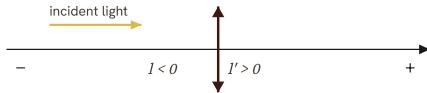




OPTICS AND REFRACTION

D, m, Δ

Work in metres and dioptres unless a unit is stated. Fix one axis before you start, positive in the direction of the incident light, and keep it even after a reflection. Distances are measured from a thin lens or surface vertex; for a thick lens's equivalent power, from its principal planes.

**Vergence**

$$L = \frac{n}{l}$$

L vergence (D), n refractive index of the medium, l distance to the object or image point (m).

Lens equation

$$L' = L + F$$

L object vergence, L' image vergence, F lens power, all in dioptres.

Power of a thin lens

$$F = \frac{1}{f}$$

F power (D), f second focal length in air (m).

Lensmaker's equation (thin lens in air)

$$F = (n - 1) \left(\frac{1}{r_1} - \frac{1}{r_2} \right)$$

n refractive index of the lens, r_1 and r_2 signed radii of the front and back surfaces (m).

Power of a refracting surface

$$F = \frac{n_2 - n_1}{r}$$

n_1 index before the surface, n_2 after it, r radius of curvature (m), positive when the centre lies after the surface.

Snell's law

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

θ_1 angle of incidence, θ_2 angle of refraction, both measured from the normal.

Critical angle

$$\sin \theta_c = \frac{n_2}{n_1}$$

Light passing from the optically denser medium n_1 into n_2 , with $n_1 > n_2$. At angles of incidence beyond θ_c , measured from the normal, it is totally internally reflected.

Prentice's rule

$$P = cF$$

P prismatic effect (Δ), c distance from the optical centre (cm), F lens power (D), taken as a magnitude. The base points towards the optical centre for a plus lens and away from it for a minus lens; for an astigmatic lens, work each principal meridian separately.

Deviation by a thin prism

$$D \approx (n - 1) a$$

A thin prism in air at small angles: D angle of deviation and a apical angle in the same angular unit (not prism dioptres), n refractive index of the prism.

Prism dioptres

$$P = 100 \tan \delta$$

P in prism dioptres (Δ), δ angle of deviation. One prism dioptre displaces a ray 1 cm at 1 m, and $1\Delta \approx 0.57^\circ$.

Linear magnification

$$m = \frac{h'}{h} = \frac{L}{L'}$$

h object height, h' image height, L and L' object and image vergences.

Simple magnifier

$$M = \frac{F}{4}$$

M angular magnification against unaided viewing at 25 cm, F loupe power (D), object at the focal point so the image is at infinity. With the lens close to the eye and the image at the 25 cm near point instead, $M = 1 + F/4$.

Telescope magnification

$$M = -\frac{F_e}{F_o}$$

M angular magnification of an afocal telescope, object and image at infinity. F_e and F_o signed eyepiece and objective powers (D); a negative M (astronomical) is an inverted image, a positive M (Galilean) an erect one.

Effective power (vertex distance)

$$F_c = \frac{F_s}{1 - dF_s}$$

F_s spectacle power, F_c power needed at the cornea, d vertex distance (m).

► Moving a plus lens nearer the eye needs more plus; moving a minus lens nearer needs less minus.

Equivalent power of a thick lens

$$F_e = F_1 + F_2 - \frac{t}{n} F_1 F_2$$

F_1 , F_2 surface powers (D), t centre thickness (m), n refractive index of the lens.

Back vertex power

$$F_v = \frac{F_1}{1 - \frac{t}{n} F_1} + F_2$$

The power that focimeters read and prescriptions quote: vergence leaving the back surface for parallel incident light.

Spherical mirror

$$f = \frac{r}{2}$$

f focal length, r radius of curvature. On the fixed axis, reflected light travels backwards, so its vergence is $L' = -n/l'$ and the reflecting power in air is $F = -2/r$ (D, r in m): a concave mirror has $r < 0$ and converges, a convex mirror has $r > 0$ and diverges.

Spherical equivalent

$$SE = S + \frac{C}{2}$$

S sphere, C cylinder (D).

