

Optics and Refraction

Objectives

Understanding the eye as a dioptric device and related basic scientific knowledge.

Understanding the eye as a paired organ.

Understanding patient-related changes in refraction and symptoms of this.

Knowledge of the options for correcting optical problems in the ophthalmology clinic.

Correction of binocular disorders and the use of prisms.

Correction of optical disorders by the ophthalmologist without the assistance of orthoptists/optometrists.

Knowledge to be gained - Basics of:

- a) Physical optics
- b) Physiological optics
- c) Measurement of spectacle lenses: objective, subjective
- d) Spectacle optics
- e) Low-vision optical devices
- f) Contact lenses.

a). Physical optics

- Describe the waveform and the particle nature of light.
- Explain the phenomenon of diffraction.
- Explain the concepts of interference and coherence.
- Define optical resolution.
- Explain polarisation.
- Explain light scattering.
- Define and compare transmission and absorption.
- Explain photometry.
- Define illumination.
- Describe image quality.
- Differentiate brightness and radiance.
- Define refractive index.

b) Geometric optics

- Basics of optical images.
 - Law of reflection, law of refraction, prism, refractive index.
 - Spherical surface optics.
 - Convex, concave and cylindrical lenses.
 - Lens distortion.
- **Optical wavelength**
- Electromagnetic irradiation, interference, refraction, hologram, polarisation.

- Lighting technique
 - Basics of photometrics (Lumen, Candela, cd/m², asb, Lux)
 - light sources (daylight, bulb, neon lighting, laser), spectral composition

- Reflection (Mirrors)
 - List the laws of reflection.
 - Explain images and objects as light sources.
 - Define refractive index.

- Refraction
 - Explain the law of refraction (Snell's law), including:
 - Passage of light from one medium to another.
 - Absolute index of refraction.
 - Total internal reflection.
 - Explain critical angle and total internal reflection.

- Prisms
 - Define a prism.
 - Explain the notation of prisms (eg, prism dioptres).
 - Describe the use of prisms in ophthalmology (i.e., diagnostic and therapeutic).
 - Explain Prentice's rule.
 - Describe Fresnel and similar prisms.
 - Explain the concept of thin prisms.
 - Explain the prismatic effect of lenses.
 - Define spherical decentration and prism power.

c) Spectacle lenses

Spherical Lenses

- Define a spherical lens.
- Describe the cardinal points.
- Describe the thin and thick lens formulas.
- Define vergence of light, including dioptre, convergence, divergence and vergence formula.
- Define the terms concave and convex.
- Define the term magnification, including linear, angular, relative size and electronic.

Astigmatic Lenses

- Describe cylindrical lenses, including:
- Spherocylinder lenses and surfaces
- Cross cylinders (eg, Jackson cross cylinder)
- Describe toric lenses.

d) Basics of physiological optics

- Emmetropic eye.
- Gullstrand schematic eye.
- Refraction problems (myopia, hypermetropia, astigmatism aphakia, pseudophakia).
- Accommodation.
- Amplitude of accommodation and fusion, AC/A quotient, accommodation diagram, vergence.
- Visual acuity Presbyopia.
 - (Snellen, Landolt's ring)
 - Visual function (quality of vision, MFF, aberrometry, glare)

Visual field

Lens centring

Lens measurement (glasses)

- **Objective refraction**
 - Retinoscopy
 - Refractometer (including automatic)
 - Ophthalmometer
- **Subjective refraction**
 - Dependence of visual acuity on ametropia (spherical and astigmatic).
 - Spherical refraction (optimum spherical lens, fog method, Donders' method, red-green comparison, precision synchronisation).
 - Astigmatic refraction with cross-cylinder.
 - Binocular synchronisation (test lens or phoropter).
 - Exclusion or consideration of major heterophoria (see section 3.2.2).
 - Measurement of near-vision glasses (progressive additional lens, astigmatism additional lens).
 - Transposition of refraction results to glasses data.
 - Ergo-ophthalmology: type of glasses according to vision requirements (which glasses for which profession, for what type of job?).
- **Cycloplegic refraction**
 - Describe medication concentrations according to age (eg, cyclopentolate, atropine).

