What's a Diopter, and Why Do I Care Anyway?

I guess to start at the beginning, one thing to get out of the way is that a Diopter is NOT a little glass screw-in lens that looks like a bulging skylight filter. That's a close-up lens, which happens to have its power marked on it in Diopters.

A Diopter, in itself, is a number; or perhaps more precisely, a formula, which tells you the power, or focal length, of a lens. Specifically, one diopter is the reciprocal of one meter of focal length ...... or,

$$[\ 1 \div (\text{focal length in meters})]$$

The first thing that you can do with this information is apply it to your little "diopter" close-up lenses and see what they really are:

- Your +1 lens is 1 diopter, or 1/1 meters, or 1,000mm focal length
- Your +2 lens is 2 diopters, or 1/2 meters, or 500mm focal length
- And your +4 lens is 4 diopters, or 1/4 meters, or 250mm focal length.

This in turn will tell you what the farthest distance is that you can focus through this lens: in each case, with your prime* lens at infinity, you will focus on an object one focal length from the close-up attachment – so you can focus out to 1,000, 500 or 250mm respectively through these three attachments.

But you can do more than that: you can also use the Diopter formula to tell you what the CLOSEST distance is that you can focus through the attachment. You can do this because, just as you can use the formula to find the focal length of your close-up attachment, you can also use it to find the power in Diopters of your camera lens – and once you've done that, you can do some arithmetic.

Let's say, for instance, that you want to use a +1 attachment on a 50mm lens that normally focuses from infinity to 0.5 meters. At infinity, the optical distance from the lens to the film is equal to its focal length – in this case 50mm, or 0.05 meters, or 20 diopters. The focus movement that brings the lens down to 0.5 meters is equivalent to (1/0.5), or 2 Diopters of added power. If we now add another +1 close-up lens to the system, we have a total of 3 Diopters of focusing power when the lens is set at its closest focus limit. So how far is 3 Diopters? The Diopter formula gives the answer:

3 Diopters = 1/3 meter = 333mm (about 13 inches)

So now you know that your 50mm lens will focus from 0.33 to 1.0 meter when you have a +1 lens on it. You can run the same numbers for the +2, the +4 and multiple combinations (just add diopters) so that you know in advance which lens to pick for a given subject distance.

But Wait! There's More!

Did you notice that I said the focus movement of the lens is "equivalent to 2 Diopters of power" because it makes it focus down to 1/2 meter? But we didn't actually add any power to the lens, did we? We just moved it forward a few millimeters. So how does that work, and what does it have to do with Diopters?

Well, you may have also noticed that I referred to the "optical distance from the lens to the film" in terms of Diopters. That's odd. But it's useful. When we moved the lens forward, we didn't increase the number of diopters in the lens ... but we did DECREASE the number of diopters in the distance from the lens to the film. When the distance from the lens to the film is equal to the focal length of the lens, then it's focused at infinity ... but when the distance is GREATER than the focal length, the lens will focus CLOSER than infinity – and the distances from lens to subject and from lens to film can both be figured out from the Diopter formula. So let's go back to our 50mm lens.

The lens itself has 20 diopters of power, that's not going to change. So if we want it to focus down to 0.5 meter (2 Diopters) by increasing its distance from the film, then the distance we're looking for has to be (20 – 2), or 18 Diopters. So back to the formula, 18 Diopters = (1/18) meters, or 55.55 millimeters. Subtract this from the 50mm of the focal length of the lens, and we now know that the lens has to have 5.55 millimeters of focus travel to reach a minimum focus of 0.5 meters.

You can use this formula for any problem involving lens powers, focus error, positive (or negative) power attachments, bellows extension requirements... all kinds of stuff!

Ever wonder why a 400mm glass supertelephoto lens won't focus any closer than 8 meters (about 27 feet)? Well, with a lens of 2.5 Diopters power, to get to 8 meters (.125 Diopters distance) we need a distance from the film of (2.5 - .125), or 2.375 Diopters; this is a distance of (1/2.375), or 421mm – meaning that the lens has a focus travel of 21mm. That's quite a lot of travel in a focus thread.

Now, you're probably already running for your calipers to prove this wrong, so I'll add a caveat: this simple formula for focal length, focus thread travel and subject distance doesn't work for ALL lenses. It works for all unit-focusing lenses, such as you would find on a TLR, an interchangeable-lens rangefinder and most single-focal-length* SLR lenses. A notable case where it does NOT apply is in front-cell-focusing lenses... in these, when you turn the focus ring you actually are changing the focal length of the lens, making it shorter and increasing its Diopter power, rather than changing its distance from the film. The formula will still give you the correct answers for your focus limits with close-up attachments, but not for the focus thread travel. Similarly, any lens which has elements that do not move during focusing – some telephotos, mirror lenses and zooms, and anything with internal focusing – will not conform to this formula in terms of the focus movement of the lens.

Okay, one last example. Let's say you removed the lens mount from your Kiev 4A (don't actually try this), and there were a bunch of shims under it, and the little buggers are a pain in the patoot to get back in place. How far will your focus be off if you put it back together without the shims? We've got a 50mm lens, and the shims are .01" (.25mm) thick.

Without the shims, the 50mm lens will be 49.75mm from the film. This error is (1/.04975) – (1/50), or 0.10 Diopters. And, going back the other direction, 0.1 Diopters is (1/0.1) or 10 meters, about 33 feet. The lens will actually be focused at infinity when the distance scale indicates 10 meters. According to the DOF scale on the Kiev, this will come within the depth of field of the lens only if it's stopped down to f/5.6 or smaller.... and DOF scales tend to be on the liberal side, so you'll probably notice the error in prints even at smaller apertures than that.

With this one little formula, you can determine not only whether your camera is off, but how far it's off, and how much you have to add or subtract to correct it, and how close to perfect is close enough for your purposes.

* - totally off the subject, but you may have noticed my reference to a "prime" lens in one place and to a "single-focal-length" lens in another. Contrary to Digital Era usage, these terms are NOT synonymous. A "single-focal-length" lens is a lens that has only one focal length; i.e., not a zoom lens. A "prime" lens is the imaging lens that is attached to a camera, without additional attachments – as opposed to an "auxiliary" lens, whether a close-up lens or a wide-angle, telephoto or fisheye converter, that screws or slips onto the front of the prime lens to change its characteristics. The only explanation for the recent use of the term "prime" to refer to non-zoom lenses is that "non-zoom" requires too many keystrokes (and that the writers have not been around long enough to know what the term "prime lens" actually means).