
RANZCO

The Royal Australian
and New Zealand
College of Ophthalmologists

# Optics
# Curriculum Standard

May 2015

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# Purpose

The purpose of studying optics is to understand:

- the nature of light
- the principles of image formation by lens systems and by the eye
- optical correction
- ophthalmic instruments used for diagnosis and treatment.

This curriculum standard also covers an introduction to the use of ultrasound for diagnosis and treatment.

This standard should be read in conjunction with RANZCO's *Ophthalmic Basic Competencies and Skills Curriculum Standard, Clinical Refraction Clinical Curriculum Performance Standard* and *Ophthalmic Ultrasound Clinical Curriculum Performance Standard*, to enhance understanding of the clinical relevance of the study of optics.

# Structure

This curriculum standard comprises five educational elements and their associated learning outcomes and performance criteria.

Learning outcomes are statements of what the trainee is expected to know, understand and do, while performance criteria specify the level of performance required to demonstrate achievement of the element/learning outcome.

# References

### Core Reading

American Academy of Ophthalmology, Basic and Clinical Science Course (AAO BCSC), Section 3: *Clinical optics*, 2013-2014, American Academy of Ophthalmology, San Francisco, CA.

Elkington, A.R., Frank, H.J. & Greaney, M.J. 2006, *Clinical optics*, 3rd edn (reprinted), Blackwell Scientific Publications, Oxford.

*Ultrasound*: American Academy of Ophthalmology, Basic and Clinical Science Course (AAO BCSC), Section 3: Clinical optics, 2011-2012, American Academy of Ophthalmology, San Francisco, CA. (not 2013-2014 edition; extract available on RANZCO's Moodle learning management system)

### Additional Reading

American Academy of Ophthalmology, Basic and Clinical Science Course (AAO BCSC) Section 11: *Lens and cataract*, 2013-2014, American Academy of Ophthalmology, San Francisco, CA. (for methods of calculating the power of intra-ocular lenses, including after previous refractive surgery)

Australian Radiation Protection and Nuclear Safety Agency 2012, Radiation and health fact sheets: Sunglasses and protection from solar ultraviolet radiation, Canberra, accessed 10 December 2014, <http://www.arpansa.gov.au/RadiationProtection/Factsheets/is_Sunglasses.cfm>.

 

Coleman, D.J., Silverman, R.H. & Lizzi, F.L., Lloyd, H., Rondeau M.J., Reinstein, D.Z., & Daly, S.W. 2006, *Ultrasonography of the eye and orbit*, 2nd edn, Lippincott Williams and Wilkins, Philadelphia, PA.

Ogle, K.N. 1968, *Optics, an introduction for ophthalmologists*, 2nd edn, Charles C. Thomas, Springfield, IL. (a more rigorous treatise on optics for ophthalmologists: it includes the best diagram of Gullstrand's schematic eye)

Rubin, M.L. 1993, *Optics for clinicians*, Triad Pub. Co., Gainesville, FL.

Teaching and learning resources for optics on RANZCO's Moodle learning management system.

**Guidance on reading**

The American Academy Basic and Clinical Science Course, 2013-2014, Section 3: *Clinical optics* and Elkington, Frank and Greaney's *Clinical optics* are the basic references. Together they include most of the required knowledge, at the appropriate level.

Material in the American Academy's *Clinical optics* (2013-2014) which is not required is as follows:

1. *Contact lenses*: the second half of chapter, from 'Contact Lens Materials and Manufacturing' (pp. 165-194)
2. *Multi-focal intra-ocular lenses*: leave out intra-ocular lens standards and history (pp. 215-222)
3. *Lensmeter and specular microscopy*: pp. 253- 254.

