PHYS 408 2010/11 term1

Homework problem set #3 problems 1-4
Assigned: 24/09/2010
Written Solution due 01/10/20105 PM in Hennings 328
If you collaborated with anyone, please write their name at the top of your HW

Problem 1 (20 marks) (This isn't a typo)

Look at the homework solutions I posted for the previous homework (HW#2 in this case) and pick a problem that you may have gotten wrong. Describe in words what you may have done wrong and what your misconceptions were. And explain what you didn't understand and what techniques you needed to know in order to solve the problem. Explain in words what you have learned from this.

If you feel you solved all of the problems correctly, then pick a problem and try to find and explain three misconceptions that might lead a person to answer wrongly. To be an expert, you must learn to identify the possible conceptual difficulties that a person may have in order to communicate with them effectively

Problem 2 (25 marks)

a) Using the appropriate approximations covered in class and in the text derive the paraxial wave equation 2.2-23 from the scalar wave equation 2.2-7. Remember to justify each approximation and/or give its range of validity. Make sure to relate any approximations to the properties of the wave. Also remember as U(r) and A(r) are complex quantities you need to be carefully when looking at limits. In other words you need to show the approximations in this transformation in terms of PHYSICS of the wave. Remember U and A are complex. *Hint: Fig 2-2.5 will be very helpful*

$$\nabla^2 U + \frac{\omega^2}{c^2} U = 0 \quad \Rightarrow \quad \nabla_T^2 A + i2k\frac{\partial}{\partial z} A = 0$$

b) Show that the Fresnel approximation of a Spherical Wave satisfies the paraxial wave equation you derived in part a) What is the significance of this result?

c) Now show if you shift the Fresnel approximated wave by constant amount in z, it is still a solution. We will use this fact shortly

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Problem 3 (25 marks)

We will be using the concept of transmittance (Chapter 2.4 of book) to keep track of the transverse (ie x and y) phase or wavefronts of waves. Consider an incoming plane wave at angle θ that goes through a rectangular piece of glass. (see figure below)

a) Show that the transmittance is of a rectangular piece of glass in this case is: $t(x,y) = e^{ink_o dcos\theta_1}$

b) Your good friend Billy-Bob says…"that doesn't make sense: how can the transmittance be independent of x and y?" Using the figure below, prove to Billy-Bob at some fixed x and y as the wave goes through a distance of $\Delta z = d_o$ the phase change will always be given by the transmittance given above that doesn't depend on x or y.

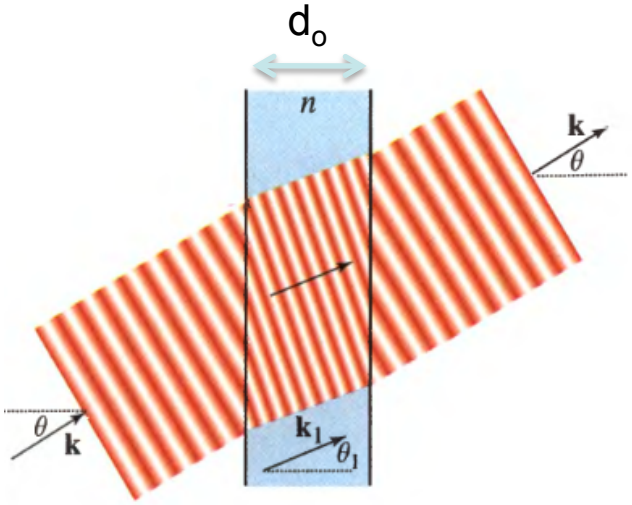


Image from B. Saleh and M Teich, *Fundamentals of Photonics*, 2nd Edition. (2007) Wiley and Sons

c) Under some approximations, the transmittance can be approximated as

$$t(x,y) = e^{i(nk_o d_o cos\theta_1)} \approx e^{ink_o d_o}$$

what are the approximation(s) you need to make in order for this result? Again give a mathematical description and a few sentences relating these expressions/limits to the physics.

Problem 4 (30 marks)

Exercise 2.4-1 in text. You must give justifcations for EACH approximation you might use.