

Main textbook

**(# 1) E. Hecht      Optics, 4 ed.**

Recommended  
**IO 2651, IO 2691**

**(# 2) Saleh, Teich      Fundamentals of Photonics**

Lecture notes,  
#1: 13.2.1-13.2.3  
#2: 4.1-4.2; 4.5  
#1: 8.11  
#2: 20.1  
Lab manual

Introduction into lab experiments;  
Basics of Fourier-optics, fiber and nonlinear optics

Demo lab, femto-second and near-field optics

#1: 1; 3.1 – 3.4  
#2: 2.1 – 2.2

Historical survey, EM wave theory – I  
Wave motion  
Maxwell equations, wave equation, Helmholtz equation  
Euler formula and wave in exponential form  
Plane, spherical, cylindrical waves  
Electric vs magnetic components of the EM field  
Irradiance, Poynting vector, EM energy density and flux  
Photons, photon pressure

#1: 3.5 – 3.6; 4.3 – 4.5; 4.8  
#2: 5.1 – 5.5

EM wave theory – II  
Harmonic oscillator; forced, damped/nondamped oscillator  
Dipole irradiation; propagation, reflection, refraction  
Phase relations to build up the transmitted (refracted) light  
Dispersion, normal vs anomalous

#1: 3.5  
#2: 5.5

Refractive index and permittivity  
Real and imaginary parts of the dispersion  
Plasma frequency

#1: 4.6  
#2: 6.1 – 6.2

**Reflection, refraction, transmission**  
Fresnel coefficients for the amplitude and phase  
Brewster angle  
Snell's law  
Reflectance/transmittance (intensity), evanescent waves  
Fermat principle

#1: 3.5  
#1: 7.1.1 – 7.1.3, 7.2

**Principle of superposition, group and phase velocity**  
Superposition, linearity, polarization  
Phasors  
Beating, phase delay, optical path difference  
Optical pulses, spectral components  
Group velocity, speed of monochromatic wave,  
speed of optical pulse  
Normal and anomalous dispersion, relation to the speed of  
light, pulse spreading

#1: 7.3, 7.4.1, 7.4.4  
#1: 11.1 – 11.2

### **Fourier transforms in optics**

Time-domain versus space-domain  
Short pulse decomposition  
Even / odd function representation  
Discrete and continuous Fourier spectra, signal periodicity  
Amplitude coefficients, information about the phase  
Frequency bandwidth and the spectrum  
2D Fourier transform  
Examples: square pulse, triangle function, exp

#1: 9.1 – 9.4, 9.6 – 9.9

### **Interference, interferometers, thin films**

Young's two-slit experiment  
Allocation of the intensity fringes, Newton's rings  
Interferometers: Michelson (including "unbalanced"),  
Mach-Zehnder, Sagnac, laser giro, multi-path interference,  
Fabri-Perot etalon and its parameters: free-spectral range,  
linewidth, finesse  
Wavelength measurement with the etalon  
Multi-layer coatings, 1D photonic crystal  
Twyman-Green interferometer

#1: 10.1 – 10.2, 10.3.1,  
10.3.5, 10.3.8, 10.4, 10.5

### **Diffraction theory: Fresnel and Fraunhofer**

Deviation from rectilinear propagation  
Diffraction at the screen edge  
Rigorous Kirchhoff's scalar theory  
Green functions in Helmholtz equation  
Fresnel-Kirchhoff formula  
Diffraction in near and far field: Fresnel, Fraunhofer  
One-, two- and multi-slit diffraction  
Diffraction on circular and square aperture  
Relation to Fourier transform  
Rayleigh resolution  
Diffractive grating, the grating formula  
Dispersion and resolution, resolution and dispersion power

#1: 8.1 – 8.9, 8.13

### **Polarization of light**

Linear, circular, elliptical polarization  
Malus's law  
Polarization states, degree of polarization  
Mueller matrix, Jones vectors, Stokes vectors  
Birefringence, crystal optics, uni-axial crystals  
Polarizers, retarders, wave plates, prisms  
How to create polarized light

#1: 8.10 – 8.12

Nonlinear optical effects, optical activity  
Magneto-optics, electro-optics, liquid crystals  
Kerr effect, Pockels effect, Faraday effect

#1: 12.1 – 12.3

### **Coherence, spatial and temporal**

Coherence and spectral width  
Van Cittert-Zernike theorem  
Stellar interferometer

#1: 13.1.2 – 13.1.3  
Lecture notes

**Laser, resonators, modes**

Excited states, spontaneous and stimulated emission  
Einstein coefficients, inversion, rate equations  
2-, 3-, 4-level systems  
Absorption and emission spectrum  
Gain and amplification  
Resonators, stability  
Modes: longitudinal and transversal, mode frequency  
Mode locking, Q-switching, Q-factor  
Laser beam, Gaussian beam  
Microcavities and microlasers  
Types of lasers

#1: 5.1 – 5.2, 5.4 – 5.6

Gaussian optics, thin lenses, mirrors, prism  
Waveguides, fiber optics and applications

**IO 2651, IO 2692**

Linear systems, spectra, transfer functions

Optical imagery, spatial filtering, imaging of phase objects

Radiation, radiometry & photometry

Stops and pupils, reflecting prisms, eyes

Optical systems, wavefront shaping, cardinal points

Ray tracing, matrix method;

Optical aberrations, chromatic aberrations