Cylinder transposition

$$S' = S + C, \quad C' = -C, \quad \text{axis}' = \text{axis} \pm 90^\circ$$

Converts between plus- and minus-cylinder forms of the same prescription; keep the new axis between 1° and 180° .

Amplitude of accommodation

$$A = R - P$$

R vergence of the far point, P vergence of the near point, both in dioptres at the eye.

Retinoscopy working distance

$$Rx = \text{neutralising lens} - \frac{1}{w}$$

w working distance (m). At 67 cm, subtract 1.50 D.

Emsley reduced eye

$$F = +60 \text{ D}, \quad n = \frac{4}{3}, \quad r = 5.55 \text{ mm}$$

Measured from the refracting surface: anterior focal length -16.67 mm, posterior focal length $+22.22$ mm (the model's axial length), nodal point $+5.55$ mm, so the nodal point lies 16.67 mm in front of the retina.

STATISTICS AND EVIDENCE-BASED MEDICINE

2 × 2 table

Diagnostic-test measures come from one 2×2 table: TP and FP are positive results with and without the disease, FN and TN negative results with and without it.

	Disease +	Disease -
Test +	TP	FP
Test -	FN	TN

Sensitivity

$$\frac{TP}{TP + FN}$$

The proportion of people with the disease who test positive.

Specificity

$$\frac{TN}{TN + FP}$$

The proportion of people without the disease who test negative.

Positive predictive value

$$\frac{TP}{TP + FP}$$

The proportion of positive results that are true. With sensitivity and specificity fixed, it rises with prevalence.

Negative predictive value

$$\frac{TN}{TN + FN}$$

The proportion of negative results that are true. With sensitivity and specificity fixed, it falls as prevalence rises.

Accuracy

$$\frac{TP + TN}{TP + FP + FN + TN}$$

The proportion of all results that are correct.

Positive likelihood ratio

$$LR^+ = \frac{\text{sensitivity}}{1 - \text{specificity}}$$

The factor a positive result multiplies the pre-test odds by; above 1 for a useful test. It does not depend on prevalence directly, though it can vary with the disease spectrum of the population studied.

Negative likelihood ratio

$$LR^- = \frac{1 - \text{sensitivity}}{\text{specificity}}$$

The factor a negative result multiplies the pre-test odds by; below 1 for a useful test.

Pre- and post-test odds

$$\text{odds} = \frac{p}{1-p}, \quad \text{post-test odds} = \text{pre-test odds} \times LR$$

p pre-test probability, from the prevalence and the patient's own clinical picture. Use LR^+ after a positive result and LR^- after a negative one, then convert back with $p = \text{odds}/(1 + \text{odds})$.

Relative risk

$$RR = \frac{a/(a+b)}{c/(c+d)}$$

Exposed: a with the outcome, b without. Unexposed: c with, d without.

Odds ratio

$$OR = \frac{ad}{bc}$$

Same table as relative risk. Approximates RR when the outcome is rare; the measure for case-control studies.

Absolute risk reduction

$$ARR = CER - EER$$

CER control event rate, EER experimental event rate: the risks of the adverse outcome over the same follow-up period, as proportions.

Relative risk reduction

$$RRR = \frac{CER - EER}{CER}$$

Equivalently $1 - RR$, where $RR = EER/CER$.

Number needed to treat

$$NNT = \frac{1}{ARR}$$

ARR as a proportion, not a percentage. Round up to the next whole person. For harm, $NNH = 1/ARI$, where $ARI = EER - CER$.

Standard error of the mean

$$SE = \frac{SD}{\sqrt{n}}$$

SD sample standard deviation, n sample size.

Standard error of a proportion

$$SE = \sqrt{\frac{p(1-p)}{n}}$$

p sample proportion, n sample size.

95% confidence interval

$$\bar{x} \pm 1.96 \times SE$$

For the mean $\bar{x}$ of a large sample; small samples use a t multiplier.

Intervals for RR and OR are calculated on the log scale, and one that includes 1 is not significant at the 5% level.



Knowing the formula is half of it. Practise exam-style optics and statistics questions with worked explanations at auroprep.com/frcophth-part-1.