**Move closer**

**Increasing the distance between the lens and the sensor or film reduces the focusing distance. That’s how macro lenses do it. But you can get similar results by fitting an extension tube.**

If you are serious about macro photography, you probably own a macro lens. They are the tool of choice for photographers who want to get close to their subjects, but do not want to compromise on image quality, ease of use or performance.

However, the performance of macro lenses comes at a price – the cost of the lens. But what if you would like to dabble in macro or close-up photography without the expense of buying a macro lens? Is there any way to get in closer and obtain increased magnification with the range of lenses you already own?

Extension tubes could be the solution you are looking for. The principle is very simple. When it comes to close-up photography, your lenses are limited by how close to the subject they can focus. The closer the focusing distance, the further the front element needs to be from the sensor plane. This distance is called extension – the greater the extension the closer you can get to the subject.

Extension tubes work by increasing the lens extension – the physical distance between the front element of the lens and the film or digital sensor.

An extension tube is simply a light-tight tube that fits between the camera body and lens. The extension of the lens is increased, the minimum focusing distance decreases, and you can get closer to your subject for greater magnification.

**Canon extension tubes**

Canon makes two extension tubes, the EF 25 II and EF 12 II. They have a length of 25mm and 12mm respectively. The EF 25 II gives more extension, and therefore greater magnification, but it is more expensive. You can also use the two together for even more extension. Canon doesn’t recommend this (it says data transfer may be affected), but it worked for us.

The EF 25 II and EF 12 II extension tubes were introduced in September 2004 at the same time as the EOS 300D camera and EF-S lenses. Prior to this date, Canon sold the EF 25 and EF 12 extension tubes. They are identical to the newer versions except in one respect – you cannot use them with EF-S lenses. These Mark I versions have long been discontinued, but you may be able to find them on the second-hand market. If you do not use EF-S lenses they could be an economical alternative.
Extension tubes in action

The magnification formula

There is a formula for working out how much magnification extension tubes will give you:

\[
\text{magnification} = \frac{\text{extension}}{\text{focal length}}
\]

Every lens has an effective extension. Canon does not make this figure available, but we can work it out once we know the focal length of the lens.

To work out the magnification, just divide the effective extension built into the lens. Canon gives the figure as 7.5mm (this is at the minimum focusing distance of 45cm). From these figures a little algebra reveals that the effective extension is 7.5mm.

Adding the EF 25 II extension tube to a 50mm lens results in an extension of 25mm. The magnification is 0.15x (25/50). Fit the EF 12 extension tube and the magnification drops to 0.25x (25/100). So the longer the focal length, the less effect is gained from adding extension tubes. This explains why extension tubes are more useful with lenses of shorter focal lengths.

Magnification and focal length

The above equation also helps to explain the effect that extension tubes have on lenses of different focal lengths. Using simplified figures, we can see that the additional magnification of a 50mm lens used with the EF 25 II extension tube is 0.5x (25/50). Fit the same extension tube to a 100mm lens and the magnification drops to 0.25x (25/100). So the longer the focal length, the less effect is gained from adding extension tubes. This explains why extension tubes are more useful with lenses of shorter focal lengths.

Does this mean that you can use the EF 25 II extension tube with a 24mm lens for 1.0x magnification? Unfortunately not, because the minimum focusing distance is greater than the distance from the camera’s sensor plane to the subject required for 1:1 magnification. You cannot focus on the subject – only on a point somewhere behind it.

Unsuitable lenses

The EF 14mm, and EF 15mm lenses are unsuitable for the EF12/EF12 II extension tubes. These lenses, plus the EF 60mm and EF 24mm are unsuitable for the EF25/EF25 II extension tubes. Zoom lenses at these focal lengths are also unsuitable.

Cropping factor effect

Magnification is determined by the focal length and the extension of the lens. From this we can see that the crop factor of the camera you use is not even a consideration. However, in practice, the crop factor does make a difference to the apparent magnification. This is because at a magnification of say 1x, an object that measures 36mm by 24mm will be reproduced at the same size on a full-frame camera. An APS-C camera, on the other hand, will only record the central part of the object, an area of approximately 15x 22.5mm (the exact sensor size varies by model). Compare the two images side by side and it appears that the photo taken with the APS-C size camera has greater magnification. This means that an APS-C camera appears to get you closer to your subject than a full-frame camera.
Focus stacking is a technique which can be used to achieve front-to-back sharpness in close-up images with shallow depth-of-field.

