Al-Furat Al-Awsat Technical University | Najaf Technical Institute Department of Optics Technology

Physical & Clinical Optics Module

Refractive Errors & Lens Power

Complete 30-lecture curriculum covering optical lens physics, ocular accommodation, refractive anomalies, retinoscopy techniques, visual acuity, and color vision optics.

Lecturer
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Academic Level
First Stage — 30 Lecture Series

Physical Principles

Lens Power Equation

Refractive Power

Bending capacity of an optical surface measured in Diopters.

$$P = 1 / f$$

P = Power (Diopters, D), f = Focal Length (Meters, m)

Sign Conventions

Convex Lenses (+): Converging rays with real focal points.

Concave Lenses (-): Diverging rays with virtual focal points.

Ophthalmic Optics

Compound Lens Combination

Thick vs Thin Contact

Thin lenses placed in direct contact sum additively without vertex axial separation gap.

Linear Power Summation Formula

$$P_{total} = P_1 + P_2 + P_3$$

Combining +2.00 D with +3.00 D produces +5.00 D net optical focal power.

Clinical Optics Mechanics

Transposition of Sphero-Cylindrical Lenses

Step 1

New Sphere Power

Sum sphere and cylinder algebraic values.

Step 2

Cylinder Sign Flip

Reverse algebraic cylinder sign value (+ to -).

Step 3

Axis Meridian Rotation

Rotate cylinder axis meridian by exactly 90 degrees.

Ocular Physiology

Accommodation Mechanism of the Eye

+4 D

Dynamic Focus Range

Crystalline lens curvature increases for near objects.

Ciliary Muscle Action

Ciliary Contraction: Relaxes zonular fibers for increased lens convexity.

Ciliary Relaxation: Tightens zonular fibers for flattened distance focus.

Accommodative Optics

Amplitude of Accommodation

$$A = P_{near} - P_{far}$$

Maximum dioptric change between far point and near point.

Hofstetter's Formula (Expected Min)

$$15 - (0.25 \times \text{Age})$$

Predicts age-related loss of accommodation capacity.

Age-Related Refractive Changes

Presbyopia Pathophysiology & Correction

Physiological Etiology

Loss of lens capsule elasticity and ciliary muscle tone beyond age 40.

Optical Near Addition

Plus spherical lenses (+1.00 D to +2.50 D) substitute lost accommodation.

Lens Prescriptions

Bifocal, trifocal, and progressive addition lenses (PALs).

Refractive Classification

Emmetropia vs Ametropia

Emmetropia (Normal)

Parallel light rays focus directly on the retina with relaxed accommodation.

Ametropia (Refractive Error)

Parallel light rays fail to focus on the retina (Myopia, Hyperopia, Astigmatism).

Refractive Anomalies

Myopia (Nearsightedness)

Optical Mechanism

Focus Point: Image forms in front of the retina.

Axial Cause: Eyeball length excessively long.

Refractive Cause: Excess corneal or crystalline focal power.



Concave (- Minus) Correction

Diverging lenses push the focal point backward onto the retina.

Refractive Anomalies

Hyperopia (Farsightedness)

Optical Mechanism

Focus Point: Image forms behind the retina.

Axial Cause: Eyeball length too short.

Refractive Cause: Insufficient optical converging power.



Convex (+ Plus) Correction

Converging lenses pull the focal point forward onto the retina.

Aspheric Optics

Astigmatism Classification

With-The-Rule

Vertical corneal meridian steepest (90° ± 30°).

Against-The-Rule

Horizontal corneal meridian steepest (180° ± 30°).

Oblique Astigmatism

Principal meridians lie at 45° and 135° axes.

Ophthalmic Diagnostics

Retinoscopy Clinical Overview

Objective Refraction

Requires zero subjective verbal feedback from the patient.

Non-Verbal Application

Essential for infants, young children, and uncooperative subjects.

Media Integrity Check

Detects corneal scars, lens cataracts, and vitreous opacities.



Instrument Design

Retinoscope Components & Mechanics

Light Source & Condenser

Halogen bulb with condensing lens focusing light toward mirror.

Reflecting Mirror

Projects light beam along observer's line of sight into pupil.

Focusing Sleeve

Sliding sleeve switches between plane mirror and concave mirror modes.

Clinical Instrumentation

Streak vs Spot Retinoscopy

Streak Retinoscopy (Standard)

- Linear beam rotated 360 degrees.
- Precise astigmatic axis determination.
- Gold standard in modern clinical practice.

Spot Retinoscopy

- Circular light patch illumination.
- Less precise for cylinder axis refinement.
- Mostly superseded by streak instruments.

Examination Principles

Red Reflex Movement Patterns

With Motion

Reflex Moves Same Direction

Indicates Hyperopia, Emmetropia, or Myopia < Working Distance. Add + Plus Lenses.

Against Motion

Reflex Moves Opposite Direction

Indicates Myopia > Working Distance. Add - Minus Lenses to neutralize.

Neutrality Point

Pupil Fills Completely

Streak motion disappears and pupil illuminates uniformly.

Retinoscopy Technique

Characteristics of Neutrality

Maximum Speed

Reflex movement becomes infinitely fast across pupil.

Maximum Width

Reflex streak widens to fill entire pupil diameter.

Maximum Brightness

Reflex intensity reaches peak brightness at endpoint.

Clinical Practice Rules

Working Distance Allowance

1.00 m

1 Meter Distance

Deduct 1.00 D from gross neutral power.

0.67 m

67 cm Distance (Arm's Length)

Deduct 1.50 D from gross neutral power.

