Poon's Textbook Summaries

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1 Chapter 1: Wave optics

1.1 Maxwell's equations and the wave equation

Here are the Maxwell's equations:

$$\nabla \cdot D = \rho_v$$

$$\nabla \cdot B = 0$$

$$\nabla \times E = -\frac{\partial B}{\partial t}$$

$$\nabla \times H = J = J_c + \frac{\partial D}{\partial t}$$

E is the electric field strength in (V/m), D is the electric flux density (C/m^2), H is the magnetic field strength (A/m), and B is the magnetic flux density (Wb/m^2). J_c is the current dnesity (A/m^2), and ρ_v is the electric charge density (C/m^3). The D and E, B and H are related in the following fashion.

$$D = \epsilon E$$

$$B = \mu H$$

ϵ is the permittivity of the medium (F/m), and μ is the permeability of the medium (H/m). In linear, homogeneous, isotropic medium, ϵ and μ are scalar constants. Based on these equations, we can derive the three-dimensional scalar wave equation in a source-free medium.

$$\nabla^2 \Psi \ = \frac{1}{v^2}\frac{\partial^2 \psi}{\partial t^2}$$

1.2 Plane waves and spherical waves

The plane wave solution of a simple harmonic oscillation at angular frequency w_0 (radian/second) is:

$$\psi(x,y,z,t) = A \exp[j(w_o t - k_0 \cdot R)]$$

where $j = \sqrt{-1}$, k_0 is the propagation vector, and R is the position vector. Magnitude of k_0 is the wave number, A is the amplitude of the plane wave. If wave is travelling along positive z-direction, this equation becomes:

$$\psi(z,t) = A \exp[j(w_0 t - k_0 z)$$

which is a solution to the wave equation

$$\frac{\partial^2 \psi}{\partial z^2} = \frac{1}{v^2}\frac{\partial^2 \psi}{\partial t^2}$$

The spherical wave solution of the same oscillation is:

$$\frac{\partial^2 (R\psi)}{\partial R^2} = \frac{1}{v^2}\frac{\partial^2 (R\psi)}{\partial t^2}$$

$$\psi(R,t) = \frac{A}{R}\exp[j(w_0 t - k_0 R)]$$

1.3 Scalar diffraction theory

2 Chapter 2

The intensity I(x,y) is proportional to the complex amplitude squared: I(x,y) = $|\psi|$