Electromagnetic Waves & Optics: Lecture Notes

Notes from some random guy named Jacob that texts Lowa
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(pg 1) Preface.

The objective of the course is to provide an account of the study of optics taking up the subject from where the study of electric and magnetic fields finished with the elucidation of the Maxwell equations and developing these into a wave description of light. Some basics of the properties of electromagnetic waves will be studied allowing an exploration of physical optics.

As with any subject, it is necessary to begin by developing a language with which to discuss the subject matter. In this case it is electromagnetic waves that are the subject of interest and electromagnetic waves have several properties of interest in common with other waves; sound, water, quantum mechanical etc. For the purposes of this study these include at the top of the list the wave amplitude and phase.

The module outline eschews traditional development of the subject by beginning with physical optics before going on to geometric optics in keeping with its emphasis on the electromagnetic wave nature of light. The development of the module will proceed as follows;

- i) The module begins by exploring the meaning of the amplitude of the EM wave, in terms of the electric field (and in terms of the accompanying magnetic field) and its relationship to the intensity (power per unit area) carried by that wave. This will enable the development of an understanding of how transmission and reflection at a dielectric interface may be described and evaluated.
- ii) The module will then focus on the phase of the wave and how this is to be used in circumstances (the most general ones) where the overall optical effect is produced by a superposition of many waves; specifically in interference and diffraction effects.
- iii) Geometric optics will then, ignoring the wave properties of the light, provide an understanding of simple optical components and the use of such components in some common optical instruments.
- iv) The course will end by exploring some of the quantum aspects of light and in particular a simple description of the interaction of light with matter by describing that interaction in terms of a basic two (quantum) level system.

(pg 2) Maxwells Equations & the Wave Equation (draft)

Maxwell’s equations in free space.

The starting point of this course is where the first year electromagnetism course ended, namely with the four Maxwell’s equations and the electromagnetic wave equation. A review of these equations is therefore a good place to start.

Beginning with the simplest situation of Maxwell’s equations in vacuum (no charges or currents). There are a set of four equations, established by Maxwell, that relate the magnetic fields and the electric fields. These equations may be written in differential form as:

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