/2

5pts f) Resolution. Diffraction angle in the direction theta is approximately equal to lambda/(L*cos(theta)). To resolve two frequencies, must be separated by they diffraction angle.

delta w = 2*(delta theta)/(dM/dw)*cos(theta) = (lambda/L)*2/(dn/dw)*(4*pi*c)/(w*dn/dw)*(1/L).

5pts g) w*dn/dw = 0.007 * (625/50) = 0.0875

Therefore, 10^11 = (2*3*10^10)/0.0875*(1/L) so L = 6.869

Problem #2 (30 points)

6pts a) Id_1 = P_1*e^-(aL)*ne/(hbar*w), Id_2 = P_2e^(-aL)*ne/(h*w)

6pts b) Id_1 = (I1 - Ith)*n_i*dm/(a_i + a)*n*e^(-aL), Id_2 = (I2 - Ith)*n_i*dm/(a_i + a)*n*e^(-aL)

7pts c) i_NT^2 = 4kT/R*(delta f), K^2 = (I1 - I2)^2/(4kT*(delta f)/R)*[(n_i*n*dm)/(a_i + a)*e^(-aL)]^2

11pts d) Thermal noise i_NT^2 = 4kT/R*(delta f), Shot noise = 2*e*n*P_2*e^(-aL)*n*e/(hbar*w)*M^2*F.

Equate these and solve for M.

Problem #3 (10 points)

Sampling rate = 2*(delta f) = 100E6 Hz. 10 bits/sample ==> Bit rate = 1GBit/sec.

Bit Rate = 2*(delta f)*ln_2(M)
1E9 = 1E8 * ln_2(M)
ln_2(M) = 10 ==> M = 2^10 = 1028
M = (1 + S/N)^(1/2) ==> S/N = 2^20

10*log(S/N) = 20*log(1028) = 60dB

Often change Eq(1) to base 10.

Bit Rate = 2*(delta f)*[log(1 + S/N)]^(1/2)*log10 = 2*(delta f)*[log(1 + S/N)]^(1/2)*3.32 = 3.32/10*(delta f)*10*log(1 + S/N)

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