0.50 m

50 cm Distance

Deduct 2.00 D from gross neutral power.

Diagnostic Procedures

Static vs Dynamic Retinoscopy

Static Retinoscopy

- Patient fixates distant non-accommodative target (6m).
- Accommodation fully relaxed.
- Measures total distance refractive error.

Dynamic Retinoscopy

- Patient fixates near target on retinoscope.
- Accommodation actively engaged.
- Evaluates accommodative lag and response.

Pharmacological Refraction

Cycloplegic Refraction

Clinical Indications

Pediatric patients, accommodative esotropia, and pseudomyopia.

Common Cycloplegics

Cyclopentolate 1%, Atropine 1%, and Tropicamide 1%.

Mechanism of Action

Blocks muscarinic receptors, paralyzing ciliary muscle accommodation.

Visual Function Testing

Visual Acuity & Resolution

Clinical Definition

Spatial resolving capacity to distinguish two separate points.

Minimum Angle of Resolution (MAR)

Standard eye resolves details subtending 1 minute of arc (1').

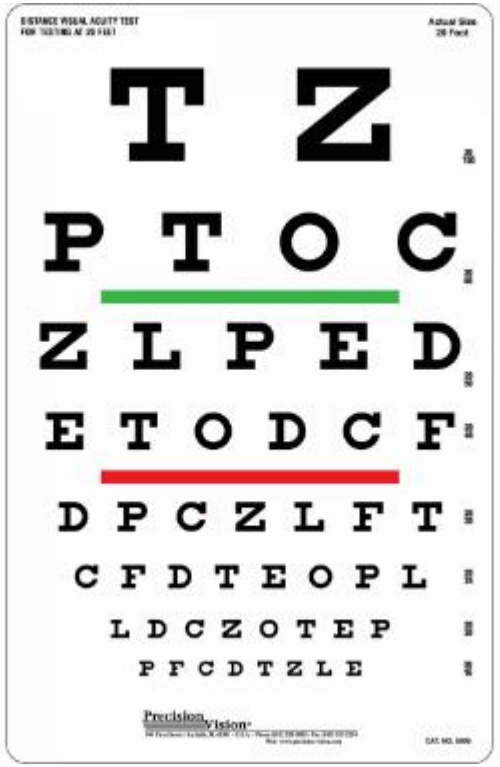

Chart Standards

Snellen Chart Principles

6m / 20ft

Standard Distance

- Light rays from 6 meters are virtually parallel.
- Accommodation requirement is zero at 6m.
- Expressed as fraction: Distance Tested / Distance Normal Reads.

5 Arc Min

Optotype Geometry

- Entire 6/6 letter subtends 5 minutes of arc.
- Individual stroke width subtends 1 minute of arc.
- 6/6 optotype height measures 8.73 mm at 6m.

Standardized Acuity

LogMAR Chart System

Logarithmic Progression

Letter size increases by 0.1 log units per line.

Uniform Letter Count

Exactly 5 Sloan letters per line eliminates row bias.

Proportional Spacing

Inter-letter and inter-line gaps equal letter size.

Clinical Execution

Visual Acuity Test Sequence

01

Right Eye First (OD)

Occlude left eye (OS) and test right eye monocularly.

02

Left Eye Second (OS)

Occlude right eye (OD) and test left eye monocularly.

03

Binocular Test (OU)

Test both eyes unoccluded for binocular summation.

04

Near Acuity (N-Scale)

Test reading vision at 40 cm with N-chart.

Low Vision Testing

Low Acuity Step Hierarchy

FC

Finger Counting

Count fingers at measured distance (e.g. FC at 2m).

HM

Hand Motion

Detect horizontal or vertical hand movement.

LP

Light Perception

Perceive presence or absence of penlight beam.

NLP

No Light Perception

Total absence of visual light perception (blindness).

Clinical Refraction

Subjective Refraction Procedures

Pinhole Test

Eliminates peripheral optical aberrations. If acuity improves, error is refractive.

Fogging Technique

Adds plus spherical power to relax ocular accommodation during subjective testing.

Refinement Tests

Cylinder Refinement & Duochrome

Jackson Cross-Cylinder (JCC)

Flips ±0.25 D cross-cylinder to refine astigmatic axis and power precision.

Duochrome Test

Uses chromatic aberration (red vs green) to verify spherical endpoint accuracy.

Retinal Physiology

Rods vs Cones Photoreceptors

Rods (120 Million)

- High sensitivity for night vision (scotopic).
- Located predominantly in peripheral retina.
- Lack color discrimination capability.

Cones (6 Million)

- Daylight vision and fine detail (photopic).
- Concentrated densely in fovea centralis.
- Three types responsible for color perception.

Color Vision Physiology

Trichromatic Cone Spectrum

S-Cones

Short Wavelength

Peak sensitivity at 420 nm (Blue light absorption).

M-Cones

Medium Wavelength

Peak sensitivity at 530 nm (Green light absorption).

L-Cones

Long Wavelength

Peak sensitivity at 560 nm (Red light absorption).

Diagnostic Screening

Color Deficiency & Ishihara Test



Protanopia & Deuteranopia

Red-green congenital color vision defects affecting L or M cones.

Ishihara Pseudoisochromatic Plates

Clinical gold standard screening for red-green color vision defects.



Lecture Series Complete

Mastery of lens power equations, retinoscopy neutralization, visual acuity grading, and color vision evaluation forms the foundation of clinical optics practice.

Image Sources



https://theeyesongroup.com/wp-content/uploads/2024/10/Focusing-on-Retinoscopy.jpg

Source: theeyesongroup.com



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