Spectacle optics

- Advantages and disadvantages of monofocal, bifocal and trifocal lenses.
- Centration of spectacle lenses.
- Special lenses including aspherical lenses, high refractive index lenses, filter, tinted and anti-reflective lenses.

e) Magnifying devices

- Refraction characteristics in the near-sighted and far-sighted.
- Non-magnifying aids.
- Ranges of magnifying aids.
- Advice to the visually impaired: knowledge of institutions and potential financial support.

f) Contact lenses

- Contact lenses (CL)
 - CL indications and contra-indications.
 - Optical component of CL adjustment, on refraction, the tear film.
 - Physiological change and adjustment of the eye to CL.
 - Knowledge of materials, the advantages and disadvantages.
 - Care of CL.
 - Theoretical cosmetic adjustment of CL and in a limited/practical context.
 - CL check, assessment of adjustment, screening for complications and treatment thereof.
 - Therapeutic CL: in-depth knowledge and correct, independent adjustment.

Clinical knowledge of ancillary testing:

A. Clinical Refraction

- Objective Refraction: Retinoscopy

List the principles and indications for retinoscopy.

- Subjective Refraction Techniques

Describe the major types of refractive errors.

Describe the indications for and use of trial lenses for simple refractive error.

- Cycloplegic Refraction

Describe medication concentrations according to age (eg, cyclopentolate, atropine).

B. Instruments and tests

- Direct ophthalmoscope
- Indirect ophthalmoscope.
- Retinoscope
- Glare and contrast sensitivity testing.
- Automated refractor.
- Higher-order aberrations.
- Stereoacuity testing.
- Corneal topography (eg, placido disc, keratometer, automated corneal topography).
- Hess screen.

- Synoptophore.
- Colour vision tests (eg, Ishihara colour plates; Hardy-Rand-Rittler test, Farnsworth-Munsell test).

C Abberometry

- Explain the principles underlying Hartmann-Shack aberrometers.
- Describe the concept of Zernike polynomials.

D Diagnostic equipment

- List indications for and the use of intraocular lens (IOL) calculation algorithms.
- List indications for the use of corneal pachymetry
- List indications for the use of specular microscopy.
- List indications for the use of corneal tomography with anterior segment optical coherence tomography (OCT).
- List indications for the use of topographic/elevation corneal evaluation (i.e., Pentacam, Orbscan II, Galilei).
- List indications for the use of accommodometer.
- List indications for the use of laser interferometry for macular testing.

Clinical knowledge of diagnosis and pathology

Clinical Optics

- Define emmetropia.
- Define ametropia.
- Define myopia.
- Define hypermetropia (hyperopia).
- Define astigmatism.
- Define anisometropia.
- Define aniseikonia (including Knapp rule).
- Define aphakia.
- Explain optical parameters affecting retinal image size.
- Pupillary response and its effect on the resolution of the optical system (Stiles-Crawford effect).
- Define visual acuity, including:
 - a. Distance and near acuity measurement
 - b. Minimal acuity (i.e., visible, perceptible, separable, legible)
 - c. Visual acuity charts
- Describe higher-order aberrations of the eye.
- Explain how accommodation is affected by age.
- Explain how the pinhole effect impacts visual acuity.
- Explain accommodative problems.
- Describe convergence or accommodative insufficiency or excess.
- Define accommodative-convergence over accommodation (AC/A) ratio.
- Describe the epidemiology of refractive errors, including:

- a. Prevalence
- b. Inheritance
- c. Changes with age

Clinical knowledge of treatment

Optics

Spectacles

- a. Describe the index of the materials
- b. Describe the principles underlying progressive spectacle lens design.
- c. Describe progressive lenses measurements.
- d. Describe spectacles prescribing in children.

Lasers

- a. Describe the technology behind the excimer laser and the femtosecond laser.
- b. List different wavelengths used in ophthalmic lasers.
- c. Describe indications for refractive surgery.

Surgical considerations

- Potential problems with aphakic spectacles.
- Effect of spectacles and contact lens correction on accommodation and convergence (i.e., amplitude, near point, far point).
- Explain the principles of contrast sensitivity measurements.
- Describe the correction of ametropia, including:
 - a. General principles
 - b. Spectacle lenses
 - c. Contact lenses
 - d. Intraocular lenses
 - e. Principles of refractive surgery