In our regular series on dispensing calculations, **Janet Carlton** explains how to calculate the refractive index of a lens

What is the index of an unknown lens?

WHAT IS THE INDEX of an unknown lens, and why do we need to know? Many of your myopic patients will be wearing a higher index lens, and may want a new lens with the same index as before. That's fine if you originally supplied the lenses, but with patients 'shopping around' you could easily be seeing a patient who has no previous records with you.

Experienced practitioners may be able to identify some of the higher-index materials, for example the unique sound a polycarbonate lens makes when it is tapped. But as professionals you need to demonstrate skill, not guesswork (Table 1).

TABLE 1

-12.00 lens in a 50 eye frame

1.6 lens	Cost £40	t=1mm	e=7.8mm	
1.7 lens	Cost £80	t=1mm	e=6.7mm	1.1mm thinner than 1.6
1.8 lens	Cost £125	t=1mm	e=5.4mm	1.3mm thinner than 1.7 (2.4mm thinner than 1.6)

Where t = centre thickness and e = edge thickness

Imagine the scenario where a patient says that he is wearing a thinner lens, he remembers paying extra for it.

Your new patient is wearing a 1.7 index lens, but you had assumed that it was 1.6. Your patient would be happy that your lenses were cheaper (half the price in the above data) but may decide that the lens was not as thin as the previous one, and insists that you remake them. Conversely if you assumed that the lenses were 1.8 and dispensed that, the patient may think that you have over-charged him, and not appreciate the decrease in thickness. Had you calculated the index and dispensed the same, the patient would have been fairly charged, and received the thickness of lens that he was expecting.

You should have in practice a lens measure; these are normally calibrated for crown glass (1.523) though some are now calibrated for both crown and 1.7 index material. Remember to check the lens measure for accuracy against a known flat edge. A practice mirror is ideal. If the reading on a plano surface is slightly out, you will need to amend your final readings. For example, if the lens measure reads -0.25 rather than zero, all lens readings will be out by -025.

Now you can start to think about the maths. High-index lenses are normally minus lenses which can be treated as a 'thin lens'. So the calculations will be easy.

So:

$F_1 + F_2 = F'v$

F_1 may well be plano, do check though. Just because it looks flat doesn't mean it is. Use the straight edge of your ruler for an easy check system, if the edge sits well on the front surface with no gaps or rocking then assume it is a flat lens. If in doubt use the lens measure.

The only other equation you need to worry about is:

$$\frac{n-1}{F} = r$$

Where n = index, r = radius of curvature and F is the power of that curve.

It will be unnecessary to actually calculate 'r', so a slight adaptation of this equation will give you:

$$\frac{n-1}{F} \text{ (From the lens measure)} = \frac{n-1}{F} \begin{matrix}\text{(Unknown index)} \\ \text{(From focimeter)}\end{matrix}$$

You know three of the four variables:

n - 1 = 0.523 (calibrated for crown)
F left of equation = reading from lens measure ($F_1 + F_2 = F'v$)
F right of equation = reading from the focimeter
So:

$$\frac{(0.523) \times (F \text{ Actual from focimeter})}{F_1+F_2 \text{ from the lens measure}} + 1 = \text{Unknown index}$$

Do remember that by treating the lens as thin, the answer you get will only be a rough answer, so if you get something like 1.787 the index is probably 1.8.

If the current lens is spherical, then this calculation is simple, but it is more likely that the lenses will be toric. Take both the lens measure reading and the focimeter readings along the highest (or lowest) power meridian.

You should never need to worry about index when you have a hyperopic patient, as high-index materials make very little noticeable difference in thickness. Should you need to calculate the index of a plus lens you will need the 'thick lens' equation to replace '$F_1 + F_2 = F'v$' in the previous equation.

The thick lens equation is:

$$F'v = \frac{F_1 + F_2 - dF_1F_2}{1 - dF_2}$$

where d = t/n, (t is measured with thickness callipers, in metres and n = 1.523)

TABLE 2

Some values for index (N), Abbé number (V) and density for currently available lens materials

	N	V	Density g/cm^3
Plastics			
ADC 'CR 39' (Allyl diglycol carbonate monomer)	1.498	58	1.32
PMMA (Polymethyl methacrylate)	1.491	58	1.2
Triology/Trivex	1.53	45	1.1
Resin lenses	1.537	47	1.21
	1.56	37.7 – 41	1.17 - 1.27
Polycarbonate	1.586	30	1.2
Glass			
	1.523	58	2.55
	1.6	42	2.65

Table 2 shows some optical properties (including refractive index) for a range of lens materials.

We need to take care in using the index as the only criterion for providing the best lens for our patients. In our example above the 1.6 lens was 7.8mm thick, but a polycarbonate lens (1.589) almost identical in index is another millimetre thicker. That seems strange until you realise that the centre thickness of a polycarbonate lens is greater, at 2mm. A higher-index lens is not always the answer, especially with today's fashion for small frames. Looking back to our original data, where a 50mm diameter CR39 lens was 10.7mm thick, were that glazed in a 44 eye the edge thickness would be 7.8mm, the same as a 1.6 lens. Interesting!

◆ *Janet Carlton is the dispensing clinic manager at City University Optometry Clinic*