

Chapter 1

SIMG-303 – OPTICS for IMAGING

1.1 INTRODUCTION

The science of optics is often divided into three fields:

I. **Physical Optics** (microscopic scale)

considers light (electromagnetic radiation) to be a *WAVE*;

the action of light is described by *Maxwell's equations*;

light has a wavelength λ , frequency ν , velocity c ;

leads to explanations of *reflection, refraction, diffraction, interference, polarization, dispersion*.

II. **Geometrical Optics** (macroscopic scale)

considers light to be a *RAY*, *i.e.*, $\lambda \rightarrow 0, \nu \rightarrow \infty$;

explains *reflection* and *refraction*

useful for designing imaging systems.

III. **Quantum Optics** (atomic scale)

light is a *photon*, has both wave-like and particle-like characteristics;

used to analyze the interaction of light and matter on a sub-microscopic level;

explains the photoelectric effect, lasers.

Referenced Sources: Optics Texts:

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[JW] F. Jenkins and H. White, *Fundamentals of Optics*, 4th Edition, McGraw-Hill, 1976.

[NP] A. Nussbaum and R. Phillips, *Contemporary Optics for Scientists and Engineers*, Prentice-Hall, 1976.

[I] K. Iizuka, *Engineering Optics*, Springer-Verlag, 1985.

[FBS] D. Falk, D. Brill, and D. Stork, *Seeing the Light*, Harper and Row, 1986.

Physics Texts:

[HR] D. Halliday and R. Resnick, *Physics*, 3rd Edition, Wiley, 1978.

[C] F. Crawford, *Waves*, Berkeley Physics Series Vol. III, McGraw-Hill, 1968.

1.2 Optics Course Outline

1. Nature of Light

(a) Oscillations

- (b) Superposition of oscillations
 - (c) Traveling waves
 - (d) Doppler effect for waves in a medium (“acoustic” waves)
 - (e) Electromagnetic Waves
 - i. vector calculus
 - ii. Maxwell’s Equations
 - iii. Plane-wave solution to Maxwell’s equations
 - (f) Wave polarization
 - (g) Birefringence
2. Imaging in the Ray Model
- (a) Fermat’s principle
 - (b) Snell’s Law for reflection and refraction
 - (c) Refraction from a single spherical surface, paraxial approximation
 - (d) Thin lens equation
 - (e) multiple thin lenses
 - (f) thick lenses
 - (g) pupils and stops
3. Imaging in the Wave Model
- (a) Interference and interferometers
 - (b) Diffraction
 - (c) Huygens’ principle, propagation of light in the wave model
 - (d) Diffraction limit