Important material which is not adequately covered in the core reading references includes the following:

1. *The cardinal points and planes of lens systems (principal planes and points, nodal points, and foci).* These are adequately covered in Rubin's *Optics for clinicians* and in Ogle's *Optics: an introduction for ophthalmologists*.
2. *Maddox rod:* covered in Rubin's *Optics for clinicians,* and elsewhere.
3. *Applanation tonometry:* covered in the 2011-2012 edition of the *AAO BCSC, Section 3: Clinical optics.*
4. *Intra-ocular lens power determination, including after previous refractive surgery:* covered in *AAO BCSC, Section 11: Lens and cataract*.
5. *Ultrasound:* suggest *American Academy of Ophthalmology, Basic and Clinical Science Course, 2011-2012, Section 3, Clinical optics.* This is a bare minimum, and the texts under additional reading above will help with understanding.
6. *Eyepieces:* This important topic is poorly covered in the standard texts. An article on eyepieces may be found on Moodle.

# Assessment Methods

The trainee's learning is assessed in a 3 hour written examination, comprising 12 questions of equal weight.

 

# Learning outcomes and performance criteria

| **OP1 PHYSICAL OPTICS** | |
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| Physical optics describes phenomena such as interference, diffraction and polarisation that are most readily understood in terms of the wave properties of light. | |
| **LEARNING OUTCOMES** | **PERFORMANCE CRITERIA** |
| **1.1 Understand and apply the theories of light, its properties and propagation** | 1.1.1 Be able to describe the nature of light in terms of wave and quantum theories<br><br>1.1.2 Be able to describe the following properties of light:<br>• electromagnetic spectrum<br>• interference and coherence<br>• polarisation<br>• diffraction<br>• scattering<br>• optical path length (Fermat principle)<br>• transmission and absorption<br>• fluorescence<br>• dispersion |
| **1.2 Understand the theory and properties of lasers used in ophthalmology** | 1.2.1 Be able to describe the:<br>• physical properties of laser light<br>• physics of production of laser light<br>• laser-tissue interactions |

 

## OP2 GEOMETRICAL OPTICS

Geometric optics uses the principles of geometry to model the behaviour of light and the propagation of images.

| LEARNING OUTCOMES | PERFORMANCE CRITERIA |
|---|---|
| **2.1 Understand and apply the principles of real and virtual image production including size, brightness and location as well as to be able to draw accurate basic diagrams of refraction, reflection and lens systems** | 2.1.1 Define vergence and vergence power<br><br>2.1.2 Describe, using labelled diagrams where appropriate, the application of the vergence equation in the following cases:<br>• refraction<br>• Snell's Law<br>• critical angle<br>• total internal reflection<br><br>2.1.3 Define refractive index<br><br>2.1.4 Explain the behaviour of light in different optical media and at optical interfaces<br><br>2.1.5 Describe image formation, including ray diagrams, by reflection and refraction at plane and spherical surfaces<br><br>2.1.6 Define the point spread function and the modulation transfer function, and explain their application in ophthalmology<br><br>2.1.7 Describe the characteristics and uses of spherical, cylindrical and toric lenses<br><br>2.1.8 Describe the characteristics of prisms, including:<br>• dispersion<br>• refraction<br>• total internal reflection<br>• prism dioptre<br>• aberrations<br>• uses of prisms in ophthalmology<br>• prisms designed specifically for ophthalmology and ophthalmic instruments<br>• Prentice rule<br>• Prism positioning during prism cover testing – frontal, minimum deviation and Prentice positions |

 

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| | 2.1.9 Describe the characteristics of lenses<br>• minus and plus<br>• focal points<br>• power- true, back vertex, and surface<br>• principal planes and points<br>• nodal points<br>• image formation<br>• effectivity<br>• aberrations<br>• lens designs to minimise aberrations<br><br>2.1.10 Draw graphical constructions of image formation in multiple lens systems and in instruments<br><br>2.1.11 Describe, using labelled diagrams where appropriate:<br>• afocal systems - telescopes, astronomical and Galilean<br>• microscopes, including slit lamp and operating microscopes |