**Depth-of-field**

Depth-of-field is determined by three factors:
- the focal length of the lens
- the aperture
- the distance between the lens and subject.

Of the three, the third factor has the greatest affect on depth-of-field. The closer your lens is to your subject, the less depth-of-field you have. When shooting close-up or macro photography with extension tubes, depth-of-field may be so limited that you cannot obtain back sharpness even at f16 or f22. This holds true regardless of focal length.

**Diffraction**

Another problem is diffraction. Diffraction is a kind of lens distortion that starts to appear at small apertures, such as f16 and f22. Diffraction degrades image quality – look closely at the same image taken with the same lens at apertures of f8 and f22 and you might see a significant difference in image quality. The image taken at f22 may have more depth-of-field, but appears to be less sharp than the image taken at f8 because of diffraction.

**The solution**

Focus stacking involves taking several photos, all at the same aperture (ideally f8 or f11 – the sharpest settings for most lenses) each with a slightly different point of focus. The first image is focused towards the front of the subject, the next a little further back, and so on. The aim is to have every part of the subject in focus in at least one of the images. You then blend the images using dedicated software to create a photo with back-to-front sharpness. Adobe Photoshop CS4 and CS5, have an auto-blending function for focus stacking. If you use Windows, CombineZM is a free program that does the same. It’s available from: http://hadleyweb.pwp.blueyonder.co.uk/CZM/News.htm.

Helicon focus is a program available for both Mac and PC users at: www.heliconsoft.com. Licenses start from £39US, and you can download the program and try it for 30 days without any restrictions.

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I have always been fascinated by macro subjects, especially insects. I used to own an EF 100mm f2.8 Macro lens, but it was rather frustrating not being able to take the shots I had in mind. So I sold my macro lens and changed my set up to a more compact solution. I now use an EF 12 II extension tube with an EF 24-70mm f2.8L lens. It’s easier, quick to change and a great combination with a fast aperture lens. It is a bit heavier than the 100mm f2.8 Macro lens, but it serves a dual purpose – a general walk around lens and a good macro option (by attaching the extension tube).

I like taking close-up and macro shots of plants, leaves, flowers, petals, butterflies, water droplets and insects – anything with symmetry, lines and interesting texture.

Most of the time I use my EF 12 II tube with my EF 24-70mm f2.8L. I normally shoot at the 70mm focal length. Using the rule of thumb for calculating magnification (magnification = extension/focal length), at 70mm the magnification is 12mm/70mm = 0.17x.

Focus shift

Another disadvantage occurs when you use extension tubes with zoom lenses. If you change the focal length of the lens, the focusing distance changes as well, and you need to refocus. You can get around this by selecting the focal length you want to use first (normally the longest) before focusing. If you don’t have this problem it you are using a prime (fixed focal length) lens.

Telephoto lenses

Extension tubes work best with lenses that have a focal length of between 35mm and 150mm. Below 35mm, you may need to get so close to your subject to focus that it becomes impractical. With longer telephoto lenses, the increase in magnification is so slight that using extension tubes may not be useful. Canon’s 250D or 500D close-up lenses will get you much closer.

Image quality

While Canon’s double element close-up lenses, the 250D and 500D, are high quality close-up lenses that have a minimal effect on image quality, less expensive close-up lenses can degrade image quality quite badly. Extension tubes contain no glass and so have little impact on image quality.

The big advantage of extension tubes is that they can be used with nearly any lens. They can also be used in combination with close-up lenses (covered in the July–September 2010 issue), or with a macro lens, for even greater magnifications.

Light loss

There is one major disadvantage – adding an extension tube reduces the amount of light reaching the film or digital sensor. This means that you need to increase the exposure by increasing the ISO, using a slower shutter speed or setting a wider aperture. Light loss can be as much as two stops at higher magnifications – although you always have the option of using off-camera Speedlites so that you can use low ISOs and small apertures. Both Lee Beel and Rodel Mandabat, whose photos appear in this article, use Speedlite flashes with diffuses fitted to them for this reason.

Of course, much of the time you might not be aware of this light loss. Unless you are using the manual shooting mode, the camera’s through-the-lens metering system will automatically adjust the exposure values to give correct exposure. However, it will reduce your creative options for smaller apertures or faster shutter speeds.