 

| **OP3 PHYSIOLOGICAL OPTICS** | |
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| Physiological optics is the study of vision, visual processes, and related phenomena | |
| **LEARNING OUTCOMES** | **PERFORMANCE CRITERIA** |
| **3.1 Understand the eye as an optical system, including schematic eyes** | 3.1.1 Describe, using labelled diagrams where appropriate, the following optical characteristics of the human eye:<br>• refractive elements<br>  − Gullstrand schematic eye<br>  − reduced schematic eye<br>• image formation in the human eye<br>• axes and angles of the eye<br>• entrance and exit pupils<br>• aberrations of the eye and their minimisation<br>• pinhole principle |
| **3.2 Understand refractive states of the eye and common refractive errors** | 3.2.1 Define the following conditions, and describe their clinical consequences:<br>• far and near point of the eye<br>• emmetropia<br>• ametropia<br>• hypermetropia and its subdivisions:<br>  − latent<br>  − manifest<br>  − facultative<br>  − absolute<br>• myopia<br>• astigmatism:<br>  − compound<br>  − simple<br>  − mixed<br>  − regular<br>  − irregular, including wavefront analysis<br>  − with the rule, against the rule and oblique astigmatism<br>• anisometropia and aniseikonia<br>• changes in refraction and accommodation with age |

 

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| **3.3 Conduct appropriate assessments for the correction of refractive errors** | 3.3.1 Describe the purpose of and procedure involved in the following assessments:<br>• trial lens set: spherical, cylindrical, and prismatic lenses, and accessory components<br>• Jackson cross cylinder<br>• Duochrome test<br>• Placido disc<br>• presbyopia correction<br>• back vertex distance and power<br><br>3.3.2 Describe the correction of ametropia using:<br>• spectacles<br>• contact lenses<br>• intraocular lenses<br>• determination of the power of intra-ocular lenses including after previous refractive surgery<br><br>3.3.3 Define aphakia, its causes and sequelae, and describe the options available for its correction<br><br>3.3.4 Describe the characteristics of spectacles:<br>• forms of lenses: bifocals, trifocals and multifocals (manufacturing techniques not required)<br>• spectacle magnification and relative spectacle magnification (simple formulae only)<br>• writing spectacle prescriptions: transposition<br>• spectacle lens materials (basic)<br>• tints for lenses including photochromic/transition lenses and polarising lenses<br>• be aware of the standards for sunglasses in Australia and New Zealand<br><br>3.3.5 Discuss the theories of multifocal and accommodating intra-ocular lenses (basic understanding only) |

 

| **OP4 ULTRASOUND** | |
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| *Ophthalmic ultrasound is an important diagnostic tool that complements optical imaging modalities* | |
| **LEARNING OUTCOMES** | **PERFORMANCE CRITERIA** |
| **4.1 Understand theory and use of ultrasound in ophthalmology** | 4.1.1 Be able to describe:<br>• the physics of ultrasound and its production<br>• A scan, B scan, and Doppler<br>• its uses in ophthalmology:<br>− corneal thickness<br>− axial length<br>− imaging anterior and posterior segments, blood flow<br>− ultrasonic cleaning of surgical instruments |

 

## OP5 OPHTHALMIC INSTRUMENTS

*The optical instruments used in ophthalmology are based on the principles described in this standard*

| LEARNING OUTCOMES | PERFORMANCE CRITERIA |
|---|---|
| **5.1 Understand the theory of ophthalmic instruments** | 5.1.1 Explain, with the use of basic but accurate diagrams of the optics of these instruments where appropriate, the purpose of the following instruments and their use in ophthalmic clinical practice<br>• retinoscope<br>• eyepieces in instruments<br>• trial lens set: spherical, cylindrical and prismatic lenses with accessory components<br>• slit lamp and its accessories, including applanation tonometer<br>• fundus lenses, contact and non-contact<br>• gonioscope (direct and indirect)<br>• ophthalmoscopes: direct and indirect<br>• keratometers: Von Helmholtz, Javal–Schiotz<br>• Placido disc<br>• corneal topography<br>• Maddox rod<br>• tests of stereo-acuity<br>• biometry: ultrasonic and partial coherence interferometry<br>• operating microscope<br>• wavefront aberrometer<br>• optical coherence tomography (OCT)<br>• low vision aids |

 

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